

# **INTRODUCTION TO STATIONARY POINT SOURCE EMISSION INVENTORY DEVELOPMENT**

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## **DISCLAIMER**

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.



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# ABBREVIATIONS, ACRONYMS, AND SYMBOLS

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## ABBREVIATIONS

ACT	Alternative Control Technology Guideline
AFS	AIRS Facility Subsystem
AIRS	Aerometric Information Retrieval System
ALAPCO	Association of Local Air Pollution Control Officials
APA	Air Pathway Analysis
APTI	Air Pollution Training Institute
ATS	Allowance Tracking System
BACT	Best available control technology
Btu	British thermal unit
CAA	Clean Air Act
CAS	Chemical Abstract Services
CD-ROM	compact disc read-only memory
CEM	Continuous Emissions Monitoring
CERR	Consolidated Emissions Reporting Rule
CFC	Chlorofluorocarbon
CFR	Code of Federal Regulations
CERCLA	Comprehensive Environmental Recovery and Comprehensive Liability Act
CHIEF	Clearinghouse for Inventories and Emission Factors
CMS	Continuous Monitoring System
CO	carbon monoxide
CTC	Control Technology Center
CTG	Control Techniques Guideline
DARS	Data Attribute Rating System
DECIM	Defense Corporate Information Management
DoD	Department of Defense



# ABBREVIATIONS, ACRONYMS, AND SYMBOLS (CONTINUED)

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DOE	Department of Energy
EA	Environmental assessment
EIIP	Emission Inventory Improvement Program
EIS	Environmental Impact Statement
EMTIC	Emission Measurement Technical Information Center
EPA	U.S. Environmental Protection Agency
ETS	Emissions Tracking System
FIP	Federal Implementation Plan
FIPS	Federal Information Processing System
FR	Federal Register
FIRE	Factor Information Retrieval System
HAP	Hazardous air pollutant
HCFC	Hydrochlorofluorocarbon
ID	Identification
LAER	Lowest achievable emission rate
lb	Pound
MACT	Maximum achievable control technology
MSDS	Material safety data sheets
MWC	Municipal waste combustors
NAAQS	National Ambient Air Quality Standard
NAICS	North American Industrial Classification System
NATICH	National Air Toxics Information Clearinghouse
NEC	Not elsewhere classified
NEDS	National Emissions Database System
NEPA	National Environmental Policy Act
NEI	National Emission Inventory

# ABBREVIATIONS, ACRONYMS, AND SYMBOLS (CONTINUED)

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NIF	National Emission Inventory Input Format;
NTI	National Toxics Inventory
NO <sub>x</sub>	Nitrogen oxides
NPL	National priority list
NSPS	New Source Performance Standard
NSR	new source review
NTIS	National Technical Information Service
OAQPS	Office of Air Quality Planning and Standards
OMB	Office of Management and Budget
PL	Public Law
PM	Particulate matter
PM <sub>10</sub>	Particulate matter of aerodynamic diameter less than or equal to 10 micrometers
PM <sub>2.5</sub>	Particulate matter of aerodynamic diameter less than or equal to 2.5 micrometers
POTW	Publicly owned treatment works
PPM	Parts per million
PSD	Prevention of significant deterioration
QA	Quality assurance
QC	Quality control
RACT	Reasonably available control technology
RCRA	Resource Conservation and Recovery Act
RE	rule effectiveness
RFP	reasonable further progress
RP	Rule Penetration
RVP	Reid vapor pressure
SARA	Superfund Amendments and Reauthorization Act
SAEWG	Standing Air Emissions Work Group

# ABBREVIATIONS, ACRONYMS, AND SYMBOLS (CONTINUED)

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STAPPA	State and Territorial Air Pollution Program Administrators
SCC	Source Classification Code
SIC	Standard Industrial Classification
SIP	state implementation plan
SO <sub>2</sub>	sulfur dioxide
TAP	toxic air pollutant
tpy	tons per year
TRIS	Toxic Chemical Release Inventory System
TSDf	treatment, storage, and disposal facility
U.S.	United States
U.S.C.	United States Code
UTM	universal transverse mercator
VOC	volatile organic compound

# DEFINITIONS OF COMMONLY USED TERMS

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***Actual Emissions*** are the actual rate of emissions of a pollutant from an emissions unit calculated using the unit's actual operating hours, production rates, and types of materials processed, stored, or combusted during the selected time period.

***Allowable Emissions*** are the emissions rate that represents a limit on the emissions that can occur from an emissions unit. This limit may be based on a federal, state, or local regulatory emission limit determined from state or local regulations and/or 40 Code of Federal Regulations (CFR) Parts 60, 61, and 63.

***Ambient Standards*** limit the concentration of a given pollutant in the ambient air. Ambient standards are not emissions limitations on sources, but usually result in such limits being placed on source operation as part of a control strategy to achieve or maintain an ambient standard.

***Area Sources*** are smaller sources that do not qualify as point sources under the relevant emissions cutoffs. Area sources encompass more widespread sources that may be abundant, but that, individually, release small amounts of a given pollutant. These are sources for which emissions are estimated as a group rather than individually. Examples typically include dry cleaners, residential wood heating, auto body painting, and consumer solvent use. Area sources generally are not required to submit individual emissions estimates.

***Carbon Monoxide (CO)*** is a colorless, odorless gas that depletes the oxygen-carrying capacity of blood. Major sources of CO emissions include industrial boilers, incinerators, and motor vehicles.

***Class I Substances*** as defined in Title VI of the Clean Air Act Amendments include chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform. According to the CAAA, all of these compounds must be phased out of production by the year 2000 with the exception of methyl chloroform, which must be phased out of production by the year 2002. Provisions are also made that allow for acceleration of this phaseout.

***Class II Substances*** as defined in Title VI of the Clean Air Act Amendments include hydrochlorofluorocarbons (HCFCs). These substances must be phased out of production by the year 2015.

***Continuous Emissions Monitoring (CEM)*** is any monitoring effort that "continuously" measures (i.e., measures with very short averaging times) and records emissions. In addition to measuring

and recording actual emissions during the time of monitor operation, CEM data can be used to estimate emissions for different operating periods and longer averaging times.

**Criteria Pollutants** are carbon monoxide (CO), lead (Pb), nitrogen oxides (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>), volatile organic compounds (VOC), and particulate matter of aerodynamic diameter less than or equal to 10 micrometers (PM<sub>10</sub>). The National Ambient Air Quality Standards (NAAQS) were mandated by the Clean Air Act of 1970, and are based on criteria including adverse health or welfare effects. NAAQS are currently used to establish air pollutant concentration limits for the six air pollutants listed above that are commonly referred to as **criteria pollutants**.

**Design Standards** impose certain hardware requirements. For example, a design standard might require that leaks from compressors be collected and diverted to a control device. Design standards are typically used when an emissions limit is not feasible.

**Data Quality Indicators (DQIs)** are qualitative and quantitative descriptors used to interpret the degree of acceptability or utility of data to the user. The principal data quality indicators are accuracy, comparability, completeness, and representativeness.

**Data Quality Objectives (DQOs)** are qualitative and quantitative statements developed to ensure that data of known and appropriate quality are obtained to support decisions or actions. DQOs encompass all aspects of data collection, analysis, validation, and evaluation.

**Emission Concentration Standards** limit the mass emissions of a pollutant per volume of air. Emission concentration standards are expressed in terms such as grams per dry standard cubic meter (g/dscm) or other similar units.

**Emission Factors** are ratios that relate emissions of a pollutant to an activity level at a plant that can be easily measured, such as an amount of material processed, or an amount of fuel used. Given an emission factor and a known activity level, a simple multiplication yields an estimate of the emissions. Emission factors are developed from separate facilities within an industry category, so they represent typical values for an industry, but do not necessarily represent a specific source. Published emission factors are available in numerous sources.

**Emissions Reduction Standards** limit the amount of current emissions relative to the amount of emissions before application of a pollution control measure. For example, an emission reduction standard may require a source to reduce, within a specified time, its emissions to 50 percent of the present value.

**Emission Standards** are a general type of standard that limit the mass of a pollutant that may be emitted by a source. The most straightforward emissions standard is a simple limitation on mass of pollutant per unit time (e.g., pounds of pollutant per hour).

**Engineering Estimate** is a term commonly applied to the best approximation that can be made when the specific emission estimation techniques such as stack testing, material balance, or emission factor are not possible. This estimation is usually made by an engineer familiar with the specific process, and is based on whatever knowledge may be available.

**Equipment Standards** require a specific type of equipment to be used in certain processes. Equipment standards are typically used when an emissions limit is not feasible.

**Fugitive Emissions** are emissions from sources that are technically infeasible to collect and control (e.g., storage piles, wastewater retention ponds).

**Hazardous Air Pollutants (HAPs)** are listed in Section 112(b) of the 1990 Clean Air Act Amendments (CAAA). These pollutants are generally emitted in smaller quantities than criteria pollutants but may be reasonably anticipated to cause cancer, developmental effects, reproductive dysfunctions, neurological disorders, inheritable gene mutations, or other chronically or acutely toxic effects in humans. The CAAA specifies an initial list of 189 HAPs to be subject to further regulation. The list of HAPs includes relatively common pollutants such as formaldehyde, chlorine, methanol, and asbestos, as well as numerous less-common substances. Pollutants may, under certain circumstances, be added to or deleted from the list.

**Lead (Pb)** is an element that causes several types of developmental effects in children including anemia, neurobehavioral alterations, and metabolic alterations. Lead is emitted from industries such as battery manufacturing, lead smelters, and incineration. Although regulated in highway fuels, lead may also be emitted from unregulated off-highway mobile sources.

**Material Balance or Mass Balance** is a method for estimating emissions that attempts to account for all the inputs and outputs of a given pollutant. If inputs of a material to a given process are known and all outputs except for air emissions can be reasonably well quantified, then the remainder can be assumed to be an estimate of the amount lost to the atmosphere for the process.

**Maximum Achievable Control Technology (MACT) Standards** in addition to National Emissions Standards for Hazardous Air Pollutants (NESHAP), are promulgated under Section 112 of the Clean Air Act Amendments (CAAA). Technically NESHAP and MACT standards are separate programs. MACT standards differ from older NESHAPs because MACT standards are mandated by law to require the maximum achievable control technology. MACT standards are source category-specific, and each standard covers all the pollutants listed in Section 112 of the CAAA that are emitted by that source category. The first MACT standard promulgated (for the Synthetic Organic Chemical Manufacturing Industries) was originally developed as a NESHAP and is still referred to as the Hazardous Organic NESHAP (HON).

**Means of Release to the Atmosphere** is the mechanism by which emissions enter the atmosphere. Environmental agencies usually classify release mechanisms into three categories: process

emissions, fugitive emissions, and process fugitive emissions. This characteristic of an emission source is important because emission factors and other estimation methods are specific to the type of release.

**Mobile Sources** include all nonstationary sources, such as automobiles, trucks, aircraft, trains, construction and farm equipment, and others. Mobile sources are a subcategory of area sources, and are generally not required to submit individual emissions estimates.

**National Ambient Air Quality Standards (NAAQS)** are the main ambient standards for the following six criteria pollutants: carbon monoxide (CO), lead (Pb), nitrogen oxides ( $\text{NO}_x$ ), sulfur oxides ( $\text{SO}_x$ ), ozone ( $\text{O}_3$ ), and particulate matter of aerodynamic diameter less than or equal to 10 micrometers ( $\text{PM}_{10}$ ).

**National Emissions Standards for Hazardous Air Pollutants (NESHAP)** are a class of standards limiting emissions of HAPs. The common usage of NESHAP actually refers to two different sets of standards. First, there are 22 emissions standards promulgated prior to the 1990 Clean Air Act Amendments (CAAA). Some of these standards are pollutant-specific (e.g., the NESHAP for vinyl chloride), others are source-category specific (e.g., the NESHAP for benzene waste operations), and still others are both pollutant- and source-category specific (e.g., the NESHAP for inorganic arsenic emissions from glass manufacturing plants).

**New Source Performance Standards (NSPS)** are promulgated for criteria, hazardous, and other pollutant emissions from new, modified, or reconstructed sources that the U.S. Environmental Protection Agency (EPA) determines contribute significantly to air pollution. These are typically emission standards, but may be expressed in other forms such as concentration and opacity. The NSPS are published in 40 Code of Federal Regulations (CFR) Part 60.

**Nitrogen Oxides ( $\text{NO}_x$ )** are a class of compounds that are respiratory irritants and that react with volatile organic compounds (VOCs) to form ozone ( $\text{O}_3$ ). The primary combustion product of nitrogen is nitrogen dioxide ( $\text{NO}_2$ ). However, several other nitrogen compounds are usually emitted at the same time (nitric oxide [NO], nitrous oxide [ $\text{N}_2\text{O}$ ], etc.), and these may or may not be distinguishable in available test data. They are usually in a rapid state of flux, with  $\text{NO}_2$  being, in the short term, the ultimate product emitted or formed shortly downstream of the stack. The convention followed in emission factor documents is to report the distinctions wherever possible, but to report total  $\text{NO}_x$  on the basis of the molecular weight of  $\text{NO}_2$ .  $\text{NO}_x$  compounds are also precursors to acid rain. Motor vehicles, power plants, and other stationary combustion facilities emit large quantities of  $\text{NO}_x$ .

**North American Information Classification System (NAICS)** is the newest U.S. Department of Commerce's categorization of business by their products or services.

**Opacity Standards** limit the opacity (in units of percent opacity) of the pollutant discharge rather than the mass of pollutant.

**Operational Standards** impose some requirements on the routine operation of the unit. Such standards include maintenance requirements or operator training certification requirements. Operational standards are typically used when an emission limit is not feasible.

**Ozone ( $O_3$ )** is a colorless gas that damages lungs and can damage materials and vegetation. It is the primary constituent of smog, and is formed primarily when nitrogen oxides ( $NO_x$ ) and volatile organic compounds (VOCs) react in the presence of sunlight. It is also emitted in insignificant quantities from motor vehicles, industrial boilers, and other minor sources.

**Particulate Matter of aerodynamic diameter less than or equal to 10 micrometers ( $PM_{10}$ )** is a measure of small solid matter suspended in the atmosphere. Small particles can penetrate deeply into the lung where they can cause respiratory problems. Emissions of  $PM_{10}$  are significant from fugitive dust, power plants, commercial boilers, metallurgical industries, mineral industries, forest and residential fires, and motor vehicles.

**Particulate Matter of aerodynamic diameter less than or equal to 2.5 micrometers ( $PM_{2.5}$ )** is a measure of fine particles of particulate matter that come from fuel combustion, agricultural burning, woodstoves, etc. On November 27, 1996 the U.S. Environmental Protection Agency proposed to revise the current primary (health-based) PM standards by adding a new annual  $PM_{2.5}$  standard.

**Plant Level Emissions** are consolidated for an entire plant or facility. A plant may contain one or many pollutant-emitting sources.

**Plant Level Reporting** is generally required if total emissions from a plant (which may be composed of numerous individual emission points) meet the point source cutoff. These data can be used by the state to conduct a detailed estimate of emissions from that plant. The plant level reporting used by most air pollution control agencies generally requires that the facility provide data that apply to the facility as a whole. Such data include number of employees and the Standard Industrial Classification (SIC) code designation for the plant. A plant usually has only one SIC code denoting the principal economic activity of the facility. For the purpose of clearly identifying and tracking emissions data, each plant is generally assigned a plant (alternatively, "facility") name and number. The plant is also identified by geographic or jurisdictional descriptors such as air quality control region, county, address, and universal transverse mercator (UTM) grid coordinates (or latitude/longitude) that identify a coterminous location. An owner or operator engaged in one or more related activities is also identified. In some cases, plantwide emissions may be reported at the plant level.

**Point Level Emissions** typically represent single stacks or vents individually large enough to be considered point sources.



**Point Level Reporting** includes specific data for individual emission points (typically stacks). These data are more detailed than that submitted in Plant Level Reporting and may include emission-related and modeling information such as stack height of the release point, diameter of the stack, emission rate, method of determination, fugitive emissions, gas exit velocity from a stack, gas temperature, and operating schedule. Source identification information, as previously described under Plant Level Reporting, is usually also required at the point level to ensure that emission data for a single plant remain clearly identified. Regulatory agencies generally maintain individual emission-related records at the point level.

**Point Sources** are large, stationary, identifiable sources of emissions that release pollutants into the atmosphere. Sources are often defined by state or local air regulatory agencies as point sources when they annually emit more than a specified amount of a given pollutant, and how state and local agencies define point sources can vary. Point sources are typically large manufacturing or production plants. They typically include both confined "stack" emission points as well as individual unconfined "fugitive" emission sources.

Within a given point source, there may be several **emission points** that make up the point source. Emissions point refers to a specific stack, vent, or other discrete point of pollution release. This term should not be confused with point source, which is a regulatory distinction from area and mobile sources. The characterization of point sources into multiple emissions points is useful for allowing more detailed reporting of emissions information.

For point sources, the emission estimate reporting system used by most state and local air regulatory agencies groups emission sources into one of three categories and maintains emission-related data in a different format for each. The three categories are plant level, point level, and process or segment level.

**Potential Emissions** are the potential rate of emissions of a pollutant from an emissions unit calculated using the unit's maximum design capacity. Potential emissions are a function of the unit's physical size and operational capabilities.

It is important to note that annual potential emissions from a unit are not necessarily the product of 8760 hours per year times the hourly potential emissions. For most processes, the operation of one piece of equipment is limited in some way by the operation of another piece of equipment upstream or downstream. For example, consider a batch process involving vessels X, Y, and Z in series (i.e., the output from Vessel X is the feed to Vessel Y, and the output from Vessel Y is the feed to Vessel Z) where the residence time for each vessel is different. In this process, Vessel Y may not operate 8760 hours per year because either the output from Vessel X is not feeding Vessel Y at all times or Vessel Z may not always be available to accept the output from Vessel Y.

It is also possible for the emission rate to vary over time. For instance, if a reaction requires 6 hours to reach completion, the emissions from the reaction vessel during the first hour will be

different than those during the last hour. Thus, the highest hourly emission rate is not sustained during the entire cycle or for the entire year.

**Process-based Emission Standards** limit the mass emissions per unit of production. These standards may limit mass emissions per unit of material processed or mass emissions per unit of energy used. As process rate increases (e.g., an increase in tons of ore processed per hour), the allowable emissions increase (e.g., an increase in pounds of pollutant per hour).

**Process Emissions** are emissions from sources where an enclosure, collection system, ducting system, and/or stack (with or without an emission control device) is in place for a process. Process emissions represent emissions from process equipment (other than leaks) where the emissions can be captured and directed through a controlled or uncontrolled stack for release into the atmosphere.

**Process Fugitive Emissions** occur as leaks from process equipment including compressors, pump seals, valves, flanges, product sampling systems, pressure relief devices, and open-ended lines. Emissions from the process that are not caught by the capture system are also classified as process fugitive emissions.

**Process or Segment Level Emissions** usually represent a single process or unit of operation.

**Process or Segment Level Reporting** involves each process within a plant being identified by a U.S. Environmental Protection Agency (EPA) source classification code (SCC). For point sources, reporting guidelines may require that a plant identify, for each process or operation (designated by SCC), the periods of process operation (daily, weekly, monthly, annually); operating rate data including actual, maximum, and design operating rate or capacity; fuel use and fuel property data (ash, sulfur, trace elements, heat content, etc.); identification of all pollution control equipment and their associated control efficiencies (measured or design); and emissions rates. Source identification information, as previously described under Plant Level Reporting, is usually also required at the process level to ensure that emissions data for a single plant are clearly identified.

**Process-specific Empirical Relationships** are similar to emission factors in that they relate emissions to easily identifiable process parameters. However, these relationships are represented by more detailed equations that relate emissions to several variables at once, rather than a simple ratio. An example is the estimate for volatile organic compound (VOC) emissions from storage tanks that is based on tank size and throughput, air temperature, vapor pressure, and other variables.

**Quality Assurance (QA)** is a planned system of activities designed to provide assurance that the quality control program is actually effective. QA is a process that involves both the inventory team and external reviewers to insure the overall quality of the inventory.

**Quality Control (QC)** comprises the activities undertaken by all members of the inventory team during the inventory preparation that will result in the correction of specific problems such as mistaken assumptions, lost or uncollected data, and calculation and data entry errors.

**Reported Emissions** are those emission estimates that are submitted to a regulatory agency. Emissions inventories can be used for a variety of purposes such as State Implementation Plan (SIP) base year inventories, environmental compliance audits, air quality rule applicability, and reporting information in an air quality permit application. Emissions can be reported on an actual, potential, or maximum basis. Many state and local air pollution control agencies have rules and regulations that define an allowable emission value for a particular piece of equipment. Because of this, a facility should first define the purpose of the inventory and then choose the appropriate means of reporting emissions to the regulatory agency. For example, SIP base year inventories for point sources would contain actual emissions. However, regulatory applicability and air quality permit applications can require that actual, allowable, and potential emissions be reported.

**Rule Effectiveness (RE)** is the measure of a regulatory program to achieve all of the emission reductions possible, which reflects the assumption that controls are typically not 100 percent effective, because of equipment downtime, upsets, decreases in control efficiencies, and other deficiencies in emission estimates.

**Rule Penetration (RP)** is the percentage of an area source category that is covered by an applicable regulation.

**Source Classification Code (SCC)** is a process-level code that describes the equipment or operation emitting pollutants. These codes were developed by EFIG. There are four level descriptions within each 8-digit code.

**Source Tests** are short-term tests used to collect emissions data that can then be extrapolated to estimate long-term emissions from the same or similar sources. Uncertainties arise when source test results are used to estimate emissions under process conditions that differ from those under which the test was performed.

**Standard Industrial Classification (SIC)** is the U.S. Department of Commerce's initial categorization of business by their products or services;

**Stratospheric Ozone-depleting Compounds** are chlorofluorocarbons (CFCs), halons, carbon tetrachloride, methyl chloroform, and hydrochlorofluorocarbons (HCFCs). These pollutants are regulated by Title VI of the Clean Air Act Amendments (CAAA) because they may destroy stratospheric ozone. Title VI is primarily designed to limit the manufacture of these materials, not their use. The pollutants are divided into two classes (Class I and Class II) based on the dates by which their manufacture must be discontinued. Methods to estimate emissions of ozone-depleting compounds are not discussed in Emission Inventory Improvement Program (EIIP) documents.

Information on emissions of ozone-depleting compounds can be obtained from the U.S. Environmental Protection Agency (EPA) Office of Atmospheric and Indoor Air Programs, Global Climate Change Division, located at EPA Headquarters in Washington, D.C.

**Sulfur Oxides ( $SO_x$ )** are a class of colorless, pungent gases that are respiratory irritants and precursors to acid rain. Sulfur oxides are emitted from various combustion or incineration sources, particularly from coal combustion.

**Volatile Organic Compounds (VOCs)** react with nitrogen oxides ( $NO_x$ ) in the atmosphere to form ozone ( $O_3$ ). Although not criteria pollutants, VOC emissions are regulated under criteria pollutant programs because they are ozone precursors. Large amounts of VOCs are emitted from motor vehicle fuel distribution, chemical manufacturing, and a wide variety of industrial, commercial, and consumer solvent uses.

The use of certain photochemical models requires estimation of methane, ethane, and several other less photochemically reactive compounds and particulates. While not regulated as VOCs, these compounds may need to be estimated for certain modeling inventories or to meet certain state inventory requirements. For this reason, the term **total organic compounds (TOCs)** is used to refer to this broader class of chemicals.

**Work Practice Standards** require some action during the routine operation of the unit. For example, volatile organic compound (VOC) monitoring of a compressor might be required on a quarterly basis to ensure no leaks are occurring. Work practice standards are typically used when an emission limit is not practical.

# 1

## INTRODUCTION

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### 1.1 BACKGROUND

The Clean Air Act, as amended in 1990 (hereafter referred to as the CAA), has expanded the continuing role of the U.S. Environmental Protection Agency (EPA) in its effort to improve air quality in the United States. Among the mandates set forth in the CAA is the requirement that the EPA improve the quality of emission estimates of air pollutants.

Over the last two decades, the CAA and numerous other federal, state, and local programs have required industry to report the amount of air pollutants emitted. With the CAA in place, it is useful for industry to understand the methods used to estimate emissions in order to comply with regulations.

The Emission Inventory Improvement Program (EIIP) is a joint program of the EPA, Standing Air Emissions Work Group (SAEWG), and the State and Territorial Air Pollution Program Administrators and the Association of Local Air Pollution Control Officials (STAPPA/ALAPCO). The ultimate goal of the EIIP is to provide cost-effective, reliable inventories by improving the quality of emissions data collected and provide for uniform reporting of this information. These emissions-related data will be made available to state and local agencies, the regulated community, the public, and EPA. The EIIP has been designed to increase the likelihood that acceptable quality emission inventory data will be available. The use of these procedures will promote consistency in these activities among the emission inventory reporting groups.

Using standardized approaches enables federal, state, and local agencies to generate data of known quality at acceptable or reasonable costs. The EIIP has implemented this concept by selecting preferred and alternative methods for use in determining emissions for various source categories of interest. Their findings are reported in the following series of guidance documents, which can also be located on the Internet [www.epa.gov/ttn/chief/eiip](http://www.epa.gov/ttn/chief/eiip):

- Volume I: *Introduction and Use of EIIP Guidance for Emissions Inventory Development*
- Volume II: *Point Sources Preferred and Alternative Methods*
- Volume III: *Area Sources Preferred and Alternative Methods*
- Volume IV: *Mobile Sources Preferred and Alternative Methods*
- Volume V: *Biogenic Sources Preferred and Alternative Methods*
- Volume VI: *Quality Assurance Procedures*

- Volume VII: *Data Management Procedures*
- Volume VIII: *Estimating Greenhouse Gas Emissions*
- Volume IX: *Particulate Emissions*
- Volume X: *Emission Projections*

Volume II in the series of EIIP guidance documents is intended to familiarize the private and government sectors with the basic concepts and procedures involved in estimating air pollutant emissions from point sources. Volume II should also be used to provide state agencies with instructional guidance on preferred methods for developing emission inventories for point sources.

Point sources are those facilities/plants/activities for which individual source records are maintained in the inventory. Under ideal circumstances, all sources would be considered point sources. However, in practical applications, only sources that emit (or have the potential to emit) more than some specified cutoff level of emissions are considered point sources.

Area sources, in contrast, are those activities for which aggregated source and emissions information is maintained for entire source categories rather than for an individual source. Sources not treated as point sources should be included in an area source inventory. Area sources are addressed in Volume III of the EIIP series of guidance documents.

Volume II consists of various combustion, manufacturing, and production activities that comprise point sources. The major chapters within Volume II at various stages of production are as follows:

- Chapter 1: *Introduction to Stationary Point Source Emission Inventory Development*
- Chapter 2: *Preferred and Alternative Methods for Estimating Air Emissions from Boilers*
- Chapter 3: *Preferred and Alternative Methods for Estimating Air Emissions from Hot-Mix Asphalt Plants*
- Chapter 4: *Preferred and Alternative Methods for Estimating Fugitive Air Emissions from Equipment Leaks*
- Chapter 5: *Preferred and Alternative Methods for Estimating Air Emissions from Wastewater Collection and Treatment*
- Chapter 6: *Preferred and Alternative Methods for Estimating Air Emissions from Semiconductor Manufacturing Facilities*

- Chapter 7: *Preferred and Alternative Methods for Estimating Air Emissions from Surface Coating Operations*
- Chapter 8: *Preferred and Alternative Methods for Estimating Air Emissions from Paint and Ink Manufacturing Facilities*
- Chapter 9: *Preferred and Alternative Methods for Estimating Air Emissions from Metal Production Facilities*
- Chapter 10: *Preferred and Alternative Methods for Estimating Air Emissions from Oil and Gas Field Production and Processes Operations*
- Chapter 11: *Preferred and Alternative Methods for Estimating Air Emissions from Plastic Products Manufacturing*
- Chapter 12: *How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emissions Inventory Estimates*
- Chapter 13: *Preferred and Alternative Methods for Estimating Emissions from Stone Mining and Quarrying Operations*
- Chapter 14: *Uncontrolled Emission Factor Listing for Criteria Air Pollutants*

Each industry- or source-specific document contains a brief process description; identification of emission points; an overview of methods available for estimating emissions; example calculations for each technique presented; a brief discussion on quality assurance and quality control; and the source classification codes (SCCs) needed for entry of the data into a database management system. The SCCs included in each volume apply to the process emission points, in-process fuel use, storage tank emissions, fugitive emissions, and control device fuel (if applicable).

## 1.2 PURPOSE OF CHAPTER 1

This introductory chapter of Volume II is intended to introduce the information applicable to all stationary point sources as well as identify basic concepts of emission estimation techniques. Chapter 1 provides an introduction to air pollutant emission assessment, the basic procedures involved in estimating emissions, and industry-specific techniques for estimating emissions. Practical, detailed calculations and procedures applicable to a specific category are found within subsequent chapters (documents). These later chapters present several different estimation scenarios and provide example calculations to aid in actual emission estimation. Figure 1.1-1 is included to assist readers tasked with inventory preparation in decision making and to refer them to the applicable chapters within this volume and other volumes in the EIIP series.

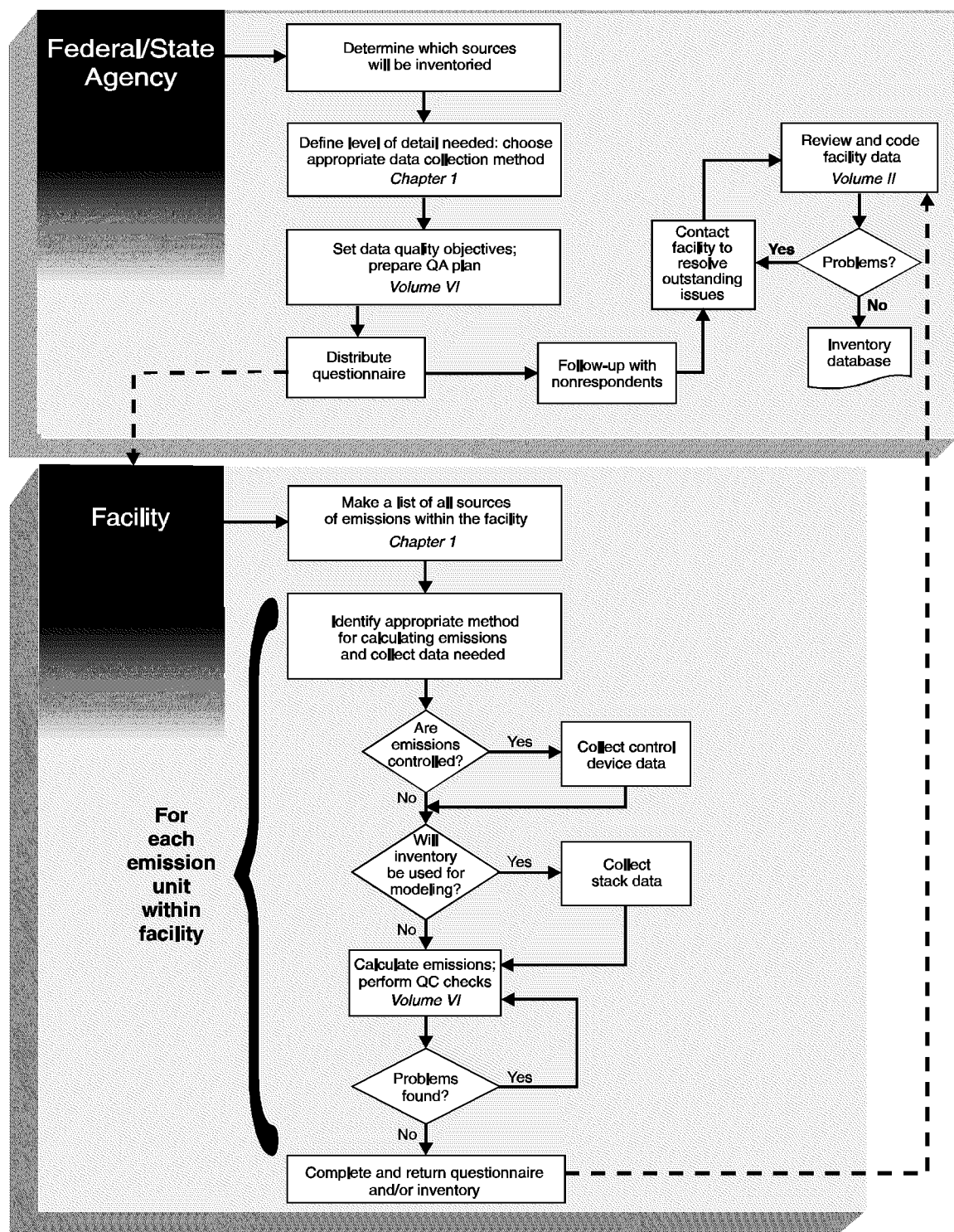


FIGURE 1.1-1. POINT SOURCE INVENTORY DEVELOPMENT PROCESS



Cumulatively, the chapters of Volume II provide a comprehensive series of manuals which should successfully serve the user in generating a point source emissions inventory.

This chapter is organized into 8 text sections and 14 appendices. Table 1.1-1 highlights the contents of each section.

**TABLE 1.1-1**  
**OVERVIEW OF DOCUMENT CONTENTS**

<b>Section Title</b>	<b>Overview of Contents</b>
1. Introduction	Introduces purpose and content of the chapter
2. Purposes for Assessing Emissions	Identifies several purposes for industries to generate emissions estimates including federal and state regulations, and plant initiatives
3. Emissions Inventory Planning	Discusses the emission inventory planning effort, including data handling and documentation requirements
4. Emission Estimation Procedures	Describes basic techniques employed to estimate emissions, including emission factors, source tests, models, and material balances.
5. Data Collection	Describes the basic procedures for data collection and the types of data available for estimating emissions
6. Inventory Documentation and Reporting	Outlines guidelines and procedures for documentation of the emission estimation process and preparation of a summary report
7. Quality Assurance/Quality Control	Describes QA/QC procedures relevant to the emissions estimation process
8. References	Presents complete references for all documents cited in the report text
Appendices	Contain additional, detailed information to support the discussions provided in the document text

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# 2

## PURPOSES FOR ASSESSING EMISSIONS

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In order to comply with various federal and state regulations, sources must initiate an emissions estimation effort. This section primarily focuses on the federal requirements for reporting emissions, while typical state requirements are also briefly discussed. Figure 1.2-1 provides an overview of some of the key emissions estimation relationships among industry, and state and federal agencies (EPA, 1993a, 2000a)

### 2.1 FEDERAL REQUIREMENTS

Various federal requirements are linked to emissions estimation requirements. The major federal requirements for both sources and states, with emphasis on those requirements that are likely to lead to emissions estimation requirements for industry, are discussed in this section.

Requirements discussed stem mainly from the Clean Air Act, and from other legislation such as the National Environmental Policy Act (NEPA), the Comprehensive Environmental Recovery and Comprehensive Liability Act (CERCLA), the Superfund Amendments and Reauthorization Act (SARA), the Resource Conservation and Recovery Act (RCRA), and the Pollution Prevention Act. Additional requirements stem from policy issued by the EPA, the Department of Energy (DOE), and the Department of Defense (DoD). The form and content of the specific emissions information varies with each requirement. A useful source for identifying which specific data elements are necessary under each requirement is the document entitled *Integrated Reporting Issues: Preliminary Findings* (EPA, 1992e). Table 1.2-1 provides an overview of the key federal emissions estimation requirements. In addition, Table 1.2-2, taken from the *Integrated Reporting Issues* document, provides an overview of the data elements for permit programs and emission statements contained in the major emissions reporting programs described in this section.

Table 1.2-3, taken from the Federal Register Proposed Rule, May 23, 2000 (EPA, 2000d) provides a listing of the program reporting elements specific to the annual and triennial National Emission Inventory (NEI).

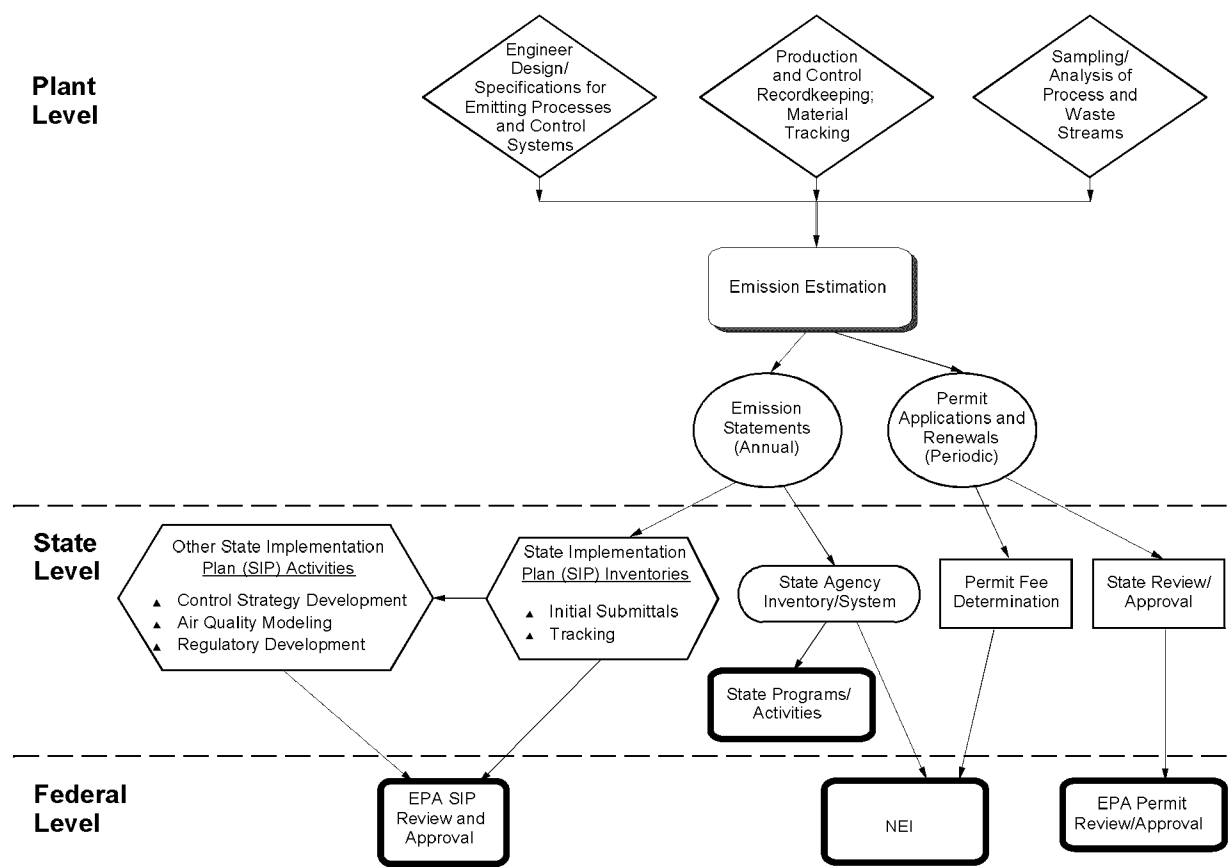


FIGURE 1.2-1. KEY RELATIONSHIPS FOR INDUSTRY AIR POLLUTANT EMISSION ESTIMATION

TABLE 1.2-1

## OVERVIEW OF KEY FEDERAL EMISSION ESTIMATION REQUIREMENTS

Statutory Requirement and Agency	Pollutant	Due Date	Size Cutoff	Data Requirements
<b>NEI/NIF</b>				
40 CFR 51(Proposed) Agency: State to EPA	PM <sub>10</sub> , sulfur oxides, VOC, NO <sub>x</sub> , CO, and lead	June 1, annually	Facility-100 tpy PM <sub>10</sub> , sulfur oxides, VOC, and NO <sub>x</sub> , PM <sub>2.5</sub> and NH <sub>3</sub> ; 1,000 tpy CO; 5 tpy lead. Point-25 tpy PM <sub>10</sub> , sulfur oxides, VOC, and NO <sub>x</sub> ; 250 tpy CO; and 5 tpy lead	General plant information, year of inventory, general operating parameters, emissions data, and control equipment data
<b>Emission Inventory (base year and periodic)</b>				
Clean Air Act Section 172(c)(3) Section 182(a)(1) <sup>a</sup> Section 182(a)(3)(A) <sup>a</sup> Section 187(a)(1) <sup>b</sup>  Agency: State to EPA	All criteria pollutants	November 15, 1992 and every 3 years thereafter	Point sources-10 tpy VOC; 100 tpy PM <sub>10</sub> moderate; 70 tpy PM <sub>10</sub> serious; 100 tpy PM <sub>2.5</sub>	General plant information, year of inventory, source operating data, physical data (i.e., stack height, process rate data, source emissions data, and emission limitation data)
<b>Emission Statement</b>				
Clean Air Act Section 182(a)(3)(B) <sup>c</sup>  Agency: Source to state	VOC, NO <sub>x</sub>	April 15, annually;	25 tpy VOC or NO <sub>x</sub> ; in nonattainment area; 50 tpy VOC or 100 tpy NO <sub>x</sub> in attainment portion of transport region	Source identification, source emissions data (annual and typical summer day), control equipment data, process rate data and a certification that the data are accurate

TABLE 1.2-1  
(CONTINUED)

Statutory Requirement and Agency	Pollutant	Due Date	Size Cutoff	Data Requirements
<b>Title V Operating Permits</b>				
Clean Air Act Title V Agency: Source to state	All criteria pollutants, all HAPs, CFCs, HCFCs	At time of initial Title V permit application submittal, which is generally one year after EPA approval of state permit program. Annual submission according to state schedule to determine fee basis.	Potential to emit "major" amounts of regulated air pollutants <sup>d,e</sup>	General company information, plant description, emissions information, regulatory requirements and compliance information
<b>New Source Review</b>				
Clean Air Act Section 172(c)(5) Agency: Source to state	Criteria pollutants, fluorides, sulfuric acid mist, hydrogen sulfide, total reduced sulfur, reduced sulfur compounds, MWC organics, metals and gases, ozone-depleting substances <sup>f</sup>	Prior to construction or operation of a new or modified major source	Potential to emit "major" amounts for new sources, significant net emissions increase for modified sources	Legal authority, technical specifications, potential emissions, emission compliance demonstration, definition of excess emissions, administrative and other conditions
<b>Economic Incentive Programs (EIP)</b>				
40 CFR Part 51 (some required, some optional) Agency: Source to state	All criteria pollutants	Specific to individual EIP	Major <sup>d</sup>	Specific to individual EIP. Emissions must be "quantifiable."

TABLE 1.2-1  
(CONTINUED)

Statutory Requirement and Agency	Pollutant	Due Date	Size Cutoff	Data Requirements
<b>Early Reductions Program</b>				
Clean Air Act Section 112(i)(5)  Agency: Source to state	All HAPs as defined in Section 112(b)	Reduction must be achieved before January 1, 1994, therefore demonstration must come before then	Any stationary source	Same as permit with the early reduction demonstration
<b>Urban Air Toxics Program</b>				
Clean Air Act Section 112(k)  Agency: EPA to Congress	All HAPs as defined in Section 112(b) or (k)	EPA must report by November 15, 1993	Any source of HAPs contributing to urban concentrations, with emphasis on area sources	Data as necessary to characterize emissions of HAPs and prioritize threats to public health in urban areas
<b>Great Lakes and Coastal Waters Program</b>				
Clean Air Act Section 112(m)  Agency: EPA to Congress	All HAPs as defined in Section 112(b)	EPA must report by November 15, 1993, and biennially thereafter	Any source contributing to deposition of HAPs	Data as necessary to determine sources and deposition rates of HAPs
<b>Accidental Release Program</b>				
Clean Air Act Section 112(r)	All extremely hazardous substances as defined in regulation developed under Section 112(r)	As specified in Section 112(r) regulations to be published	Sources emitting amounts above threshold quantities as specified in Section 112(r) regulations to be published	Risk management plan including estimate of potential release quantities, determination of downwind effects, previous release history, and an evaluation of the worst case accidental release

TABLE 1.2-1

(CONTINUED)

Statutory Requirement and Agency	Pollutant	Due Date	Size Cutoff	Data Requirements
<b>New Source Performance Standards (NSPS)</b>				
40 CFR Part 60 Agency: Source to state agency or EPA	SO <sub>2</sub> , NO <sub>x</sub> , total reduced sulfur, hydrogen sulfide, CO, opacity, VOC, PM	30 days after reporting period ends	As specified in standard	Pollutant, reporting period, general company information, emission limitation, monitor manufacturer and model number, data of last CMS certification or audit, process units description, total source operating time, emissions data, CMS performance data
<b>Acid Rain Allowance Trading (Title IV)</b>				
Title IV Clean Air Act	SO <sub>2</sub> , NO <sub>x</sub>	30 days after end of quarter (beginning January 30, 1994 for Phase I and April 30, 1995 for Phase II)	Any facility listed in Table A or B of Title IV or any facility that opts-in (Phase I approx. 110 sources, Phase II approx. 800 sources). Also applies to any new fossil-fuel combustion device that supplies electricity for sale or serves an electricity-generating device that supplies electricity for sale.	General plant information, emissions data, fuel use data
<b>Section 114 General Requirements (i.e., "Section 114 letter")</b>				
Clean Air Act Section 114 Agency: Source to EPA	As specified by EPA	As specified by EPA	Determined case-by-case by EPA	General company information, pollutant, compliance information, operating information



TABLE 1.2-1

(CONTINUED)

Statutory Requirement and Agency	Pollutant	Due Date	Size Cutoff	Data Requirements
<b>Section 114 Compliance Certification</b>				
Clean Air Act Section 114(a)(3)  Agency: source to EPA	All criteria pollutants and all hazardous air pollutant as defined in Section 112(a)(1)	30 days after quarter ends, on a quarterly or annual basis	Major <sup>d</sup>	General company information, pollutant, emission information, description of enhanced monitoring system, summary of compliance demonstration, deviation description, violation information, and operation data
<b>National Air Toxics Information Clearinghouse (NATICH)</b>				
Clean Air Act Section 112(1)(3)  Agency: State/local agency to EPA	Any hazardous air pollutant (i.e., any noncriteria air pollutant)	Voluntary	Voluntary	Agency name, general plant information, year permit issued, control equipment data, pollutant names, emission limit data, actual emission rate data, source testing data
<b>Best Available Control Technology (BACT)/Lowest Achievable Emission Rate (LAER) Clearinghouse</b>				
N.A.  Agency: State/local agency to EPA	Criteria pollutants	Voluntary - after issuance of a BACT or LAER determination	Voluntary	General company information, plant description, year permit issued, emissions data, control technology data, compliance data
<b>National Environmental Policy Act (NEPA)</b>				
PL 91-190  Agency: EPA	Anything that may result in a "significant environmental impact"	Prior to implementation of any federal agency action	NA	Description of the proposed action, alternatives to the action, and environmental, social, and economic impacts of the proposed action and alternatives. May lead to specific requests from EPA to industry

TABLE 1.2-1

(CONTINUED)

Statutory Requirement and Agency	Pollutant	Due Date	Size Cutoff	Data Requirements
<b>Comprehensive Environmental Recovery and Comprehensive Liability Act (CERCLA)</b>				
PL 96-510, amended SARA 42 U.S.C. Section 9601  Agency: Source to state	Chemicals listed in Sections 307, 311 of Clean Water Act, Section 3001 of RCRA, Section 112 of CAA, Section 7 of Toxic Substances Control Act, others designated by EPA under Superfund	Upon release	Releases to the environment that exceed the reportable quantity for that material	Report on release of the toxic substance, including substance and quantity released. (See SARA Section 304.)
<b>Superfund Amendments and Reauthorization Act (SARA)</b>				
SARA Title III Section 313 ("right to know")  Agency: EPA and states	EPA designated "toxic chemicals" (329 on original list; 284 added 1995)	July 1, annually	Chemicals used $\geq 10,000$ lb/yr, chemical manufactured or processed $\geq 25,000$ lb/yr	Chemical identify, name, location and principal business identity, certification by senior officials of business, use of each listed chemical, maximum on-site quantity at any time, amount (lb/yr) released to the environment of each chemical, amount (lb/yr) transferred offsite, method of waste treatment and disposal including treatment efficiency, release data (fugitive air emissions in lb/yr, stack/point air emissions in lb/hr, wastewater discharges, releases to land, transfers to off-site locations, underground injection)
SARA Section 304 (hazardous releases)  Agency: Source to public	Hazardous substances as defined by CERCLA, extremely hazardous substances as defined by EPA	Immediately upon release	Any episode that releases more than published reportable quantity	Chemical name or identity, quantity released, time and duration of release, media into which released, anticipated health risks, medical attention requirements, precautions, evacuation information, name of person to contact for more information

TABLE 1.2-1  
(CONTINUED)

Statutory Requirement and Agency	Pollutant	Due Date	Size Cutoff	Data Requirements
<b>Resource Conservation and Recovery Act (RCRA)</b>				
40 CFR Subtitle C Agency: Source to EPA	Hazardous waste as defined by 40 CFR 261.31, acutely defined by 40 CFR 261.33	Biennially	Small generators: 100-1000 kg non-acutely hazardous waste/month; large generators >1 kg acutely hazardous waste, >1000 kg non-acutely hazardous waste/month	EPA ID number, record of hazardous waste transfers (manifests), records of any test results, waste analyses, etc., waste minimization plan
<b>Pollution Prevention Act</b>				
PL 101-508 Section 6607 Agency: Source to EPA	EPA designated "toxic chemicals"	Annually	Chemicals used $\geq$ 10,000 lb/yr, chemical manufactured or processed $\geq$ 25,000 lb/yr	Toxic chemical source reduction and recycling report

Source: EPA, 1993a, 2000a.

<sup>a</sup> For ozone.

<sup>b</sup> For CO.

<sup>c</sup> The periodic inventory requirement is only for ozone nonattainment areas.

<sup>d</sup> Definition of major and significant net emissions increase depends on pollutant (e.g., for ozone it depends on an area's classification).

<sup>e</sup> Additional nonmajor sources may be added by EPA rule expected in 2001.

<sup>f</sup> Applicability determination is based on emissions of all pollutants regulated under the Act. However, emission inventory submitted to the state is generally on pollutants listed to determine control technology requirements.

CMS = Continuous Monitoring System.

NA = Not applicable.

TABLE 1.2-2

## COMPARISON OF EMISSIONS REPORTING PROGRAM DATA ELEMENTS

<b>Data Element</b>	<b>Permit Program<sup>a</sup> (Source to State)</b>	<b>Emission Statement (Source to State)</b>
<b>Plant - General Level</b>		
FIP State Code	T	T
FIP County Code	T	T
Year of Record	T	T
Plant AFS/NEDS ID	T	T
Plant Name		T
Plant Address	T	T
FIP City Code	T	T
Plant Zip Code	T	T
UTM Zone, Easting, and Northing or Latitude and Longitude		T
Primary SIC Code	T	T
Type of Inventory		
Annual Nonbanked Emissions (Estimated Actual)	T	
<b>Point - General Level</b>		
FIP State Code		T
FIP County Code		T
Plant AFS ID		T
Point AFS ID		T
Operating hours/day		T
Operating days/week		T

TABLE 1.2-2

(CONTINUED)

<b>Data Element</b>	<b>Permit Program<sup>a</sup> (Source to State)</b>	<b>Emission Statement (Source to State)</b>
Operating hours/year		<b>T</b>
Percent throughput: Dec-Feb		<b>T</b>
Percent throughput: Mar-May		<b>T</b>
Percent throughput: Jun-Aug		<b>T</b>
Percent throughput: Sep-Nov		<b>T</b>
<b>Stack Level</b>		
FIP State Code		
FIP County Code		
Plant AFS ID		
Stack AFS ID		
Stack Height		
Stack Diameter		
Plume Height		
<b>Segment - General Level</b>		
FIP State Code		<b>T</b>
FIP County Code		<b>T</b>
Plant AFS ID		<b>T</b>
Point AFS ID		<b>T</b>
Segment AFS ID		<b>T</b>
SCC Number		<b>T</b>
Process Rate Units		<b>T</b>
Actual Annual Process Rate		<b>T</b>

TABLE 1.2-2

(CONTINUED)

<b>Data Element</b>	<b>Permit Program<sup>a</sup> (Source to State)</b>	<b>Emission Statement (Source to State)</b>
Ozone Season Daily Process Rate		<b>T</b>
CO Season Daily Process Rate		
Stack ID for Segment		
<b>Segment - Pollutant Level</b>		
FIP State Code	<b>T</b>	<b>T</b>
FIP County ID	<b>T</b>	<b>T</b>
Plant ID	<b>T</b>	<b>T</b>
Point ID		<b>T</b>
Segment ID (Process)		<b>T</b>
Pollutant/CAS Number	<b>T</b>	<b>T</b>
Primary Control Device Code		<b>T</b>
Secondary Control Device Code		<b>T</b>
Control Efficiency		<b>T</b>
SIP Regulation in Place		
Compliance Year for Segment		
Emission Limitation Description		
Emission Limitation Value		
Emission Limitation Units		
Emission Estimation Method		<b>T</b>

TABLE 1.2-2

(CONTINUED)

<b>Data Element</b>	<b>Permit Program<sup>a</sup> (Source to State)</b>	<b>Emission Statement (Source to State)</b>
Emission Factor		T
Annual Nonbanked Emissions (Estimated Actual)		T
Rule Effectiveness		T
Ozone Season Daily Emissions		T
CO Season Daily Emissions		

Source: EPA, 1992e.

<sup>a</sup> Proposed AFS permit enhancements.

TABLE 1.2-3

**EMISSION REPORTING DATA ELEMENTS  
FOR THE NATIONAL EMISSION INVENTORY**

<b>Data Element</b>	<b>NEI Annual Update (State to EPA)</b>	<b>NEI Triennial Update (State to EPA)- Attainment</b>	<b>NEI Triennial Update (State to EPA)- Nonattainment</b>
Inventory Year	T	T	T
Inventory Start Date	T	T	T
Inventory End Date	T	T	T
Inventory Type	T	T	T
State FIPS Code	T	T	T
County FIPS Code	T	T	T
Federal ID Code (plant)	T	T	T
Federal ID Code (point)	T	T	T
Federal ID Code (process)	T	T	T
Site Name	T	T	T
Physical Address	T	T	T
SCC	T	T	T
Heat Content (fuel) (annual)	T	T	T
Ash Content (fuel) (annual)	T	T	T
Sulfur Content (fuel) (annual)	T	T	T
Pollutant code	T	T	T
Activity/Throughput (annual)	T	T	T
Activity/Throughput (daily)	T	T	T
Work weekday emissions	T	T	T



TABLE 1.2-3

(CONTINUED)

<b>Data Element</b>	<b>NEI Annual Update (State to EPA)</b>	<b>NEI Triennial Update (State to EPA)- Attainment</b>	<b>NEI Triennial Update (State to EPA)- Nonattainment</b>
Annual Emissions	T	T	T
Emission Factor	T	T	T
Winter Throughput (%)	T	T	T
Spring Throughput (%)	T	T	T
Summer Throughput (%)	T	T	T
Fall Throughput (%)	T	T	T
Hr/day in operation	T	T	T
Start Time (hr)	T	T	T
Day/wk in operation	T	T	T
Wk/yr in operation	T	T	T
Federal ID Code (stack number)		T	T
X stack coordinate (latitude)		T	T
Y stack coordinate (longitude)		T	T
Stack height			T
Stack diameter			T
Exit gas temperature			T
Exit gas velocity			T
Exit gas flow rate			T
SIC/NAICS		T	T
Design capacity		T	T

TABLE 1.2-3

(CONTINUED)

<b>Data Element</b>	<b>NEI Annual Update (State to EPA)</b>	<b>NEI Triennial Update (State to EPA)- Attainment</b>	<b>NEI Triennial Update (State to EPA)- Nonattainment</b>
Maximum nameplate capacity		T	T
Primary control efficiency (%)		T	T
Secondary control efficiency (%)		T	T
Control device type		T	T
Rule Effectiveness (%)		T	T

Sources: EPA.

### 2.1.1 CLEAN AIR ACT REQUIREMENTS

The Clean Air Act is the major legislation addressing air pollution in the United States. It mandates a wide variety of programs to manage air quality. The federal air quality management effort begins with the national ambient air quality standards (NAAQS). The NAAQS set nationwide minimum air quality goals. Each state must assess all areas' air quality relative to the NAAQS. For those areas meeting the standard, the state is required to submit plans showing prevention of significant deterioration (PSD).

For nonattainment areas, the state must develop and submit to EPA a detailed, comprehensive and legally binding plan to meet the NAAQS by a specified date and to continue to meet the NAAQS beyond that date. This legally binding plan is called a state implementation plan (SIP). In the SIP, each state has the responsibility for selecting a control strategy that determines which sources must control emissions and the degree of control needed to achieve and/or maintain the NAAQS. States that have been totally or partially designated as nonattainment areas must develop emissions inventories as part of their SIP to reduce emissions. If the state fails to submit an adequate plan, the EPA will impose its own plan, called a federal implementation plan (FIP).

In addition to those requirements related to maintenance of the NAAQS, other federal-state programs addressing emissions of various air pollutants have also been established to improve air quality. These include emissions standards for hazardous air pollutants (HAPs), emission and fuel standards for motor vehicles, provisions for control of acid deposition, requirements for operating permit programs, and stratospheric ozone protection. The following sections briefly describe these programs.

#### SIP Requirements (CAA Amendments, Title I)

The CAA requires that the base year SIP inventories be prepared according to a set of minimum standards. The requirements for ozone, CO, and PM SIP inventories are listed in Table 1.2-4.

#### Operating Permits Program (CAA Amendments, Title V)

Title V of the Clean Air Act mandates that states establish operating permits programs requiring the owners or operators of major and other sources to obtain permits addressing all applicable pollution control obligations under the CAA. These obligations include emissions limitations and standards, and monitoring, recordkeeping, and reporting requirements. Such requirements are to be contained in an operating permit which is issued to the source for a period of no more than five years, before renewal. EPA published its final regulations on operating permits in Part 70 of Title 40 of the *Code of Federal Regulations*.

TABLE 1.2-4

**INVENTORY REQUIREMENTS OF THE CLEAN AIR ACT AMENDMENTS  
FOR OZONE, CO, PM<sub>10</sub> AND PM<sub>2.5</sub>**

<b>Activity</b>	<b>Requirement</b>	<b>Date</b>
Ozone Base Year Inventory--Basis For All Other Inventories	<ul style="list-style-type: none"> <li>• Comprehensive, accurate inventory for 1990</li> <li>• Include VOC, NO<sub>x</sub>, and CO from point, area, and mobile sources</li> <li>• Include anthropogenic and biogenic sources</li> <li>• Same requirements for all nonattainment classifications</li> </ul>	11/15/92
Adjusted Ozone Base Year Inventory	<ul style="list-style-type: none"> <li>• Needed to demonstrate 15 % VOC reduction by 1996</li> <li>• Excludes biogenic emissions and emissions reductions required before CAAA</li> </ul>	11/15/93
CO Base Year Inventory	<ul style="list-style-type: none"> <li>• Comprehensive, accurate inventory for 1990</li> <li>• Include CO emissions from point, area, and mobile sources for a 24-hour period</li> <li>• For moderate and serious areas</li> </ul>	11/15/92
PM <sub>10</sub>	<ul style="list-style-type: none"> <li>• Comprehensive, accurate inventory due with the attainment plan</li> <li>• Most significant inventory will be for serious areas--due later</li> </ul>	11/15/92
Inventory Work Plan	<ul style="list-style-type: none"> <li>• The EPA requires states to submit plans to explain how they will develop, document, and submit their inventories</li> </ul>	10/01/91

(CONTINUED)

Activity	Requirement	Date
Periodic Inventories for Ozone and CO	<ul style="list-style-type: none"> <li>• Same information as base year</li> <li>• 1993 base for first year</li> <li>• Purpose is to track emissions reductions for all nonattainment classifications</li> </ul>	Ozone - 11/15/96 CO-09/30/95 Update every 3 years until attainment
Ozone Modeling Inventory	<ul style="list-style-type: none"> <li>• Required for all areas using photochemical grid model and other moderate areas making an attainment demonstration</li> <li>• Requires base year and projected inventory</li> <li>• Photochemical grid model requires allocated, speciated, and spatially gridded inventory</li> </ul>	Areas using a photochemical grid model--inventory due 11/15/94. Other modeling approaches--inventory due 11/15/93.
CO Modeling	<ul style="list-style-type: none"> <li>• Needed for nonattainment areas with design values exceeding 12.7 ppm</li> <li>• Requires base year and projected inventory</li> <li>• Detail will reflect model used (proportional rollback or gridded dispersion model)</li> <li>• Used for determining whether proposed SIP control strategies are adequate to reach attainment by specified date.</li> <li>• Moderate areas demonstration plan for attainment.</li> <li>• Serious areas demonstration plan for attainment.</li> </ul>	11/15/93          12/31/95          12/31/00

TABLE 1.2-4

(CONTINUED)

Activity	Requirement	Date
RFP Projection Inventory for 3% per year VOC Reduction	<ul style="list-style-type: none"> <li>• Serious and above areas show 3 % per year VOC reduction after 1996</li> <li>• Continue until attainment</li> <li>• Base year will be final year of demonstration (i.e., 1999, 2002, 2005, 2008, 2010)</li> <li>• Based on allowable emissions reflecting regulatory limits</li> </ul>	11/15/94
Emission Statements	<ul style="list-style-type: none"> <li>• For all nonattainment classifications</li> <li>• Annual statements from owners of stationary sources showing actual emissions of NO<sub>x</sub> or VOCs</li> <li>• Certify information is accurate</li> <li>• Sources less than 25 tpy can be waived if included in inventory and the EPA emission factors used</li> </ul>	11/15/93
PM <sub>2.5</sub>	<ul style="list-style-type: none"> <li>• Comprehensive, accurate inventory due with the attainment plan</li> <li>• Most significant inventory will be for serious areas-due later</li> </ul>	11/15/92

The Part 70 regulations specify the requirements under Title V of the CAA for permittees, as well as the administrative duties required of state air permitting agencies. The minimum requirements for information to be submitted by subject sources in the permit application, which include certain emissions-related information, are listed in 40 CFR 70.5(c). Emissions-related information required to be in the application includes the following:

- All emissions of pollutants for which the source is major [including unregulated Section 112(b) pollutants], and all emissions of regulated air pollutants from all emissions units;
- Identification and description of all emissions points;
- Emissions rate in tpy and in any other units necessary to establish compliance with standards;
- Fuels, fuel use, raw materials, production rates, and operating conditions used to determine emissions, fees, or compliance;
- Pollution control and compliance monitoring activities;
- Limitations on source operation affecting emissions;
- Other relevant information, including stack height limitations; and
- Calculations on which any of the above are based.

A state's permit program may also require additional information under its own laws.

### **New Source Review (CAA Amendments, Title I)**

Section 172(c)(5) of the CAA states that SIPs for nonattainment areas will require preconstruction permits for the construction and operation of new or modified major stationary sources anywhere within the nonattainment area. Likewise, Section 165(a)(1) of the CAA requires that new or modified sources in attainment areas must also secure preconstruction permits. These permits must contain certain basic elements, including legal authority, technical specifications (including an estimate of emissions of each pollutant that the source would have the potential to emit in significant amounts), emission compliance methods, a definition of excess emissions, and other administrative and miscellaneous conditions (EPA, 1992e). Once the source begins operation it will be necessary to determine source emissions under design operating conditions in order to demonstrate compliance or noncompliance with the allowable levels of emissions. Sources obtaining permits for new sources often use trading transactions, which also require emissions estimations.

## Emissions Statements (CAA Amendments, Title I)

Section 182(a)(3)(B) of the CAA requires that states with areas designated as nonattainment for ozone obtain emissions statement data from VOC and NO<sub>x</sub> sources in the nonattainment areas. Emissions statements are derived from point source data through plant contacts. A revision to a state's SIP to include emissions statements should have been submitted within 2 years of the CAA Amendments enactment date.

The emissions statement requirement applies to all ozone nonattainment areas, regardless of their classification, and to stationary sources that emit, or have the potential to emit, 50 tons per year (tpy) or more of VOC or 100 tpy or more of NO<sub>x</sub> in attainment areas within ozone transport regions. A state may, with the EPA's approval, waive the requirement for emissions statements for classes or categories of sources with less than 25 tpy of actual plantwide NO<sub>x</sub> or VOC emissions in nonattainment areas if the class or category is included in the base year and periodic inventories and emissions are calculated using emission factors established by the EPA (such as those found in *AP-42*) or other methods acceptable to the EPA. Whatever minimum reporting level is established, if either VOC or NO<sub>x</sub> is emitted at or above this level, the other pollutant should be included in the emissions statement, even if it is emitted at levels below the specified cutoffs.

At a minimum, emissions statements should include: (1) certification of data accuracy, (2) operating schedule, (3) emissions information (to include annual and typical ozone season day emissions), (4) control equipment information, and (5) process data. Agencies are responsible for reviewing the consistency of the emissions statement data with other available data sources and resolving any inconsistencies (EPA, 1992c).

The emissions statement reporting format provides for two data collection mechanisms. Traditional sources should review and/or correct their NEI data. Nontraditional sources (i.e., those that do not have emissions data in NEI) should submit an "Emissions Statement Initial Reporting Form." In both cases, an explanatory letter and detailed instructions should be included. Agencies have the option of developing their own emissions statement reporting format, in which case care should be taken to ensure that the minimum emissions statement data elements are requested and that the emissions statement data are provided to the EPA via the NEI system.

Facilities must submit their first emissions statement within three years of the CAA Amendments enactment date, and annually thereafter. The first emissions statement will be based on 1992 emissions. The EPA strongly recommends that agencies require a submittal date of April 15 to allow use of the emissions statement data in the preparation of the annual point source inventory. Adequate records of emissions statement data and source certifications of emissions should be maintained by an agency for at least three years to allow for review or verification of the information, as needed.



Agencies should provide the EPA with a status report that outlines the degree of compliance with the emissions statement program. Since July 1, 1993, agencies are required to report the total number of sources affected by the emissions statement provisions, the number that have complied with the emissions statement provisions, and the number that have not. This report is a quarterly submittal until all the regulated sources have complied for the reporting year. The status report also includes the total annual and typical ozone season day emissions from all reporting sources, both corrected and non-corrected for rule effectiveness. Agencies should include in their status report a list of sources that emit 500 tpy or more of VOC or 2,500 tpy or more of NO<sub>x</sub> and that are delinquent in submitting their emissions statements.

Your state must report data for the point source inventory and the three-year cycle inventory 17 months (June 1) after the end of the calendar emission year. For example, your calendar year 1999 emission inventory is due to EPA by June 1, 2001.

The emissions statement data elements were developed to be consistent with other source and agency reporting requirements. This consistency is essential to assist agencies with an avenue to check emissions estimates and to facilitate consolidation of all EPA reporting requirements. Thus, emissions statement data will provide information useful for the development, quality assurance, and completion of several emissions reporting requirements, including tracking of RFP, periodic inventories, annual AFS submittals, the operating permit program of the CAA, emissions trends, and compliance certifications. The goal of emissions statement reporting in the future is to consolidate all these reporting requirements into one annual effort.

### **Hazardous Air Pollutants (CAA Amendments, Title III)**

Section 112 of the CAA requires EPA to promulgate regulations for reducing the emissions of HAPs. Section 112(b) contains a list of 188 pollutants which are regulated as HAPs.

Section 112 may lead to additional emission estimation or inventory requirements for sources. All sources subject to Section 112 are also subject to the Title V requirements. As such, sources of HAPs must include emissions estimates in their operating permits. In addition, four special programs under Section 112 may lead to additional requirements for emissions estimates:

- The early reductions program under Section 112(i)(5);
- The Urban Air Toxics Study under Section 112(k);
- The Great Lakes and Coastal Waters program under Section 112(m), and
- The accidental releases program under Section 112(r).

Under Section 112(s), EPA is required to maintain a database on pollutants and sources subject to Section 112. This database will be required to contain information from all of the programs

described above, as well as information from standard development projects under Section 112(d).

**Early Reduction Program.** Under the early reduction program, existing sources may opt to apply for a 6-year extension of the regular 3-year MACT compliance deadline if such sources can demonstrate a 90 percent reduction (or 95 percent reduction for particulate emissions) or more of HAPs prior to the proposal of the applicable MACT standard. As a condition of the compliance extension, states may require additional emission reductions from such sources. Such reductions generally must be based on actual and verifiable emissions in a base year no earlier than 1987. The source must provide a one-time demonstration of the required reduction, which will require estimation and comparison of current emissions and emissions during the relevant base year. It should be noted that the emissions reductions used to qualify under this extension will be federally enforceable, and hence also require a Title V permit revision.

**Urban Air Toxics Study.** Under the Urban Air Toxics Study, EPA is required to conduct a program of research on sources of HAPs in urban areas. This program must include an analysis to characterize sources of such pollution with a focus on area sources. EPA, in implementing this program, may request specific emissions estimates and other relevant information from sources.

**Great Lakes and Coastal Waters Program.** Under the Great Lakes and Coastal Waters program (often referred to as the Great Waters Program), EPA is required to assess the extent of atmospheric deposition of HAPs into the Great Lakes, Chesapeake Bay, Lake Champlain, and coastal waters. In addition to numerous monitoring and sampling efforts, this assessment will include an investigation of the deposited chemicals and their precursors and sources. This investigation will likely lead to emissions estimation requirements for sources which emit HAPs that could be deposited into these waters.

**Accidental Release Program.** Under the accidental release program, sources which emit HAPs above certain threshold quantities must submit risk management plans designed to detect and prevent accidental releases of HAPs. The risk management plan must assess the potential effects of an accidental release, which will include an estimate of potential release quantities, determination of downwind effects, previous release history and an evaluation of the worst case accidental release. The plan must also include an accidental release prevention program and an emergency response program to be implemented in the event of such a release. Such plans must be submitted to EPA, the Chemical Safety and Hazard Investigation Board, and state and local air pollution control agencies.

**Section 114 Reporting Requirements, Compliance Certifications and Compliance Monitoring.** Section 114 of the CAA gives EPA the authority to require sources to, on a one-time, periodic, or continuous basis, report to EPA information which EPA deems necessary for developing standards or SIPs, determining compliance, or meeting

other provisions of the Act. Under Section 114, EPA can require sources to establish recordkeeping; make reports; sample emissions; keep production, control technology, or other operations data; or provide other necessary information. The EPA may include emissions estimates as part of these information requirements.

## **Allowance Trading (CAA Amendments, Title IV)**

In order to control sources of acid deposition, Title IV of the CAA Amendments establishes the allowance trading program. This program seeks to reduce emissions of SO<sub>2</sub> by 10 million tpy, relative to 1980 levels. Two databases, Emissions Tracking System (ETS) and the Allowance Tracking System (ATS), are set up under this program to track emissions, and allowance trading. Sources affected by Title IV (i.e., those listed in Table A, Title IV, of the CAA Amendments), or those that opt in will be responsible for reporting to these databases. These reports will include general plant information, hourly emissions data, and fuel use data. It should also be noted that sources subject to Title IV requirements are also subject to Title V operating permit provisions.

### **2.1.2 REQUIREMENTS UNDER OTHER EPA REGULATIONS**

A number of other EPA requirements which are not directly related to the CAA require some form of emissions estimation. These requirements are a result of the following federal laws: NEPA, CERCLA, SARA, RCRA, and the Pollution Prevention Act. This subsection briefly highlights these requirements.

#### **National Environmental Policy Act (NEPA) of 1969**

The National Environmental Policy Act (NEPA) requires that, where a federal agency action may result in a significant environmental impact, an environmental assessment be prepared before such policy can be implemented. An environmental assessment (EA) is a study that provides background information and preliminary analyses of the potential impact of a new policy. If the results of an EA indicate that significant environmental impact may result, EPA will prepare an Environmental Impact Statement (EIS). The EIS examines, in detail, the potential impact of a proposed agency action. Generally, industries are not required to prepare EISs, but EPA may require industry input, including emissions estimates, for its evaluation of the impact of proposed rulings (EPA, 1993a).

#### **Comprehensive Environmental Recovery and Comprehensive Liability Act of 1980**

Under CERCLA, facility managers are required to perform an Air Pathway Analysis (APA) in order to assess the potential for exposure of personnel to toxics in the ambient air at National Priority List (NPL) sites and to provide input to the Superfund risk assessment process. Air pathway analysis involves a combination of modeling and monitoring methods to assess actual or potential emissions from a hazardous waste site. The APA has three major components:

(1) characterization of air emission sources (e.g., estimation of contaminant emission rates) for the control and recordkeeping process; (2) determination of the effects of atmospheric processes (e.g., transport and dilution) on the personnel at a site; and (3) evaluation of receptor exposure potential (i.e., what air contaminant concentrations are expected at receptors of interest for various exposure periods) (EPA, 1989).

### **Superfund Amendments and Reauthorization Act (SARA) of 1986**

SARA, which was passed in 1986 to amend CERCLA, contains two requirements likely to lead to emissions estimation. First, Section 313 of SARA requires that companies that process, manufacture, or otherwise use toxic compounds listed in Section 313 of the Act report to EPA the annual quantities used of those compounds and any releases to the environment (including air emissions) that result from their use. The Section 313 "Right-to-Know" requirements were enacted by Congress to increase public awareness and information on toxic emissions. The EPA has made Section 313 data publicly available. A database has been established, known as the Toxic Release Inventory System (TRIS), which contains information from SARA toxic chemical release reports (EPA, 1993a). TRIS reports are generated by the facility, and then sent to EPA for upload. Facilities under certain SIC codes are required to submit data if they meet the applicability thresholds of employment and chemical use. Therefore, there may be significant deficiencies in the data.

Second, Section 304 of SARA requires that any source which emits amounts in excess of threshold levels of any "hazardous" or "extremely hazardous" substance as defined by EPA pursuant to CERCLA must report the quantities of the substance(s) released. These reports are to be filed with the National Response Center, and are due immediately upon release of the substance (EPA, 1993a).

### **Resource Conservation and Recovery Act (RCRA) of 1976**

RCRA was established to minimize the generation of hazardous waste, and to aid in the management of such hazardous waste. Sections 3001 and 3002 of RCRA require hazardous waste generating facilities to report and analyze their generation of certain hazardous wastes. Such an analysis could include estimation of emissions of certain substances. These facilities must report biennially to EPA.

### **Pollution Prevention Act of 1990**

The Pollution Prevention Act is designed to facilitate the reduction of pollution at the source, rather than to mandate "end-of-pipe" controls. In general, this Act requires several EPA activities to facilitate pollution prevention, including establishing a clearinghouse for pollution prevention information, a grants program, reports to Congress, and others. It also imposes a specific reporting requirement on certain sources. Specifically, sources that are required to file an annual toxic release form under Section 313 of SARA must also file an annual toxic chemical source

reduction and recycling report. Section 6607 of the Pollution Prevention Act describes the specific requirements for this report. For many sources, meeting these requirements will require some form of emissions estimation (EPA, 1991c).

### **2.1.3 FEDERAL REQUIREMENTS OUTSIDE OF EPA**

In addition to EPA, two other federal agencies have requirements that may lead to emissions estimates for certain sources. The Department of Energy (DOE) requires electric power plants to report information on fuels, cooling equipment, environmental control equipment, and other information from which air emissions may be estimated. The Department of Defense (DoD) is in the process of establishing a central air emissions database which is to be part of the Defense Corporate Information Management (DECIM) system. This database may require additional emissions reporting. It should also be noted that each facility subject to any DOE or DoD requirements is also subject to any relevant EPA requirements.

## **2.2 STATE REQUIREMENTS**

As previously described, the EPA places several requirements on states which may indirectly lead to reporting requirements for sources. These include the requirements that the states update emissions inventories on an annual basis for NEI, that the states submit base year and periodic inventories for SIP development, and that the states develop Title V Operating Permits programs. Although states must comply with federal requirements, states are not restricted from establishing their own, more stringent requirements. While the federal laws and regulations identify a minimum set of requirements, states may choose to develop additional estimating and reporting requirements. Individual state agencies can provide assistance to sources on identifying and complying with individual state requirements.

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# 3

## EMISSIONS INVENTORY PLANNING

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### 3.1 PRELIMINARY PLANNING ACTIVITIES

Prior to initiating the actual compilation of an emissions inventory, an agency or facility must plan a basic approach for collecting, handling, and reporting emissions data. An inventory preparation plan should identify the required resource allocations and specify the procedures to be used to collect, handle, review, and report emissions data. Figure 1.3-1 illustrates the activities involved in preparing an inventory. Careful consideration of the approach to be used in developing the emissions inventory program will greatly facilitate the inventory process and can prevent major revisions to the inventory during review. As part of the preliminary planning activities, the inventory preparer should consider the following:

- End use of the data;
- Scope of the inventory;
- Availability and usefulness of existing data; and
- Strategy for data collection and management.

Each of these issues is discussed in more detail below.

#### 3.1.1 END USE OF THE DATA

A basic consideration in planning the inventory is establishing the end uses of the completed inventory. For the regulatory agency, the end uses of all inventories fall into three general categories:

- Air quality control strategy development;
- Air quality maintenance;
- Air quality research.

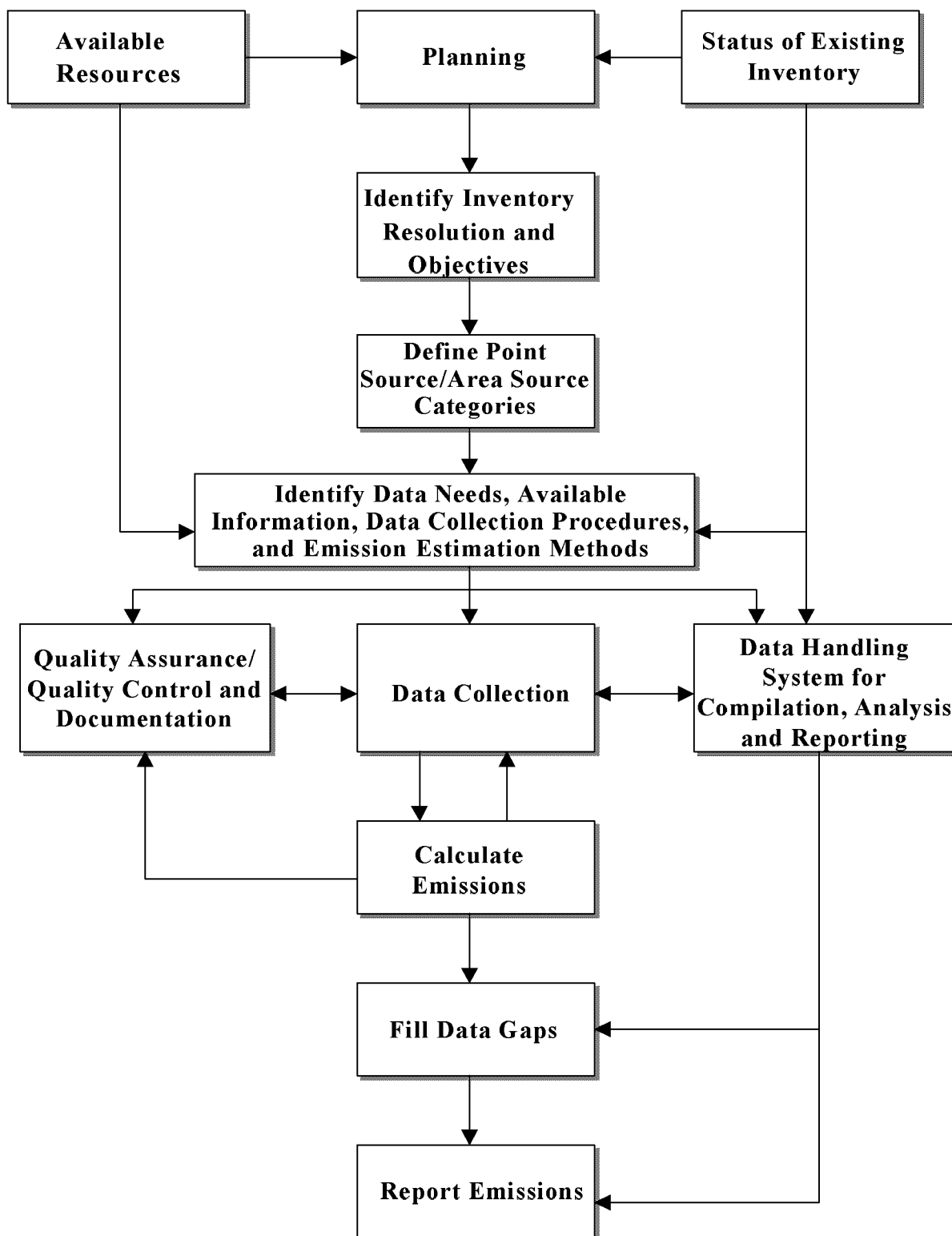


Figure 1.3-1. Activities For Preparing an Inventory



For an individual facility, the inventory may be:

- The measure of progress towards a corporate goal for emission reductions; and/or
- A means of identifying opportunities for process improvements.

Possible future use of the inventory, as well as immediate objectives, should be considered in determining inventory procedures and data needs.

### 3.1.2 SCOPE OF THE INVENTORY

In defining the scope of the inventory, the primary considerations are the desired level of detail, the desired number of sources, and the pollutant(s) of interest. Point sources can be inventoried at three levels of detail:

- The plant level, which denotes a plant or facility that could contain several pollutant-emitting activities;
- The point/stack level, where emissions to the ambient air from stacks, vents, or other points of emission are characterized; and
- The process/segment level, representing the unit operations of specific source categories. The appropriate level of detail will be a function of the intended use of the data.

Under ideal circumstances, all stationary sources would be considered point sources for purposes of emission inventories. In practical applications, however, only sources that emit more than a specified cutoff level of pollutant are considered point sources. In general, the higher the cutoff level, the fewer the facilities that are included in an inventory of point sources; a lower cutoff level would result in the inclusion of more sources. As a rule, the lower the cutoff level, the greater the cost to develop the inventory. However, a low cutoff level will increase user confidence in the source and emissions data, and the inventory will have a greater number of applications.

Identification of the pollutants to be inventoried is a major element in determining the scope of the inventory. The pollutants of interest for ozone inventories are VOCs, NO<sub>x</sub>, and CO. For other criteria pollutants, only the criteria pollutant itself is of interest in the inventory. For HAP inventories on the federal level, the CAA list of 189 HAPs determines the pollutants to be inventoried.<sup>a</sup> States and local agencies may have additional toxic pollutants on their state/local toxic air pollutant (TAP) lists.

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<sup>a</sup> Caprolactam was delisted as a HAP (*Federal Register*, Vol. 61, page 30816, June 18, 1996).

Table 1.3-1 presents source categories that should be considered for inclusion in point source emission inventories. The table also indicates the types of pollutants emitted from these categories. In defining the scope of an inventory, the emphasis should be on those source categories that are located in the geographic area covered by the inventory and that are addressed by regulations applicable to point sources. The selected sources and source categories should be compatible with available information and be of sufficient detail to facilitate control strategy projections. Appendices A and B provide additional detail, cross-referencing HAPs and associated MACT source categories.

### 3.1.3 AVAILABILITY AND USEFULNESS OF EXISTING DATA

A major inventory planning consideration is whether, and to what extent, existing information can be used. Existing inventories should be examined to determine whether the appropriate sources have been included and whether the emissions data represent current conditions. Existing inventories can serve as a starting point for developing extensive data and support information, such as documentation of procedures. Information may also be drawn from other regulatory agency operations such as permitting, compliance, and source inspections and from other facility resources such as corporate reporting or compliance report submittals. For effective use of resources, an agency or facility should plan to fulfill specific emissions inventory requirements by building upon and improving the quality of regularly collected data.

For effective use of resources, an agency or facility should plan to fulfill specific emissions inventory requirements by building upon and improving the quality of regularly collected data.

### 3.1.4 STRATEGY FOR DATA COLLECTION

Another key decision in inventory planning regards what particular data collection procedures will be followed. Point source inventories are generally compiled using a “bottom-up” approach. This means that emissions are estimated for individual sources and summed to obtain state- or county-level estimates. Alternative data collection methods include questionnaires, plant inspections, and review of existing agency permit and compliance files. You may need to use a combination of data gathering techniques to ensure complete and accurate data are available for compilation of an inventory. Section 5 of this chapter describes data collection methods in detail.

Depending on the approach selected, the available data may be in various forms such as source tests, material balances, purchasing records, or actual emission estimates. The resources (staff and budget) required to gather the data and manipulate it into the desired inventory will vary depending on the selected approach. The inventory preparer must keep these considerations in mind during the preliminary planning phase in order to decide on the strategy that best matches the data quality needs and the available resources.

TABLE 1.3-1

## POTENTIAL POINT SOURCES AND POLLUTANTS

Source Name	Description	POLLUTANTS							
		VOC	CO	NO <sub>x</sub>	NH <sub>3</sub>	SO <sub>2</sub>	PM <sub>10</sub>	Lead	HAP
Fuel Combustion, Electric Utilities	Coal	X	X	X	X	X	X	X	X
	Oil	X	X	X	X	X	X	X	X
	Gas	X	X	X	X	X	X	X	X
	Other	X	X	X		X	X	X	
	Internal Combustion	X	X	X	X	X	X		X
Fuel Combustion, Industrial	Coal	X	X	X	X	X	X	X	X
	Oil	X	X	X	X	X	X	X	X
	Gas	X	X	X	X	X	X		X
	Other	X	X	X	X	X	X	X	
	Internal Combustion	X	X	X	X	X			X
Fuel Combustion, Other	Commercial/Institutional Coal	X	X	X	X	X	X	X	X
	Commercial/Institutional Oil	X	X	X	X	X	X	X	X
	Commercial/Institutional Gas	X	X	X	X	X			X
	Misc. Fuel Comb. (Except Residential)	X	X	X	X	X		X	X
	Residential Wood	X	X		X	X	X		
	Residential Other			X	X	X			X
Chemical and Allied Product Mfg.	Organic Chemical Mfg.	X	X	X		X	X		X
	Inorganic Chemical Mfg.	X	X	X		X	X	X	X
	Polymer and Resin Mfg.	X		X		X	X		X
	Agricultural Chemical Mfg.	X	X	X	X	X	X		X
	Paint, Varnish, Lacquer, Enamel Mfg.	X					X		X
	Pharmaceutical Mfg.	X							X
	Other Chemical Mfg.	X	X	X		X	X		X

TABLE 1.3-1

(CONTINUED)

Source Name	Description								
		VOC	CO	NO <sub>x</sub>	NH <sub>3</sub>	SO <sub>2</sub>	PM <sub>10</sub>	Lead	HAPs
Metals Processing	Non-Ferrous Metals Processing	X	X	X	X	X	X	X	X
	Ferrous Metals Processing	X	X	X	X	X	X	X	X
	Metals Processing Not Else Classified (NEC)	X			X	X	X	X	X
Petroleum and Related Industries	Oil and Gas Production	X			X	X			X
	Petroleum Refineries and Related Industries	X	X	X	X	X	X		X
	Asphalt Manufacturing	X	X			X	X		X
Other Industrial Processes	Agriculture, Food, and Kindred Products	X			X		X		X
	Textiles, Leather, and Apparel Products	X					X		X
	Wood, Pulp and Paper, and Publishing Products	X	X			X	X		X
	Rubber and Miscellaneous Plastic Products	X							X
	Mineral Products	X	X	X	X	X	X	X	X
	Machinery Products	X					X		X
	Electronic Equipment						X		X
	Transportation Equipment						X		X
	Construction						X		X
	Miscellaneous Industrial Processes	X					X		X
Solvent Utilization	Degreasing	X							X
	Graphic Arts	X		X					X
	Dry Cleaning	X							X
	Surface Coating	X					X		X
	Other Industrial	X							X
	Nonindustrial	X				X			X

TABLE 1.3-1  
(CONTINUED)

Source Name	Description	POLLUTANTS							
		VOC	CO	NO <sub>x</sub>	NH <sub>3</sub>	SO <sub>2</sub>	PM <sub>10</sub>	Lead	HAPs
Storage and Transport	Bulk Terminals and Plants	X				X			X
	Petroleum and Petroleum Product Storage	X							X
	Petroleum and Petroleum Product Transport	X							X
	Service Stations: Stage I	X							X
	Service Stations: Stage II	X							X
	Service Stations: Breathing and Emptying	X							X
	Organic Chemical Storage	X							X
	Organic Chemical Transport	X							X
	Inorganic Chemical Storage						X		X
	Inorganic Chemical Transport					X	X		X
	Bulk Materials Storage	X					X	X	X
	Bulk Materials Transport						X	X	X
Waste Disposal and Recycling	Incineration	X	X	X		X	X	X	X
	Open Burning	X	X	X		X	X		X
	Publicly Owned Treatment Works (POTW)	X							X
	Industrial Waste Water	X							X
	Treatment, Storage, and Disposal Facility	X					X		X
	Landfills	X	X	X			X		X
	Other	X		X			X	X	X
Miscellaneous	Agriculture and Forestry			X			X		X
	Other Combustion	X	X				X		X
	Catastrophic/Accidental Releases	X				X	X		X
	Repair Shops	X							X
	Health Services	X							X
	Cooling Towers	X					X		X
	Fugitive Dust						X		X

Source: EPA, 1999a. EIIIP, Volume II, Chapter 14, Uncontrolled Emission Factor Listing for Criteria Pollutants. Revised draft, final December 2000.

Because it is not always certain whether a category will be ultimately be inventoried as a point or an area source, data collection efforts should always include as much detailed information as possible. For example, employment by standard industrial classification code may not be used in a point source inventory, but would be helpful for preparing an area source inventory.

Once the strategy for data collection is chosen, the inventory preparer needs to consider how data will be handled and managed, including QA/QC procedures. Emissions inventory data for a single point source or area source category may be minimal and can be handled using spreadsheets or by hand calculations. For large sets of data, an electronic database will be needed to organize, manipulate, and simply store the collected data. There are a wide variety of available software packages designed for tracking environmentally related emissions and release information. The system used should be able to handle the types of information being collected as well as have the ability to export information for state and federal reporting requirements.

## 3.2 INVENTORY PREPARATION PLAN

The inventory work plan is a concise, to-the-point document that declares how an agency or plant intends to develop and present its inventory. It allows a line of communication between the inventory preparer, his/her management, and the receiving agency to ensure that the inventory is conducted effectively. The work plan should include inventory objectives and general procedures and should address all sources (regardless of size) of all the target pollutants.

Although no specific format is required by EPA, generally, the inventory preparation plan should:

- Define the geographic inventory area by attainment or nonattainment status;
- Define the scope of the inventory (i.e., identify which sources and pollutants will be covered);
- Define the data quality objectives;
- Provide the background/basis for the inventory (i.e., describe previous efforts that are related and describe purpose of this inventory);
- Specify who is responsible for preparing the inventory, with a detailed organization chart of key personnel/consultants;
- Specify each person's responsibilities;
- Specify the QA coordinator and the technical reviewers (which are different than the technical team generating the inventory);

- Describe the approach to be used to estimate emissions (i.e., identify plans for data collection, analysis, source definition thresholds, emission estimation methods by source category type, and data reporting and storage procedures);
- Describe QA/QC procedures; and
- Describe how the agency plans to present and document the inventory for submittal to EPA and/or others.

For point sources, an agency must define how all pertinent emissions sources will be identified and located. The work plan should describe how point source activity levels and associated parameters will be developed, and how these data are used to calculate emissions estimates. It should also describe the type of source surveys that are planned and the use of existing data contained in systems such as the National Emission Inventory (NEI), state emission inventory systems, or state permitting files.

### 3.3 TRAINING

Training is an important component of the facility's or agency's preliminary planning activities. The extent of training needed will depend on the staff chosen to prepare the inventory and the number of new procedures required by the inventory process.

Training courses for the critical components of an emissions inventory are provided annually by the EPA's Air Pollution Training Institute (APTI). These courses provide detailed instruction in:

- Inventory planning;
- Inventory management;
- Point source emissions;
- Emissions calculations;
- Projection techniques; and,
- Data reporting.

These courses are available to any individuals with the education, experience, or employment responsibilities involving enforcement or compliance with regulatory programs for achievement of air quality standards. Further information can be obtained by contacting the APTI (Internet address: [www.epa.gov/oar/oaqps/eog/apti.htm](http://www.epa.gov/oar/oaqps/eog/apti.htm)).

## 3.4 DATA SOURCES

This section introduces the various data sources available to an inventory preparer compiling an emissions inventory. The types of data needed to compile a complete emissions inventory include:

- Inventory guidance;
- Existing emission data;
- Emission factor resources;
- Models resources;
- Source characterization documents (documents that characterize an industry, including a description of processes, operating parameters, equipment used, emissions generated; and volume and type of output produced); and
- Activity data references.

Note that in many cases a single document can provide information on one or more of the types of data needed for your inventory. For example, EIIP is an excellent resource for inventory guidance as well as source characterization, and *AP-42* is an excellent resource for both emission factors and source categorization.

### 3.4.1 FINDING INVENTORY GUIDANCE

The primary guidance on emission inventory development is summarized in the EIIP volumes. These volumes present EPA's recognized standard for the development of reliable, quality-rated inventories. The EIIP documents present preferred and alternative methods for estimating emissions from point, area, mobile, and biogenic source categories. Hard copies of these manuals are available from the National Technical Information Service (NTIS). Electronic copies of the EIIP documents can be downloaded off the World Wide Web through the EIIP Web site at <http://www.epa.gov/ttn/chief/eiip/>.

Additional emissions inventory guidance, such as memoranda from OAQPS, can be downloaded off the World Wide Web through EPA's CHIEF Web site at <http://www.epa.gov/ttn/chief/index.html>.



### 3.4.2 EXISTING EMISSION DATA

A well-documented, existing air emissions inventory is a good source of emissions data. If an agency has previously estimated emissions based on a survey of the industry, sometimes an inventory preparer can use those data to estimate emissions for the newer inventory. This may be as simple as applying a growth factor to the emissions, or it may require further adjustments to account for other changes in the industry such as new controls. Information contained in these inventories can at least serve as a starting point for developing extensive data and support information, such as documentation of procedures.

NOTE: Existing inventories may focus on pollutants other than those needed in the inventory being prepared. Thus, certain sources that emit only one type of pollutant may not be well represented.

The most current and accessible national emission databases available for review and assessment in developing a criteria hazardous air pollutants inventory include:

- The National Emission Inventory (NEI) Database:  
*FTP://ftp.epa.gov/pub/emisInventory/net\_96;*
- The National Toxics Inventory (NTI) Database,  
*FTP://ftp.epa.gov/pub/emisInventory/nti\_96;*
- AIRSWeb: <http://www.epa.gov/airsweb/sources.htm>

Detailed descriptions of these databases are provided in Appendix C.

A less desirable but possible source of emissions data is through the extrapolation of emissions from one geographic region to another. This approach may be most appropriate when the socioeconomic conditions between two regions are comparable. In these situations, the emissions data for one region can be extrapolated to the other region based on population, employment, or other representative surrogates of the activity causing the emissions.

### 3.4.3 FINDING EMISSION FACTOR INFORMATION

The most commonly used emission factor resources are listed below and described in greater detail in Appendix D.

- *AP-42*: One of the most frequently cited resources for emission factor information is the EPA document, *Compilation of Air Pollutant Emission Factors (AP-42)*. This document contains criteria pollutant emission factors for point and area sources. *AP-42* is available on the World Wide Web at

<http://www.epa.gov/ttn/chief/ap42/index.html>. *AP-42* is also available on the *Air CHIEF* CD-ROM, and in hard copy from the Government Printing Office (GPO) at (202) 512-1800.

- Emission factor databases: Several emission factor databases are currently available in easy-to-access formats to state and local agencies. Two of these tools include:
  - Factor Information Retrieval (FIRE) Data System (EPA, 2000c)
    - ▶ Web reference for FIRE -  
<http://www.epa.gov/ttn/chief/software/fire/index.html#access>, and
  - Air Clearinghouse for Inventories and Emission Factors (Air CHIEF) CD-ROM, <http://www.epa.gov/ttn/chief/software/airchief/index.html> or (919) 541-1000.

In addition, you should conduct a search of technical papers for source test and background information for the emission source category or pollutants in question. You can conduct this search using EPA library services or through government document depositories at local universities. Examples of references and documents that you should review include:

- Miscellaneous private sector resources. For example, the National Council of the Paper Industry for Air and Stream Improvements, Inc. (NCASI) compiles, through a highly focused research program, reliable environmental data and information on the forest products industry.
- Emission factor reports published by other state and local agencies, and other states' databases and source tests. This information can be identified and acquired through direct communication with the agencies.
- Source test data used for compliance purposes and in developing operating permits for stationary sources may be readily available through state and local air permitting agencies. The use of source test data reduces the number of assumptions regarding the applicability of emission factors to a source.
- Professional societies (e.g., AWMA) symposia publications contain up-to-date information.

### 3.4.4 EMISSION ESTIMATION MODELS

Several emission estimation models are available for download free-of-charge.

- Landfill Gas Emissions Model:  
*<http://www.epa.gov/ttn/catc/products.html#software>*
- TANKS: *<http://www.epa.gov/ttn/chief/software/tanks/index.html>*
- WATER9: *<http://www.epa.gov/ttn/chief/software/water/>*
- CHEM9: *<http://www.epa.gov/ttn/chief/software/chem9/index.html>*
- PMCalc: *<http://www.epa.gov/ttn/chief/software/pmcalc/index.html>*

### 3.4.5 SOURCE CHARACTERIZATION INFORMATION

Inventory preparation requires source categorization information to identify the sources to be included in the inventory. Source categorization information includes:

- Description of the sources, facilities, or activities included in the source category. For example, the boiler source category comprises sources that combust fuels to produce hot water and/or steam. The source category definition can include the SIC code or the EPA source classification code (SCC).
- Description of emission sources within the source category. For example, the boilers category includes coal-fired boilers, oil-fired boilers, boilers using other types of fuel, cogeneration units, and auxiliary sources.
- Discussion of the factors influencing emissions such as control techniques, influences of weather conditions, or process operating factors.

Several resources are available for source characterization. Primary resources include:

- *AP-42.*
- *Locating and Estimating Air Emissions from Sources of (Source Category or Substance) (L&E) Documents.* About 30 L&E documents are currently available. Although L&E documents concentrate on hazardous air pollutants (HAPs), these documents can be useful for criteria pollutant inventories because each volume includes general descriptions of the emitting processes, and provides source characterization. L&E documents are available on the CHIEF Web site at

<http://www.epa.gov/ttn/chief/le/index.html>. A complete list of L&E documents is included in Appendix E.

- Industry Sector Notebooks: The EPA's Office of Compliance has developed a series of notebooks profiling selected major industrial groups. Each sector-specific notebook brings comprehensive details that include an environmental profile, industrial process information, and bibliographic references. A detailed description of the Industry Sector Notebooks project is provided in Appendix F. Industry Sector Notebooks are available on the World Wide Web at <http://es.epa.gov/oeca/sector/index.html>

Additional resources include:

- EPA reports presenting the results of engineering investigations of air emissions from various industrial processes, such as Control Techniques Guidelines (CTGs) and Available Control Techniques (ACT) documents, and Background Information Documents (BIDs) for New Source Performance Standards (NSPS) and National Emission Standards for Hazardous Air Pollutants (NESHAP) or Maximum Achievable Control Technology (MACT) standards. These reports are available through the GPO, the National Technical Information Service (NTIS), and on the World Wide Web at <http://www.epa.gov/ttn/>
- The Integrated Data for Enforcement Analysis (IDEA) system: IDEA is an interactive data retrieval and integration system developed by EPA's Office of Enforcement and Compliance Assurance (OECA). IDEA integrates facility data across EPA's various program office databases. A detailed description of IDEA is provided in Appendix F and on OECA's Web site at <http://es.epa.gov/oeca/idea/>
- Air pollution control agency files: Compliance, enforcement, permit application, or other air pollution control agency files may provide valuable information on the location and types of sources in the area of concern. For example, permit applications generally include enough information about a point source to describe the nature of the source and to estimate the magnitude of emissions that will result from its operations. A compliance file might contain a list of air pollution regulations applicable to a given source, a history of contacts made with that source on enforcement matters, and an agreed-upon schedule for the source to effect some sort of control measures.
- Annual emission statements: Most states require facilities emitting above a certain threshold to submit an annual emission statement listing various processes and their emissions. Annual emission statements should be examined to determine whether the appropriate sources have been included and that the emissions data represent current conditions.

- Other government-funded agencies, such as the Paint and Coating Resource Center (PCRC) and the National Metal Finishing Resource Center (NMFRC): The main function of these Centers is to provide regulatory compliance and pollution prevention information on their respective industries. The PCRC can be accessed on the World Wide Web at <http://www.paintcenter.org/> and the NMFRC can be accessed at <http://www.nmfrc.org/>.

### 3.4.6 APPLICABLE ACTIVITY PARAMETERS

Inventory preparers may need to use different types of activity data to estimate emissions from area and point sources - even within the same source category. Point sources may require direct measurement or direct activity (i.e., throughput) applied to an emission factor, while emissions from area sources are often estimated using surrogate activity factors, such as population or employment.

For point sources, activity parameters are generally reported as fuel consumption rates or process weight rates for fuel-burning equipment and industrial processes, respectively. You will need detailed data on process equipment, throughput, capacity, and other parameters to estimate emissions from point sources. You can obtain this information from contacts with individual facilities. The two most common types of plant contacts are surveys and questionnaires, and direct plant inspections. A type of indirect plant contact also commonly employed is the use of permit applications or compliance files. Other traditional sources of activity data for point sources include:

- State and local industrial directories;
- State Departments of Commerce and Labor statistics;
- National and state directories of manufacturers;
- Data compiled by private research and development companies such as the *Directory of Chemical Producers* compiled by SRI International; and
- Trade and professional associations.

## 3.5 DATA HANDLING

Inventory data can be managed almost entirely by computer. During the inventory planning stages, the inventory preparer should anticipate the volume and types of data-handling needed in the inventory effort and should weigh the relative advantages of manual versus computerized systems. If the inventory preparer must deal with large amounts of data, maximizing the use of computerized inventory data-handling systems will allow them to spend more time gathering, analyzing, and validating the inventory data, as opposed to manipulating the data.

Computerized data handling becomes significantly more cost-effective as the database, the variety of tabular summaries, or the number of iterative tasks increases. In these cases, the computerized inventory requires less overall time and has the added advantage of forcing organization, consistency, and accuracy.

Some activities that can be performed efficiently and rapidly by computers include:

- Printing mailing lists and labels;
- Maintaining status reports and logs;
- Calculating and summarizing emissions;
- Performing error checks and other audit functions;
- Storing source, emissions, and other data;
- Sorting and selectively accessing data; and
- Generating output reports.

Additional information on data handling is presented in Volume VII of the EIIP series of guidance documents.

## 3.6 DOCUMENTATION REQUIREMENTS

Documentation is an integral part of an emissions inventory. Before submittal, internal review of the written documentation provides an opportunity to uncover and correct errors in assumptions, calculations, or methods. Following submittal of the inventory, the documentation allows the results of the inventory to be clearly understood and the quality of the inventory to be effectively judged. Complete and well-organized documentation is necessary to prepare a reliable and technically defensible inventory document. The goal of documentation is to ensure that the final written compilation of the data accurately reflects the inventory effort. Documentation requirements are discussed in detail in Section 6 of this chapter.

Although documentation requirements may evolve during the inventory data collection process, the calculation and reporting steps of the emissions inventory development process should be anticipated during planning. Planning the level of documentation required will:

- Ensure that important supporting information is properly developed and maintained;

- Allow extraneous information to be identified and discarded, thereby reducing the paperwork burden;
- Help determine data storage requirements; and
- Aid in identifying aspects of the inventory on which to concentrate the QA efforts.

### 3.7 SCHEDULE

If the development and maintenance of an emissions inventory is conceptualized as a network of activities or events with a definite start and end, various techniques can be used to formulate a project schedule. One method is to graphically present the inventory tasks, their estimated completion times, major project milestones, and labor requirements. This is a useful way to visualize the activities and their relationships to one another. By identifying the "critical path" events at this early point in the schedule-planning activities, the inventory preparer can anticipate potential bottlenecks in the process and avoid delays that might affect the timely submittal of the final inventory.

It is important to remember that a schedule must be frequently compared to the actual progress of the inventory effort. By closely tracking the activities, the preparer can:

- Ensure that each task is being completed expeditiously;
- Revise labor commitments to reflect schedule and data changes; and
- Learn from experience so that this knowledge can be applied towards future inventory efforts.

### 3.8 SUMMARY OF ISSUES TO CONSIDER WHEN ESTIMATING EMISSIONS FROM POINT SOURCES

When compiling a point sources emissions inventory an inventory preparer should consider the issues presented in Table 1.3-2.

TABLE 1.3-2

## ISSUES TO CONSIDER WHEN ESTIMATING EMISSIONS FROM POINT SOURCES

For a point source inventory, you should...	Because...	Helpful references include...
Carefully consider what source categories to include in the inventory.	Attempting to inventory all source categories may overburden an agency's resources, especially if a majority of the sources are deemed insignificant contributors to pollution by the state. A screening study will help you focus the inventory effort.	Guidance on how to conduct screening studies for the purpose of inventory development is available in Appendix F.
Consider threshold levels of emissions for sources to be included in the inventory.	If the agency does not preclude reporting of emissions below specific exemption or <i>de minimis</i> levels, the effect on agency resources may be similar to that of inventorying all source categories for all criteria pollutants.	
Consider the differences in the source definition(s) for the purposes of criteria and HAP inventories when using a HAP inventory as a starting point for the criteria pollutant inventory.	Some industrial sources with PM or VOC emissions below typical cutoff levels may be categorized as area sources for the purpose of a criteria pollutant inventory, but may qualify as major point sources for the purpose of a HAP inventory.	
Check the results of any survey for completeness.	When surveying sources directly, there may be a need to follow-up with a facility, particularly if you believe it is emitting a certain pollutant it does not report.	



TABLE 1.3-2

(CONTINUED)

For a point source inventory, you should...	Because...	Helpful references include...
Stay informed of air regulations and rule development activities and implementation information.	Some MACT standards may also contain information that addresses emission limits on criteria pollutants (e.g., a standard may use PM concentration as a surrogate to measure non-volatile metals concentration as part of total HAP reductions).	You can access comprehensive MACT rule-specific information including <i>Federal Register</i> publications and citations, compliance dates, and MACT rule contact names and phone numbers through the UATW site at <a href="http://www.epa.gov/ttn/uatw/eparules.html">http://www.epa.gov/ttn/uatw/eparules.html</a> .
Keep in mind that nationally-derived emission factors may not apply directly to your area and may need to be adjusted.	Emissions calculated using national emission factors may vary considerably from actual values at a specific source or within a specific geographic area.	
Avoid double counting of sources and emissions.	Overlap can occur between point and area sources.	EIIP Volumes II and III.
Know your pollutants.	For example, several VOC are considered photochemically nonreactive by the U.S. EPA as defined in the CAA and are not included in VOC emissions inventories (63 FR 17331, April 9, 1998: Part 51 "Air Quality Revision to Definition of VOC - Exclusion of Methyl Acetate.").	

TABLE 1.3-2  
(CONTINUED)

For a point source inventory, you should...	Because...	Helpful references include...
Make sure you account for fugitive emissions. Fugitive emissions are emissions that are technically infeasible to collect and control such as emissions from stockpiles, material handling and transfer operations, and process leaks.	Fugitive emissions may account for a substantial portion of actual emissions from many facilities.	
Account for factors influencing emissions such as process variability and/or equipment malfunctions and upset conditions.	Variations in emissions due to normal process variability or abnormal operating conditions can result in emissions increases which can be difficult to quantify.	Volume II, Chapter 12, of the EIIP document series addresses this topic and should be reviewed for details on how control device malfunctions affect emissions. The document also provides example calculations.

# 4

## EMISSION ESTIMATION PROCEDURES

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Air pollutant emissions may be released from numerous sources within a facility. Depending on the facility size, the nature and number of processes, and the emission control equipment in place, emission estimation may be very simple or extremely difficult. The inventory preparer should consider the types of emissions to be reported (i.e., actual, potential, or allowable), the availability of data, and the cost when selecting which method of emissions estimation is appropriate.

Selecting a method to estimate source specific emissions warrants a case-by-case analysis considering the cost and required accuracy in the specific situation. When selecting an emissions estimation method, you should consider several issues when analyzing the tradeoffs between cost and accuracy of the resulting estimates. These issues include:

- Availability of quality data needed for developing emissions estimates;
- Practicality of the method for the specific source category;
- Intended end use of the inventory (e.g., an inventory in support of significant regulatory implications such as residual risk or environmental justice issues may require that more accurate and costly emission estimation methods be used than would an inventory intended for simply a source characterization);
- Source category priority (e.g., if a source category is of relatively high priority, it may require a more accurate emission estimation method);
- Time available to prepare the inventory; and
- Resources available in terms of staff and funding.

Figure 1.4-1 (from *AP-42*) depicts various approaches to emission estimation that should be considered when analyzing the costs versus the quality of the results (EPA, 2000b). Ideally, plants needing emissions estimates would use continuous emissions monitoring (CEM) to obtain actual emissions measurements over very short time intervals. Some facilities currently do this. The CEM concentration data can be easily converted to mass emission rates provided the air volume through the monitor is also known. In cases where CEM or parametric monitoring data

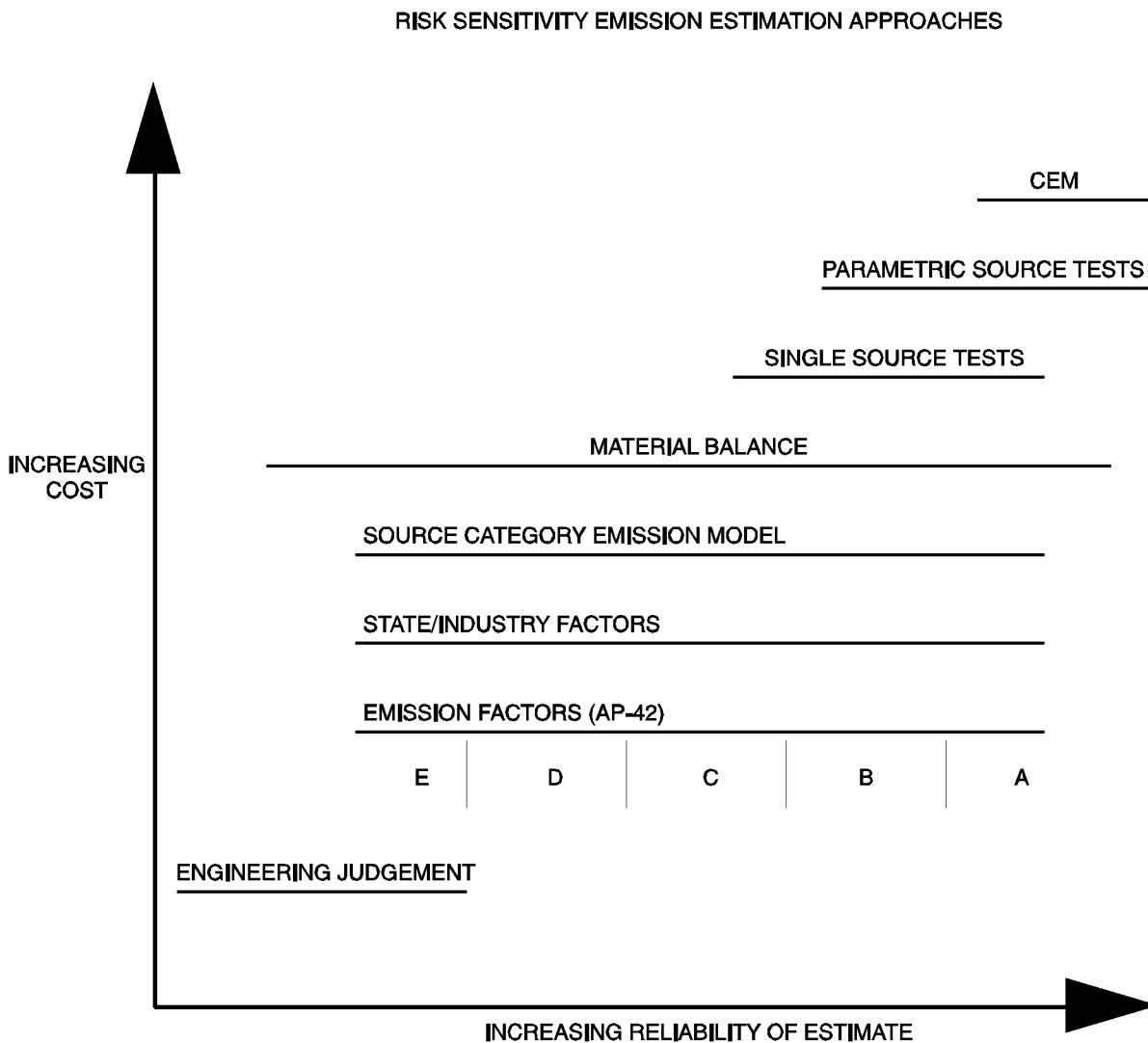


FIGURE 1.4-1. EMISSION ESTIMATION HIERARCHY

are unavailable, however, another method must be used to estimate emissions. The three principal methods for estimating emissions in such cases are source tests, material balances, and emission factors. If none of these three methods can be employed to estimate emissions for a specific process, an approximation or engineering estimate based on available process, physical, chemical, and emission knowledge may be used.

Where risks of adverse environmental or regulatory effects are high, the more sophisticated and costly emission determination methods such as CEM or source tests may be necessary. Conversely, where the risks are low, less expensive estimation methods such as the use of emission factors and emission models may be acceptable.

## 4.1 CEMS

Continuous emissions monitors (CEMs) measure and record actual emissions during the time period the monitor is operating and the data produced can be used to estimate emissions for different operating periods. CEMs are typically used to measure stack gas concentrations of  $\text{NO}_x$ ,  $\text{CO}_2$ ,  $\text{CO}$ ,  $\text{SO}_2$ , and total hydrocarbons (THC). CEMs can either be permanently installed at a source to generate data 24-hours a day or they can be used for emissions monitoring during a defined source testing period (e.g., 1 to 4 hours).

## 4.2 SOURCE TESTS

The source test is a common method of estimating process emissions. Source tests are short-term emission measurements taken at a stack or vent. Due to the substantial time and equipment involved, a source test requires more resources than an emission factor or material balance emission estimate. Typically, a source test uses two instruments: one to collect the pollutant in the emission stream and one to measure the emission stream flow rate. The essential difference between a source test and CEM is the duration of time over which measurements are conducted. A source test is conducted over a discrete, finite period of time, while CEM is continuous.

If the use of source test data reduces the number of assumptions regarding the applicability of emissions data to a source (a common consideration when emission factors are used), as well as the control device efficiency, equipment variations, and fuel characteristics. Thus, source tests typically provide better emission estimates than emission factors or material balances, if correctly applied (Southerland, 1991). However, source test data should be used for emission estimation purposes only if the data were obtained under conditions which are representative of or related to operating conditions normally encountered at the source in question.

Two items should be noted when using source test data to calculate emissions. First, because most source tests are only conducted over several hours or days at most, adjustments may need to be made when using these data to estimate emissions over longer time intervals. Emission data from a one-time source test can be extrapolated to estimate annual emissions only if the process stream does not vary and if the process and control devices are operated uniformly.

Second, a source test may not adequately describe a given facility's annual or seasonal operating pattern. For example, there may be variations in process operation throughout the year or the efficiency of control device performance may vary due to fluctuations in ambient temperature or humidity. In such cases, multiple tests must be conducted for source testing to be useful in generating an emission estimate for extended periods that are longer than the test period. If facility operation and test methods employed during the source test cannot be adequately characterized, the source test data should not be used.

If a source test is used to estimate emissions for a process, test data gathered on-site for that process is generally preferred. The second choice is to use test data from similar equipment and processes on-site, or to use pooled source tests or test data taken from literature. The reliability of the data may be affected by factors such as the number of tests conducted and the test methodology used.

The EPA has published reference methods for measuring emissions of PM, SO<sub>2</sub>, NO<sub>x</sub>, CO, and VOC. The reference methods, given in Code of Federal Regulations, Title 40, Part 60, Appendix A (updated 7/1/99), define and describe the test equipment, materials, and procedures to be used in stack tests for the various criteria pollutants. Reference methods for estimating HAP emissions are published in Title 40, Code of Federal Regulations, Part 61, Appendix B (EPA, 1986; EPA, 1988). The EPA publication, *Screening Methods for the Development of Air Toxics Emission Factors*, presents an overview of the use of these reference methods for specific HAPs (EPA, 1992d). A brief description of several EPA methods is given in Appendix E. For further information, the reader can consult with the Emission Measurement Technical Information Center (EMTIC), which provides technical guidance on stationary source emission testing. Industry personnel may access EMTIC by calling EMTIC staff directly or by going to the internet web address <http://www.epa.gov/ttn/chief/>.

Most source test reports summarize emissions for each pollutant by expressing them in terms of: (1) a mass loading rate (weight of pollutant emitted per unit of time); (2) an emission factor (weight of pollutant emitted per unit of process activity); or (3) a flue gas concentration (weight or number of moles of pollutant per some weight or volume of flue gas). Generally, when a mass loading rate or flue gas concentration is provided, the resulting emission factor can easily be calculated with knowledge of equipment size or operating parameters, as in the example below (EPA, 1993a):

- Example. A single-line paper coating plant has been subjected to an emission test for VOC emissions. Since the coating solvent is primarily toluene, the emission concentrations were measured as toluene. The data averaged for three test runs are as follows:

Stack flow rate ( $Q_s$ )	= 10,000 scf
Emission concentration ( $C_e$ )	= 96 ppm (as toluene)

Fugitive emission capture ( $\text{Eff}_{\text{cap}}$ ) = 0.90 (90 percent, as required by reasonably available control technology (RACT))

Other information needed to complete the calculations include:

Plant operation	= 16 hour/day, 312 days/year
Solvent input rate ( $M_i$ )	= 500 ton/year
Molecular weight (toluene)	= 92
Unit correction factor (f)	= $1.58 \times 10^{-7}$ (lb-mole-min)/(hr-ppm-scf)

The emission calculation begins with determination of the average mass loading rate ( $M_o$ ):

$$\begin{aligned} M_o &= (f)(MW)(C_p)(Q_s) \\ &= (1.58 \times 10^{-7})(92)(96)(10,000) \\ &= 14 \text{ lb/hr} \end{aligned}$$

The emission control efficiency ( $\text{Eff}_{\text{con}}$ ) is calculated:

$$\begin{aligned} \text{Eff}_{\text{con}} &= (M_i - M_o)/M_i \\ &= [500 - ((14)(16)(312)/2,000)]/500 \\ &= 0.93 \text{ (93 percent control)} \end{aligned}$$

## 4.3 MATERIAL BALANCES

When you use material balance, you will determine emissions by knowing the amount of a certain material that enters a process, the amount that leaves the process by all routes, and the amount shipped as part of the product itself. The simplest method of material balance is to assume that all solvent consumed by a source process will evaporate during the process.

The material balance method:

- Can be used where source test data, emission factors, or other developed methods are not available;
- Is most appropriate to use in cases where accurate measurements can be made of all process parameters except the air emission component;
- Is particularly useful for processes like solvent degreasing operations, and surface coating operations.
- Is equally applicable to point and area sources.

- Should not be used for processes where material reacts to form secondary products or where the material otherwise undergoes significant chemical changes.

**The basic emission estimation equation for mass balance is:**

$$E_x = (Q_{in} - Q_{out}) \times C_x$$

where:

$E_x$	=	total emissions for pollutant x
$Q_{in}$	=	quantity of material entering the process
$Q_{out}$	=	quantity of material leaving the process as waste, recovered, or in product
$C_x$	=	concentration of pollutant x in the material.

The term  $Q_{out}$  could involve several different “fates” for an individual pollutant. This could include the amount recovered (or recycled) or the amount leaving the process in the product or waste stream.

If a material balance method is used to estimate emissions and if the actual emissions are a small fraction of the throughput, the throughput estimate or measurement can be even more critical. For example, applying material balances to petroleum product storage tanks is not generally feasible because the losses are too small to quantify using a metering device. In these cases, *AP-42* or equations or TANKS can be used.

Because the emissions are estimated to be the difference between the material input and the known material output, a small percentage error in estimating the input or output can result in a much larger percentage error in the emission estimate. For this reason, material balances are sometimes inappropriate for estimating relatively small losses.

## 4.4 EMISSION FACTORS

Emission factors allow the development of generalized estimates of typical emissions from source categories or individual sources within a category. Emission factors, used extensively in point source inventories, estimate the rate at which a pollutant is released to the atmosphere as a result of some process activity. For example, the emission factor for  $NO_x$  emissions from the combustion of anthracite coal is 9 pounds of  $NO_x$  per 1 ton of coal burned (9 lb/ton). If you know the emission factor and the corresponding activity level for a process, you can estimate the emissions. In most cases, emission factors are expressed simply as a single number, with the underlying assumption that a linear relationship exists between emissions and the specified activity level over the probable range of application. The use of emission factors is straightforward when the relationship between process data and emissions is direct and relatively uncomplicated. Note,



however, that emission factors may be developed assuming no control device is in place. These are referred to as “uncontrolled emission factors.” When emission factors are derived from data that was obtained from facilities with a control device in place, then emission factors are referred to as “controlled emission factors.”

While the emissions calculated using emission factors may differ from actual emissions for a specific facility, emission factors nevertheless provide a reasonable estimate of pollutant emissions across an entire source category. Because emission factors are typically averages obtained from data with wide ranges and varying degrees of accuracy, emissions calculated this way for a given source are likely to indicate higher than actual emissions for some sources and lower than actual emissions for others.

When the information used to develop an emission factor is based on national data, such as a wide range of source tests or national consumption estimates, you should be aware of potential local variations. Emissions calculated using national emission factors may vary considerably from actual values at a specific source or within a specific geographic area.

National emission factors should be used when:

- No locally derived factor exists;
- The local mix of individual sources in the category is similar to the national average; and
- The source is a low priority in the inventory.

Locally derived emission factors are preferred when:

- A national level emission factor does not account for local variations; and
- The category is a high priority in the area.

Locally derived emission factors are developed based on:

- Local surveys or measurements;
- Local consumption data; and
- Adaptation of emission information in permits or another inventory.

Typically, the information gathering necessary for developing a local emission factor can be significant, but the benefits are that the emissions for the source will be well-characterized, and the emission factor or the information used to develop it can be used in subsequent inventories.

If you use factors to predict emissions from new or proposed sources, you should review the latest literature and technology to determine whether such sources would likely exhibit emission characteristics different from those sources from which the emission factors were derived.

Emission factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant. To calculate emissions using emission factors, four basic inputs to the estimation algorithm are required:

- Activity information for the process as specified by the relevant emission factor;
- An emission factor to translate activity information into uncontrolled or controlled emission estimates;
- Rule effectiveness factor; and
- When applicable, information on capture and control efficiencies of any control device when using an “uncontrolled” emission factor.

**The basic emission estimation equation when using an uncontrolled emission factor is:**

$$E = A \times EF \times (1 - C \times RE)$$

where:

- |    |   |   |
|----|---|---|
| E  | = | emission estimate for the process   |
| A  | = | activity level such as throughput   |
| EF | = | emission factor assuming no control   |
| C  | = | capture efficiency x control efficiency (expressed in percent); C equals zero if no control device is in place                  |
| RE | = | rule effectiveness, an adjustment to C to account for failures and uncertainties that affect the actual performance of control. |

**The basic emission estimation equation when using a controlled emission factor is:**

$$E = A \times EF \times RE$$

where:

E	=	emission estimate for the process
A	=	activity level such as throughput
EF	=	“controlled” emission factor
RE	=	rule effectiveness

## 4.5 EMISSION MODELS

Emission models may be used to estimate emissions in cases where the calculational approach is burdensome, or in cases where a combination of parameters have been identified which affect emissions but, individually, do not provide a direct correlation. For example, the TANKS program incorporates variables such as tank color, temperature, and windspeed to obtain an emissions estimate.

Emission models may be based on measured or empirical values. The computer model may be based on theoretical equations that have been calibrated using actual data, or they may be purely empirical, in which case the equations are usually based on statistical correlations with independent variables.

Appendix F provides information on some of the more commonly used emission estimation models.

## 4.6 BEST APPROXIMATION OR ENGINEERING JUDGEMENT

A best approximation or engineering judgement is a final option for estimating emissions, although it is considered the least desirable method. A best approximation or engineering judgement is an emission estimate based on available information and assumptions.

## 4.7 OTHER CONSIDERATIONS

### 4.7.1 RULE EFFECTIVENESS

Inventories performed before 1987 assumed that regulatory programs would be implemented with full effectiveness, achieving all required or intended emissions reductions and maintaining the reduction level over time. However, experience has shown regulatory programs to be less than 100 percent effective for most source categories in most areas of the country.

Rule effectiveness (RE), expressed as a fraction or percent, is an adjustment which reflects the ability of a regulatory program to achieve the required emissions reductions. The intent behind

the RE factor is to account for the fact that most emission control equipment does not achieve emission reductions at the designed rates at all times and under all conditions, and that some intentional noncompliance exists. Process upsets, control equipment malfunctions, operator errors, equipment maintenance, and other nonroutine operations are typical examples of times when control device performance is expected to be less than optimal.

Rule effectiveness is especially important for VOC and CO control programs because of the small size, large number, and relative complexity of most regulated sources. It is necessary to apply rule effectiveness when preparing emissions inventories because the effectiveness of existing regulations is directly related to emissions levels. Rule effectiveness must also be considered in planning for the expected effect of further regulations. Rule effectiveness should be applied for all applicable regulations: federal, state, and local.

A default fraction of 0.80 (equal to 80 percent effectiveness) has been established by the EPA to estimate rule effectiveness in the base year inventories. This fraction is a representative estimate of the average effectiveness values, based on a survey of selected state and local personnel on the perceived effectiveness of their regulatory programs for a wide range of source categories. The 80 percent default value or local category-specific rule effectiveness factor is applied if the emissions data were determined using emission factors, results of emissions tests, or estimated control efficiencies, even if the data were obtained from a survey of the source.

Although the 80-percent rule effectiveness value may generally be valid, it can vary significantly among source categories and can have a dramatic impact on sources assumed to be controlled at a high efficiency (e.g., 99.9 percent). Use of the default rule effectiveness factor should be carefully reviewed under these circumstances. A rule effectiveness of 100 percent may be applicable in some cases, but sources should be sure that no equipment downtime or emergency releases have occurred during the inventory period.

For the purpose of base year inventories under the CAA, the EPA allows the use of the 80-percent default value, but also gives agencies the option to derive local category-specific rule effectiveness factors through the use of a survey. Also, if rule effectiveness can be determined for a source category in a particular region using the protocol defined by the EPA's Office of Enforcement and Compliance Assurance, this rule effectiveness can be used. If a particular facility disagrees with the rule effectiveness factor used in an inventory, a case-by-case assessment of emissions can be performed to determine whether there is adequate data for emissions to be directly determined. If a facility can provide the explicit source data required by EPA, such as continuous source monitoring and control equipment functioning records for the inventory period, then emissions can be determined directly.

Where controls are not used, there is no need to apply rule effectiveness. The rule effectiveness factor should be applied to the estimated control efficiency in the calculation of emissions from a source. However, if emissions are estimated properly, there is no need to apply rule effectiveness. An example of the application is given below.

- Example:

Uncontrolled emissions = 50 pounds (lb) per day

Estimated control equipment efficiency	=	0.90 (90 percent)
Rule effectiveness factor	=	0.80 (80 percent)
Emissions after control	=	$50[1-(0.90)(0.80)]$
	=	$50(1-0.72)$
	=	14 lb per day

Note: The EIIP Point Sources Committee is currently evaluating the application of the rule effectiveness policy. The committee will present their findings in an issues paper to the EIIP Steering Committee upon completion of their study.

#### 4.7.2 CONTROL DEVICES

A basic description of the techniques typically used by industry to control  $PM_{10}$ , VOCs,  $SO_2$ ,  $NO_x$ , and HAPs can be found in the *Handbook: Control Technologies for Hazardous Air Pollutants* (EPA, 1991d). The handbook briefly describes the efficiencies commonly achieved by major types of control devices in current use and describes how to estimate emission reductions using control systems.

In order to determine removal efficiencies of HAPs from the air stream, it is necessary to know the nature of the HAPs involved, including such parameters as particle size, volatility, or combustibility. Control techniques guidelines (CTG) documents have been written for numerous VOC-emitting source categories; some of these documents contain information relevant to the control of HAPs. A list of several CTGs is presented in Table 1.4-1. Information on available CTG documents can also be obtained via the Control Technology Center (CTC) assistance line (see Appendix C). Another source of information on control devices for a particular source is a series of documents collectively referred to as alternative control techniques (ACT) documents. These documents provide background information on controls, but do not provide reasonably available control technology (RACT) analysis information as do the CTGs. A list of available ACT documents is presented in Table 1.4-2.

**TABLE 1.4-1**  
**CONTROL TECHNIQUES GUIDELINES DOCUMENTS**  
**(GROUPS I, II, III)**

<b>Source Description</b>	<b>EPA Report Number</b>	<b>NTIS Report Number</b>	<b>Date of Publication</b>
Surface Coating Operations	450/2-76-028	PB-260 386	1976
Coating of Cans, Coils, Paper, Fabrics, Automobiles, and Light-Duty Trucks	450/2-77-008	PB-272 445	1977
Surface Coating of Metal Furniture	450/2-77-032	PB-278-257	1977
Surface Coating of Insulation of Magnet Wire	450/2-77-033	PB-278-258	1977
Surface Coating of Large Appliances	450/2-78-034	PB-278-259	1978
Surface Coating of Miscellaneous Metal Parts and Products	450/2-78-015	PB-286-157	1978
Factory Surface Coating of Flat Wood Paneling	450/2-78-032	PB-292-490	1978
Graphic Arts - Rotogravure and Flexography	450/2-78-033	PB-292-490	1978
Bulk Gasoline Plants	450/2-77-035	PB-276-722	1977
Storage of Petroleum Liquids in Fixed Roof Tanks	450/2-77-036	PB-276-749	1977
Refinery Vacuum Producing Systems, Wastewater Separators, and Process Unit Turnarounds	450/2-77-025	PB-275-662	1977

TABLE 1.4-1

(CONTINUED)

Source Description	EPA Report Number	NTIS Report Number	Date of Publication
Use of Cutback Asphalt	450/2-77-037	PB-278-185	1977
Tank Truck Gasoline Loading Terminals	450/2-77-026	PB-275-060	1977
Design Criteria for Stage I Vapor Control Systems-Gasoline Service Stations	--	--	1975
Control of Volatile Organic Compound Leaks from Petroleum Refinery Equipment	450/78-036	PB-286-158	1978
Petroleum Liquid Storage in External Floating Roof Tanks	450/2-78-047	PB-290-579	1978
Perchloroethylene Dry Cleaning Systems	450/2-78-050	PB-290-613	1978
Leaks from Gasoline Tank Trucks and Vapor Collection Systems	450/2-78-051	PB-290-568	1978
Volatile Organic Liquid Storage in Floating and Fixed Roof Tanks	--	--	1993
Large Petroleum Dry Cleaners	450/3-82-009	PB 83-124-875	1982
Synthetic Organic Chemical Polymer and Resin Manufacturing Equipment	450/3-83-006	PB-84-161-520	1984

TABLE 1.4-1

(CONTINUED)

<b>Source Description</b>	<b>EPA Report Number</b>	<b>NTIS Report Number</b>	<b>Date of Publication</b>
Equipment Leaks from Natural Gas/Gasoline Processing Plants	450/3-83-007	PB-84-161-520	1983
Solvent Metal Cleaning	450/2-77-022	PB-274-557	1977
Manufacture of Synthesized Pharmaceutical Products	450/2-78-029	PB-290-580	1978
Manufacture of Pneumatic Rubber Tires	450/2-78-030	PB-290-557	1978
Control Techniques for Volatile Organic Emissions from Stationary Sources	450/2-78-022	PB-284-804	1978
Air Oxidation Processes in Synthetic Organic Chemical Manufacturing Industry	450/3-84-015	PB-85-164-275	1984
Manufacture of High-Density Polyethylene, Polypropylene, and Polystyrene Resins	450/3-83-008	PB-84-134-600	1983
Fugitive Emissions Sources of Organic Compounds - Additional Information on Emissions, Emissions Reductions, and Costs	450/3-82-010	PB-82-217-126	1982



**TABLE 1.4-2**  
**ALTERNATIVE CONTROL TECHNIQUES DOCUMENTS**

<b>Source Description</b>	<b>EPA Report Number</b>	<b>NTIS Report Number</b>	<b>Date of Publication</b>
Halogenated Solvent	450/3-89-030	PB 90-103268	1989
Reduction of Volatile Organic Compound Emissions from the Application of Traffic Markings	450/3-88-007	PB 89-148274	1988
Ethylene Oxide Sterilization/Fumigation Operations	450/3-89-007	PB 90-131434	1989
Reduction of Volatile Organic Compound Emissions from Automobile Refinishing	450/3-88-009	PB 89-148282	
Organic Waste Process Vents	450/3-91-007	PB 91-148270	1990
Industrial Wastewater Volatile Organic Compound Emissions-Background Information for BACT/LAER Determinations	450/3-90-004	PB 90-194754	1990
Polystyrene Foam Manufacturing	450/3-90-020	PB 91-102111	1990

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# 5

## DATA COLLECTION

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This section describes effective procedures for obtaining data for emissions inventories. Questionnaires, plant inspections, and agency air pollution files are some of the methods that are useful in collecting emissions data as well as source activity and control data. Selection of the appropriate method of data collection should include consideration of the desired level of detail of the inventory.

### 5.1 LEVEL OF DETAIL

Point sources can be inventoried at three levels of detail: (1) the plant level, which denotes a plant or facility that could contain several pollutant-emitting activities; (2) the point/stack level, where emissions to the ambient air from stacks, vents, or other points of emission are characterized; and (3) the process/segment level, representing the unit operations of specific source categories. A discussion of these three levels follows and includes the minimum information that will be needed for the inventory regardless of the method selected for collecting the data.

#### 5.1.1 PLANT LEVEL

In a plant-level survey, each plant within the area should be identified and assigned a plant number. The plant should be further identified by geographic descriptors such as nonattainment area, state, county, city, street and/or mailing address, and UTM grid coordinates (or latitude/longitude). A plant contact should also be identified to facilitate communication and interaction with the plant. Additional information gathered regarding the facility should include annual fuel consumption, process throughput, hours of operation, number of employees, and the plant's standard industrial classification (SIC) code. The SIC codes are prepared and published by the U.S. Office of Management and Budget (OMB). A facility can have more than one SIC code denoting the secondary economic activities of the facility.

#### 5.1.2 POINT/STACK LEVEL

In an inventory conducted at the point/stack level, each stack, vent, or other release point that meets or exceeds a specified minimum emission rate should be identified as an emission point. Information obtained at the point/stack level is used in application of mathematical models to correlate air pollutant emissions with ambient air quality. Thus, in addition to the facility identification, location, and plant contact, release characteristics for each emission point are necessary for establishing a comprehensive inventory and performing evaluations with modeling programs. The necessary emission point parameters include location (latitude/longitude), stack height, stack diameter, emission rate, and gas exit velocity.

It is recommended that the location of point sources be reported with a resolution of  $\pm 1$  second at 30 meters. This level of resolution is consistent with existing data specifications in EPA emissions inventory databases. However, such a high degree of precision in specifying location may only be necessary in a limited number of applications

### 5.1.3 PROCESS/SEGMENT LEVEL

A plant may include various processes or operations. Each process can usually be identified by an SCC that is used to enter emissions data into a database management system. The information necessary to establish an inventory at this level includes facility identification; facility location; plant contact; process identification information; point level data; applicable regulations; operating rate data, including actual, maximum, and design operating rate or capacity; fuel use and properties data (e.g., ash content, sulfur content, level of trace elements, heat content, etc.); and identification of all pollution control equipment and its associated control efficiency (measured or design).

## 5.2 AVAILABILITY AND USEFULNESS OF EXISTING DATA

A major inventory planning consideration is whether, and to what extent, existing information can be used. Existing inventories can serve as a starting point for developing extensive data and support information, such as documentation of procedures. Information may also be drawn from other regulatory agency operations such as permitting, compliance, and source inspections and from other facility resources such as corporate reporting or compliance report submittals. For effective use of resources, an agency or facility should plan to fulfill specific emissions inventory requirements by building upon and improving the quality of regularly collected data.

## 5.3 DATA COLLECTION METHODS

For point source inventories, you can obtain information by contacting each point source in the inventory area. The two most common types of plant contacts are:

- Surveys; and
- Plant inspections

You can also use indirect plant contact techniques to gather data for point source inventories, such as examining state files (permit applications and compliance files).

You may need to use a combination of data gathering techniques to ensure complete and accurate data are available for compilation of an inventory. Appropriate method(s) are selected during the planning phase of the inventory process, based on data quality objectives and availability of resources.

### 5.3.1 SURVEYS

You can use the survey technique to obtain source and emissions data, sending a questionnaire to each point source in the inventory area. Figure 1.5-1 shows an example of point source surveying. To conduct a survey you will need to:

- Identify the facilities to be surveyed;
- Prepare the mailing list, including facility addresses and appropriate plant contact personnel;
- Design and assemble the questionnaire;
- Deliver the questionnaire;
- Establish tracking systems to monitor the status of each step in the survey process;
- Prepare data handling procedures; and
- Establish systems to respond to questions or concerns of survey recipients.

While paper questionnaires and return forms are still in use, it is rapidly becoming more common for these forms to be sent to sources, and responses to be returned, in an electronic format. You can send questionnaires to facilities via e-mail, or post them on the Internet. By using standardized electronic forms for data submittal, you can simplify the process for both the surveyed facilities and your agency. Electronic data systems reduce the chance of data entry errors by inventory preparers.

EIIP Volume 3, Chapter 24 provides a detailed description of how to conduct a survey.

### 5.3.2 PLANT INSPECTIONS

Plant inspections give you the opportunity to examine the various processes at a particular facility, interview plant personnel, and review operations and process schematics. While plant inspection is a very resource-intensive data collection technique, it has several advantages over the survey technique:

- Plant inspection provides more complete and accurate information about a facility than a questionnaire;
- Plant inspection allows you to obtain a more complete understanding of an exceptionally complex or unique process;
- Plant inspections reduce errors that can result from misinterpretation of a question by the plant contact responding to the survey; and

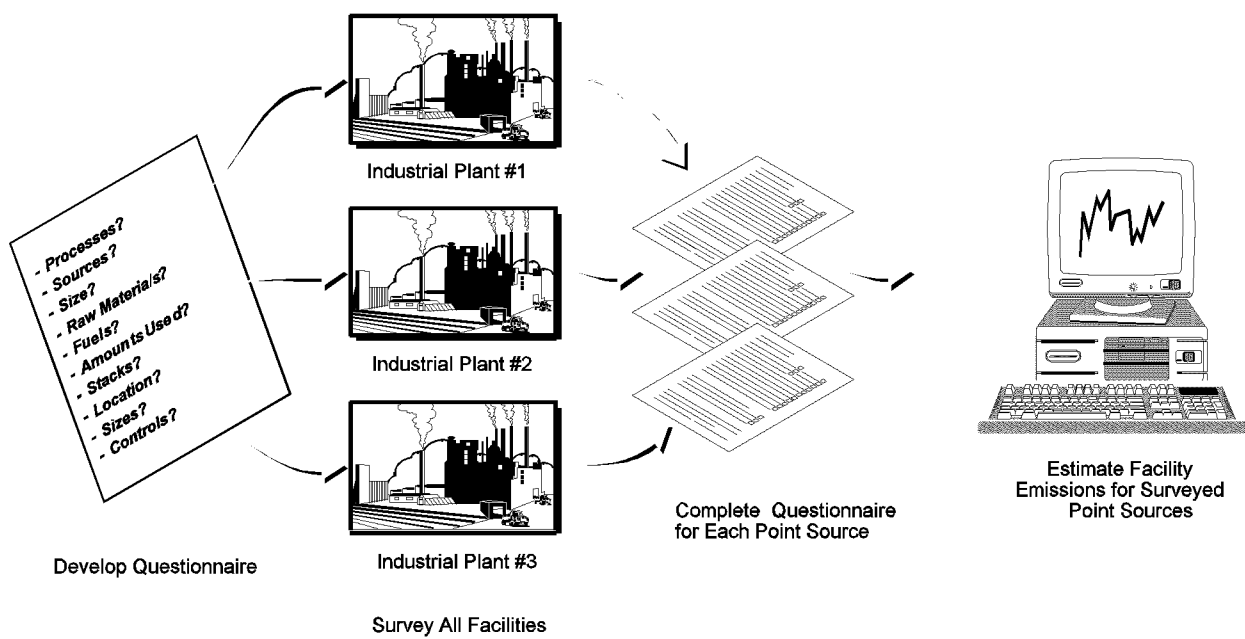


FIGURE 1.5-1. EXAMPLE OF POINT SOURCE SURVEYING

- Plant inspections reduce errors that can result from the inventory agency misinterpreting a response by the plant contact.

### 5.3.3 ACCESSING AGENCY AIR POLLUTION FILES

You can also use files maintained by your state/local agency as sources of information. Files that might include data relevant to emissions inventories include:

- Permit files: Permits are generally required for construction, start-up, modifications, and continuing operation of existing facilities. Permit applications include information that can be useful to describe the nature of the source and to estimate the magnitude of emissions that might result from operations.
- Compliance files: Some agencies also maintain compliance files for point sources. These files contain records of communication concerning enforcement issues, as well as a list of air pollution regulations applicable to the specific source.

### 5.3.4 EMISSIONS ESTIMATES CONDUCTED BY PLANT PERSONNEL

The number and complexity of processes within a given plant, in addition to the difficulty of accessing all the data necessary to complete emission calculations, can make emissions estimation a complex task, with significant opportunity for error. A few general guidelines for conducting overall emissions estimates for a plant are listed below:

- Identify and document the emission sources;
- Identify the types of pollutants and quantify the emissions;
- Compile the source and emissions data into a useable format;
- Design and implement a quality assurance plan; and
- Seek assistance from EPA, state, and local agencies.

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# 6

## INVENTORY REPORTING AND DOCUMENTATION

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Documentation is an integral part of an emissions inventory. The documentation of an inventory compilation process involves two phases: documentation of all data collection and emission estimation activities, and compilation of the inventory into a final written report.

Before submittal, internal review of the written documentation of an inventory's data sources and procedures may uncover errors in assumptions, calculations, or methods. Early correction of these errors will result in a more reliable and technically defensible database, which is essential in some critical aspects of the inventory such as source impact assessments and development of emissions control strategies.

Following submittal of the inventory, the documentation allows the quality of the inventory to be effectively judged. An emissions inventory that is documented according to standardized guidelines enables the receiving agency to review the inventory in a consistent manner. Because it is recognized that some variability is needed to meet the specific needs of each inventory region, standardization is emphasized for the types of data reported, but not the format in which they are reported. Inventories not meeting the minimum data reporting and documentation standards may be deemed unacceptable and returned to the preparer for modification before any further review of technical quality is performed.

The reporting steps of the emissions inventory development process should be anticipated during planning. Planning the level of documentation required will:

- Ensure that important supporting information is properly developed and maintained;
- Allow extraneous information to be identified and discarded, thereby reducing the paperwork burden;
- Help determine data storage requirements; and
- Aid in identifying aspects of the inventory on which to concentrate the QA efforts.

## 6.1 DOCUMENTATION OF DATA COLLECTION AND EMISSION ESTIMATION ACTIVITIES

Documentation of data collection and emission estimation activities includes the daily recordkeeping that occurs during the inventory preparation process. This documentation is critical to both the integrity of the inventory process and the preparation of the final report and includes:

- Complete documentation of methods used for all data collection, including explanation of any deviations from the prescribed methods;
- Explanation of all assumptions made in the data collection or analysis;
- All raw data, including identification of the source of each data point;
- All calculations, including copies of work conducted manually and all electronic spreadsheets or databases;
- Records of all relevant communication with team members and data contacts;
- QA/QC records, including responses to issues identified by audits; and
- Identification of sources of emissions not included in the inventory.

The source and type of the raw data will determine what type of information must be placed in the project file.

<b>If the data were collected from...</b>	<b>Then you must maintain the following records...</b>
Surveys	Original survey forms
Site visits	Site visit notes and reports
Source test reports	Complete copies of the reports
Internet pages	<ul style="list-style-type: none"><li>- Hard copy printouts of the pertinent data</li><li>- Electronic copies of complete original data</li><li>- Complete reference citation</li></ul>
Published document	<ul style="list-style-type: none"><li>- Complete reference citation</li><li>- When possible, copies of the pages with the data used in the inventory</li></ul>

<b>If the data were collected from...</b>	<b>Then you must maintain the following records...</b>
Unpublished documents or reports	<ul style="list-style-type: none"> <li>- Complete reference citation</li> <li>- Copies of all pages with data used in the inventory</li> <li>- When possible, a copy of the entire document</li> </ul>
Personal communication - written	<ul style="list-style-type: none"> <li>- Complete reference citation (contact name, affiliation, address or phone number, data of communication)</li> <li>- Copies of all pages with data used in the inventory</li> <li>- When possible, a copy of the entire document</li> </ul>
Personal communication - verbal	Standardized Contact Report Form should be completed to record information obtained by telephone or at a meeting. An example Contact Report form is presented in EIIP Volume VI, Chapter 2.

## 6.2 REPORTING THE RESULTS OF AN INVENTORY

Written documentation should include summary tables and a report discussing the inventory development procedures and point source results. Large volumes of detailed data should be put into appendices but clearly linked to the text discussion in terms of how they were used to determine emissions.

For inventories prepared by a plant, emissions may be summarized by pollutant, equipment/source, and or stack. For larger inventories prepared by a state or local agency, the presentation maybe more broadly focused by source category and/or county. Graphics may be useful to illustrate the contribution of point sources to areawide emissions.

The appendices should contain the results of all information surveys that have been conducted. All sources inventoried should be listed according to their source category type (e.g., storage tank, process vent, petroleum refinery, graphic arts, degreasing, etc.). All references and other data sources should also be included or, if they are too voluminous, they should be clearly cited in the inventory submittal and kept in a readily accessible location on site.

EPA defined a new data transfer format in order to minimize duplication of data and to enable all users the flexibility of a relational database transfer system. This new format also allows data to be mapped into a variety of alternative database structures. Further, the end use of this system is to consolidate the National Emission Trends (NET) inventory and the National Toxics Inventory (NTI) into one National Emission Inventory (NEI). The NEI Input Format (referred to as NIF), is designed to accommodate the transfer of toxics data. Table 1.6-1 lists the data elements that

TABLE 1.6-1

# DATA REPORTING ELEMENTS FOR THE NATIONAL EMISSION INVENTORY (ANNUAL AND TRIENNIAL)

Data Element	
Record type	Primary percent control efficiency
State Federal Information Processing Standards (FIPS) code	Percent capture efficiency
County FIPS code	Total capture control efficiency
Site ID	Primary device type code
Emission Unit ID	Material/Material I/O
Process ID	Process MACT code
Pollutant code	Process MACT compliance status
Emission Release Point ID	Rule effectiveness
Start Date	Stack height
End Date	Stack diameter
Annual emissions	Exit gas temperature
Emission factor	Exit gas velocity
SCC	Exit gas flow rate
SIC	Emission release point type
NAICS	XY coordinate type
Inventory year	X coordinates (longitude)
Inventory type code	Y coordinates (latitude)
Source type	UTM coordinates
Hours per day (period and average)	Transaction type
Hours per period (period and average)	Transaction creation date
Days per week (period and average)	Facility name

**TABLE 1.6-1**  
**(CONTINUED)**

<b>Data Element</b>	
Weeks per period (period and average)	Facility location (street, city, state, zip code)
Actual throughput	Facility category
Winter throughput (%)	Address type code
Spring throughput (%)	Organization name
Summer throughput (%)	Contact (name, phone number, fax number, email)
Fall throughput (%)	Contact type code
Control status	Secondary control efficiency (triennial only)
Format version of submittal	Design capacity (triennial only)
Incremental submission number	Maximum nameplate capacity (triennial only)

Source: EPA, 2000a.

should be reported for annual and triennial National Emission Inventories for criteria pollutants. This data can be downloaded at [www.epa.gov/ttn/chief/eidocs/index.html](http://www.epa.gov/ttn/chief/eidocs/index.html) for review, or for further explanation of each data element.

Further, the Consolidated Emissions Reporting Rule (CERR) has proposed reporting requirements for Hazardous Air Pollutants (HAPs). This proposed rule requires reporting of HAP emissions for plants emitting at least 10 tons per year of any one HAP, or 25 tons per year of two or more. This rule also proposes submittal of the same data elements as that required for criteria pollutants, and would be included as part of the triennial inventory. Table 1.6-2 shows the data elements that should be reported for (HAPs) inventories.

The term data element refers to any piece of information used in the inventory compilation process. These data element requirements may be modified over time and inventory agencies should contact the EPA Regional office for the most recent list of required data elements. Reports must meet the format and content requirements specified by the regulation or the agency requiring the inventory and should include:

- Introduction describing the purpose for the inventory development;

TABLE 1.6-2

**DATA REPORTING ELEMENTS FOR TOXICS FOR  
INCORPORATION INTO THE  
NATIONAL EMISSION INVENTORY**

<b>Data Element</b>	
State FIPS	Start Date
County FIPS	End Date
Site ID	Emission Release Point ID
Process ID	Emission Numeric Value
Emission Unit ID	Emission Unit Numerator
Pollutant Code	Emission Type
Primary Device Type Code	Control Status
Primary Pct Control Efficiency	Emission Data Level
Percent Capture Efficiency	Process MACT Code
Total Capture Control Efficiency	Process MACT Compliance Status
Stack Height	X Coordinate
Stack Diameter	Y Coordinate
Exit Gas Temperature	UTM Zone
Exit Gas Velocity	XY Coordinate Type
Exit Gas Flow Rate	Record Type
SIC Primary	Facility Category
NAICS Primary	Facility Name
Organization Name	Street Line 1
Transaction Type	City
Inventory Year	State
Inventory Type Code	Zip Code
Format Version	Address Type Code
Transaction Creation Date	Contact Person Name

TABLE 1.6-2

(CONTINUED)

Data Element	
State FIPS	Start Date
Incremental Submission Number	Contact Person Phone Number
Source Type	Contact Person Email Address
Contact Type Code	

- Executive summary of the inventory results;
- Base year of the inventory;
- Geographic area;
- Summary of the emissions data, presented in a matrix format to include pollutant, source, and geographic area;
- Procedures used to collect the data;
- Sources of data, including citations for all emission factors and activity data;
- Methods used to calculate emissions, including example calculations;
- Complete explanation of all assumptions made in the estimation process;
- QA/QC checklists and all audit reports;
- Sample copies of questionnaires, and information concerning the number of questionnaires sent, the number of responses received, methods for extrapolating data to account for nonrespondents, and any assumptions made; and
- Identification of sources of emissions not included in the inventory.

Each EPA Regional Office will determine what information must be submitted as hard copy documentation. Data must be submitted to EPA in an electronic form. Inventory preparers can submit data to EPA using one of several data transfer options. The appropriate data transfer method is identified during the planning stage of the inventory process, based on the end use of the inventory and availability of resources.

Keep in mind that information technology is a rapidly changing field, and electronic reporting of inventory data is an evolving issue. Refer to the EPA Data Submission page at <http://www.epa.gov/ttn/chief/eidocs/index.html#net> for updates on emissions reporting.

Three options are available for data reporting to EPA; refer to Appendix L for a detailed description of these methods. The reporting options are:

- NET Input Format;
- EIIP EDI X12; and
- Direct Source Reporting.

NOTE: The NET Input Format is the preferred option for submitting area source data. You should consult the AIRS/AFS Web site at <http://www.epa.gov/ttn/airs/afs/index.html> for the latest memos and information on the plans to migrate the emissions components of AIRS/AFS to the NET database.

If your agency decides not to use any of these methods, they are still required to submit their data in electronic form. Agencies can make special arrangements with EPA to submit another electronic format, but, because of limited resources, EPA may not be able to enter the data into the EPA system. If an agency does not submit data to EPA in a form it can process, EPA may generate data to represent the emissions from the area.



# 7

## QUALITY ASSURANCE/ QUALITY CONTROL

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The development of a reasonable and comprehensive emissions inventory requires the implementation of quality assurance/quality control (QA/QC) procedures throughout the entire inventory process. The main objective of the QA and QC for emissions inventories is the development of accurate, useful, and reliable data. These procedures should be applied consistently by the state or local agency in preparing or reviewing inventories.

Prior to establishing a quality program or plan, the meaning of quality as it relates to the inventory should be clarified. Quality control is the overall system of routine technical activities that are designed to measure and control the quality of the inventory as it is being developed. Quality assurance is an integrated system or program of activities involving planning, QC, quality assessment, reporting, and quality improvements which are designed to help ensure that the inventory meets the data quality goals or objectives established prior to developing the inventory.

### DQI

DQIs, data quality indicators, are qualitative and quantitative descriptors used to interpret the degree of acceptability or utility of the data. The principal DQIs are:

- Accuracy: The closeness of a measurement to the true value, or the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of error (precision) and systematic error (bias) that are due to sampling and analytical operations;
- Comparability: The degree to which different methods, data sets, or decisions agree or can be represented as similar;
- Completeness: The amount of valid data obtained compared to the planned amount; and
- Representativeness: Degree to which an inventory is representative of the region and sources it is meant to cover.

Refer to EIIP Volume VI for additional information about DQIs.

## DQO

DQOs, data quality objectives, are qualitative and quantitative statements to identify the level of uncertainty that a decision-maker is willing to accept. The purpose of DQOs is to ensure that the final data will be sufficient for the intended use.

DQOs are identified as part of the inventory planning process. They are determined based on the end use of the inventory, but should realistically reflect the limitations resulting from time constraints, resource (staff and funding) limitations, and lack of data. A statement of DQOs should be prepared as part of the inventory preparation plan.

**NOTE: Your task manager is responsible for defining the DQOs for the inventory. Your responsibility as the inventory preparer is to make sure your results meet the agreed upon DQOs.**

The development of a DQO statement is an iterative process. The managers must work together to balance the quality objectives and the available resources. It is important to acknowledge the constraints that limit the ultimate quality of the inventory, especially if the achievable DQOs fall short of the desired DQOs.

Refer to EIIP Volume VI for additional information about DQOs.

## 7.1 QUALITY CONTROL

Quality control is the performance of standardized activities during the course of inventory preparation to ensure data quality. Quality control activities include technical reviews, accuracy checks, and the use of approved standardized procedures for emissions calculations. These internal activities are designed to provide the first level of quality checking and should be included in inventory development planning, data collection, data analysis, emissions calculation, and reporting. Quality control is best implemented through the use of standardized checklists that assess the adequacy of the data and procedures at various intervals in the inventory process. Specifically, QC checklists are used to monitor the following procedures and tasks:

- Data collection;
- Data calculation;
- Emission estimates;
- Data validity;
- Data reasonableness;
- Data completeness;
- Data coding and recording; and

- Data tracking.

The checklist can aid the preparer in finalizing the inventory prior to submittal to a reviewing agency. An example QC checklist for stationary point sources is included in Appendix N. This checklist includes questions concerning completeness (e.g., questions whether all the VOC point sources  $\geq 10$  tpy have been accounted for); use of approved procedures (e.g., questions as to which model was used to estimate wastewater treatment emissions); and reasonableness (e.g., questions whether all stack heights are greater than 50 feet and all stack diameters between 0.5 and 30 feet). For additional information and guidance on applying reasonableness or reality checks to an inventory, please refer to Chapter 3, Volume VI of the EIIP series.

## 7.2 QUALITY ASSURANCE

The keys to the success of a QA/QC program are proper planning and the involvement of QA personnel to help design the QC program. An essential part of proper planning is the specification of the data quality objectives. Much of the data used for inventories are not sufficient to establish quantitative goals. Therefore, qualitative goals must be specified.

Quality assurance activities include helping inventory preparers identify critical phases of the inventory development process that will affect the technical soundness, accuracy, and completeness of the inventory. After identifying these phases of the process, QC procedures are developed to monitor the quality of the data and work to help ensure the generation of an accurate and complete inventory. Other QA activities include the evaluation of the effectiveness of these QC procedures by conducting data and procedural audits at critical phases of the inventory development process.

If quality concerns are found during QA audits, they should be discussed with the personnel involved so that actions can be taken immediately to resolve the issues. The quality concerns, recommendations for corrective actions, and satisfactory aspects of the QC program should be summarized in an audit report. Inventory development personnel are responsible for the resolution of the quality concerns in a timely fashion so that the work progresses as planned and the quality of the data is always being optimized.

Table 1.7-1 lists six important quality goals for inventories and gives general methods for achieving those goals.

## 7.3 QA/QC PROCEDURES FOR SPECIFIC EMISSION ESTIMATION METHODS

### 7.3.1 SOURCE TESTS AND CONTINUOUS EMISSIONS MONITORING (CEM)

The main objective of any QA/QC effort for any program is to independently assess and document the precision, accuracy, and adequacy of data. In an emissions inventory developed from source tests and CEM, the data of interest will be that generated during sampling and analysis. As a first step, a QA Plan should be developed by the team conducting the test prior to

TABLE 1.7-1

# METHODS FOR ACHIEVING EMISSION INVENTORY DATA QUALITY OBJECTIVES

Data Quality Objectives	Methods
Ensure correct implementation of EPA guidance.	<ul style="list-style-type: none"> <li>• Review inventory documentation, comparing actual procedures used to those required.</li> </ul>
Where EPA guidance was not used or unavailable, assess bias by evaluating the reasonableness of the approach used.	<ul style="list-style-type: none"> <li>• Technical review of approach used.</li> <li>• Compare with results from other methods.</li> </ul>
Ensure accuracy of input data.	<ul style="list-style-type: none"> <li>• Check accuracy of transcription of data.</li> <li>• Check any conversion factors used.</li> <li>• Assess validity of assumptions used to calculate input data.</li> <li>• Verify that the data source was current and the best available.</li> </ul>
Ensure accuracy of calculations.	<ul style="list-style-type: none"> <li>• Reconstruct a representative sample (or all) by hand.</li> </ul>
Assess comparability and representativeness of inventory.	<ul style="list-style-type: none"> <li>• Compare emissions to those from similar inventories.</li> <li>• Cross-check activity data by comparing it to surrogates.</li> </ul>
Assess completeness of inventory.	<ul style="list-style-type: none"> <li>• Compare list of source categories or emission points to those listed in EPA guidance.</li> <li>• Cross-check against other published inventories, business directories, etc.</li> </ul>

each specific field test. Next, it is essential to the production of valid test data that the emissions measurement program be performed by qualified personnel using appropriate and properly functioning test equipment. Sampling equipment, such as flow meters and gauges, must be properly calibrated and maintained. Emphasis is placed upon these standard practices as means of ensuring the validity of results. Deviations from standard procedures must be kept to a minimum and applied only when absolutely necessary to obtain representative samples. For compliance testing, deviations from standard procedures may be used only with approval of the regulatory agency. Any changes in methodology must be based on sound engineering judgement and must be thoroughly documented.

Thorough descriptions of stack sampling procedures, source sampling tools and equipment, identification and handling of samples, laboratory analysis, use of the sampling data, and preparation of reports are available in several references, such as the *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III. Stationary Source Specific Methods* (EPA, 1984). This document also contains a detailed discussion of interpretations of CEM data, required accuracy calculations, specific criteria for unacceptable CEM data, and indications that a CEM is out of control.

A systems audit should be conducted on-site as a qualitative review of the various aspects of a total sampling and/or analytical system to assess its overall effectiveness. The systems audit should represent an objective evaluation of each system with respect to strengths, weaknesses, and potential problem areas. The audit provides an evaluation of the adequacy of the overall measurement system(s) to provide data of known quality which are sufficient, in terms of quantity and quality, to meet the program objectives.

Quality control procedures for all instruments used to continuously collect emissions data are identical. The primary control check for precision of the continuous monitors is daily analysis of control standards.

The emission rates of a particular pollutant are a function of a number of stack gas parameters such as concentration and flow rate which are measured during testing. Sensitivity and error analyses illustrate the extent to which the emission estimate may be affected by variability in the measured values. See Volume VI of the EIIP series of guidance documents for additional information on evaluating how the quality of the calculated emission rates are affected by the accuracy of the measurements.

### 7.3.2 MATERIAL BALANCES

The accuracy and reliability of emission values calculated using the material balance approach are related to the quality of material usage and speciation data, and knowledge of the different fate pathways for the material.

The quantity of material used in an operation is often "eye-balled," a procedure that can easily result in an error of as great as 25 percent. This level of uncertainty can be reduced by using a standardized method of measuring quantities such as a gravimetric procedure (e.g., weighing a container before and after using the material) or use of a stick or gauge to measure the level of liquid in a container. For certain applications (e.g., those where very small quantities of materials

are used), it may be more accurate to make these types of measurements monthly or annually, rather than after each application event. Another technique for determining usage quantities would be to use purchase and inventory records.

Uncertainty of emissions using the material balance approach is also related to the quality of material speciation data, which is typically extracted from Material Safety Data Sheets (MSDSs). If speciation data are not available on the MSDS, the material manufacturer should be contacted. Finally, a thorough knowledge of the amount of a material exiting a process through each fate pathway is needed. Typical fate pathways include product, recycle/reuse, solid waste, liquid waste, and air emissions.

### 7.3.3 EMISSION FACTORS

Realizing that site specific test or CEM data are not always available or the most cost effective means for estimating air emissions from a facility, emission factors are often used as an alternative method for calculating emissions. Data used to develop emission factors available in *AP-42* or the FIRE system, for example, are obtained from source tests, material balance studies, and engineering estimates. *AP-42* and FIRE identify any qualifications or limitations of the data. *AP-42* and FIRE emission factors represent the best available information on average emissions from the identified source categories as of the date of factor publication.

Each emission factor published in *AP-42* or FIRE receives a quality rating, which serves as an assessment of the confidence the generator of that value places in the quality of the emission factor. When using existing emission factors, the user should be familiar with the criteria for assigning both data quality ratings and emission factor ratings as described in the document *Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections* (EPA, 1993b).

The data quality ratings for source tests are as follows:

- A-Rated Test - Excellent - The test(s) was performed by a sound methodology and reported in enough detail for adequate validation. These tests are not necessarily EPA reference test methods, although such reference methods are certainly to be used as a guide.
- B-Rated Test - Above Average - The test(s) was performed by a generally sound methodology but lacked enough detail for adequate validation.
- C-Rated Test - Average - The test(s) was based on a nonvalidated or draft methodology or lacked a significant amount of background data.
- D-Rated Test - Below Average - Test(s) was based on a generally unacceptable method but may provide an order-of-magnitude value for the source.

Once the data quality ratings for the source tests are assigned, these ratings along with the number of source tests available for a given emission point are evaluated. Because of the almost impossible task of assigning a meaningful confidence limit to industry-specific variables

(e.g., sample size versus sample population, industry and facility variability, method of measurement), the use of a statistical confidence interval for establishing a representative emission factor for each source category is usually not practical. Therefore, some subjective quality rating is necessary. The following factor quality ratings are used for the emission factors found in *AP-42*, *FIRE*, or any EPA published document:

- A - Excellent - The emission factor was developed only from A-rated test data taken from many randomly chosen facilities in the industry population. The source category is specific enough to minimize variability within the source category population.
- B - Above Average - The emission factor was developed only from A-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As with the A-rating, the source category is specific enough to minimize variability within the source category population.
- C - Average - The emission factor was developed only from A- and B-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As with the A-rating, the source category is specific enough to minimize variability within the source category population.
- D - Below Average - The emission factor was developed only from A- and B-rated test data from a small number of facilities, and there may be reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source category population.
- E - Poor - The emission factor was developed from C- and D-rated test data, and there may be reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability within the source category population.
- U - Unrated or Unratable - The emission factor was developed from suspect data with no supporting documentation to accurately apply an "A" through "E" rating. A "U" rating may be applied in the following circumstances (*FIRE*):
  - U1 - Mass Balance (for example, estimating air emissions based on raw material input, product recovery efficiency, and percent control).
  - U2 - Source test deficiencies (such as inadequate quality assurance/quality control, questionable source test methods, only one source test).
  - U3 - Technology transfer.
  - U4 - Engineering judgement.

U5 - Lack of supporting documentation.

### 7.3.4 MODELING

When a model or other software program is used to calculate emissions, manual verification (by hand) of each type of calculation should be performed. If the calculations are complex and can not be easily reconstructed, an alternative approach is to try to duplicate the results using another calculation method. The input data should also be verified for accuracy. For additional guidance on QA/QC procedures for using models, refer to Chapter 3, *General QA/QC Methods* (EIIP, 1996).

## 7.4 DATA ATTRIBUTE RATING SYSTEM (DARS)

The EPA has developed a Data Attribute Rating System (DARS) to assist in evaluating data associated with emission inventories (Beck, et al., 1994). The system disaggregates emission inventories into emission factors and activity data, then assigns a numerical score to each of these two components. Each score is based on what is known about the factor and activity parameters, such as the specificity to the source category and the measurement or estimation techniques employed. The resulting emission factor and activity data scores are combined to arrive at an overall confidence rating for the inventory.

The DARS defines certain classifying attributes that are believed to influence the accuracy, appropriateness, and reliability of an emission factor or activity and derived emission estimates. This approach is semiquantitative in that it uses numeric scores; however, scoring is based on qualitative and often subjective assessments. The proposed approach, when applied systematically by inventory analysts, can be used to provide a measure of the merits of one emission estimate relative to another.

The DARS provides the means for determining the comparability and transparency of rated inventories. The inventory with the higher overall rating is likely to be a better estimate given the techniques and methodologies employed in its development. Several methods of combining the values are discussed and compared in the paper entitled *A Data Attribute Rating System* (Beck, et al., 1994).



# 8

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# APPENDIX A

## LIST OF HAZARDOUS AIR POLLUTANTS AND ASSOCIATED MACT SOURCE CATEGORIES

[NOTE: These tables include only MACT source categories for which national-level HAP emission estimates have been developed under EPA's National Toxic Inventory Development Program; they do not include all HAP emissions from all MACT sources. Source: U.S. Environmental Protection Agency, 1998. *Baseline Emissions Inventory of HAP Emissions from MACT Sources*. Prepared by the Emission Factor and Inventory Group, Research Triangle Park, North Carolina.]

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## Hazardous Air Pollutants and Their Associated MACT Source Categories

<b>1,1,2,2-Tetrachloroethane (79345)</b>	
Chlorine Production	Portland Cement Manufacturing: Hazardous Waste-fired
Hazardous Waste Incineration	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Medical Waste Incinerators	Secondary Lead Smelting
MON	Sewage Sludge Incineration
Municipal Landfills	Tire Production
Polymers & Resins (Excluding P&R III)	
<b>1,1,2-Trichloroethane (79005)</b>	
Chlorine Production	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Hazardous Waste Incineration	Pulp and Paper Production (non-combustion) MACT I
MON	Steel Foundries
Paper and Other Webs (Surface Coating)	Tire Production
Pharmaceuticals Production	Utilities - Coal
Portland Cement Manufacturing: Hazardous Waste-fired	
<b>1,1-Dimethylhydrazine (57147)</b>	
Chlorine Production	MON
	Polymers & Resins (Excluding P&R III)
<b>1,2,4-Trichlorobenzene (120821)</b>	
Agricultural Chemicals Production	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Chlorine Production	Pulp and Paper Production (non-combustion) MACT I
MON	Semiconductor Manufacturing
Portland Cement Manufacturing: Hazardous Waste-fired	Tire Production
<b>1,2-Dibromo-3-chloropropane (96128)</b>	
Tire Production	
<b>1,2-Epoxybutane (106887)</b>	
Chlorine Production	Polymers & Resins (Excluding P&R III)
Pharmaceuticals Production	
<b>1,2-Propylenimine (2-Methylaziridine) (75558)</b>	
MON	Polymers & Resins (Excluding P&R III)
Pharmaceuticals Production	
<b>1,3-Butadiene (106990)</b>	
Agricultural Chemicals Production	Polymers & Resins (Excluding P&R III)
Chlorine Production	Secondary Lead Smelting
Coke By-Product Plants	Stationary Internal Combustion Engines
MON	Tire Production
<b>1,3-Dichloropropene (542756)</b>	
Agricultural Chemicals Production	Polymers & Resins (Excluding P&R III)

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

Chlorine Production	Secondary Lead Smelting
MON	Utilities - Coal
<b>1,4-Dichlorobenzene (p) (106467)</b>	
Agricultural Chemicals Production	MON
Chlorine Production	Portland Cement Manufacturing: Hazardous Waste-fired
Clay Products Manufacturing	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Friction Products Manufacturing	Sewage Sludge Incineration
Industrial Boilers	Tire Production
<b>1,4-Dioxane (1,4-Diethyleneoxide) (123911)</b>	
Aerospace Industries	Paper and Other Webs (Surface Coating)
Agricultural Chemicals Production	Pharmaceuticals Production
Chlorine Production	Polymers & Resins (Excluding P&R III)
Iron Foundries	Printing/Publishing (Surface Coating)
MON	Tire Production
<b>2,2,4-trimethylpentane (540841)</b>	
Gasoline Distribution (Stage 1)	Petroleum Refineries: Other Sources Not Distinctly Listed
Oil and Natural Gas Production	Tire Production
<b>2,4,5-Trichlorophenol</b>	
Tire Production	
<b>2,4,6-Trichlorophenol (95954)</b>	
Polymers & Resins (Excluding P&R III)	Tire Production
<b>2,4-D (2,4-Dichlorophenoxyacetic Acid) (94757)</b>	
Agricultural Chemicals Production	Polymers & Resins (Excluding P&R III)
MON	
<b>2,4-Dinitrophenol (51285)</b>	
Agricultural Chemicals Production	MON
Coke By-Product Plants	Polymers & Resins (Excluding P&R III)
Industrial Boilers	Steel Foundries
Institutional/Commercial Boilers	Tire Production
<b>2,4-Dinitrotoluene (121142)</b>	
Industrial Boilers	MON
Institutional/Commercial Boilers	Tire Production
	Utilities - Coal
<b>2,4-Toluene Diisocyanate (584849)</b>	
Clay Products Manufacturing	Polymers & Resins (Excluding P&R III)
Flexible Polyurethane Foam Production	Spandex Production
MON	Vegetable Oil Production



### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

Paper and Other Webs (Surface Coating)	
<b>2-Chloroacetophenone (532274)</b>	
Industrial Boilers	Tire Production
Institutional/Commercial Boilers	Utilities - Coal
<b>2-Nitropropane</b>	
MON	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Portland Cement Manufacturing: Hazardous Waste-fired	Printing/Publishing (Surface Coating)
<b>3,3-Dichlorobenzidine (91941)</b>	
MON	Tire Production
<b>3,3-Dimethoxybenzidine (119904)</b>	
Tire Production	
<b>3,3 -Dimethylbenzidine (119934)</b>	
Tire Production	
<b>4,4-Methylenebis(2-chloroaniline) (101144)</b>	
Polymers & Resins (Excluding P&R III)	Tire Production
<b>4,4 -Methylenedianiline (101779)</b>	
Chlorine Production	Polymers & Resins (Excluding P&R III)
MON	Tire Production
<b>4,6-Dinitro-o-cresol (including salts) (534521)</b>	
Agricultural Chemicals Production	Tire Production
MON	
<b>4,4 -Methylenedianiline (101779)</b>	
Agricultural Chemicals Production	MON
Boat Manufacturing	Plywood/Particle Board Manufacturing
Chlorine Production	Polymers & Resins (Excluding P&R III)
Flexible Polyurethane Foam Production	Printing/Publishing (Surface Coating)
Integrated Iron and Steel Manufacturing	Steel Foundries
Iron Foundries	Vegetable Oil Production
Mineral Wool Production	
<b>4-Aminobiphenyl (92671)</b>	
Tire Production	
<b>Dimethylaminoazobenzene (60117)</b>	
Tire Production	
<b>4-Nitrobiphenyl (92933)</b>	
Tire Production	

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

<b>4-Nitrophenol (100027)</b>	
Agricultural Chemicals Production	Institutional/Commercial Boilers
	MON
Industrial Boilers	Tire Production
<b>Acetaldehyde (75070)</b>	
Baker's Yeast Manufacturing	Pulp and Paper Production (combustion) MACT II
Chlorine Production	Pulp and Paper Production (non-combustion) MACT I
Industrial Boilers	Secondary Lead Smelting
Institutional/Commercial Boilers	Sewage Sludge Incineration
MON	Stationary Internal Combustion Engines
Municipal Waste Combustors	Stationary Turbines
Other Biological Incineration	Tire Production
Paper and Other Webs (Surface Coating)	Utilities - Coal
Plywood/Particle Board Manufacturing	Utilities - Oil
Polymers & Resins (Excluding P&R III)	
<b>Acetamide (60355)</b>	
MON	
<b>Acetonitrile (75058)</b>	
Agricultural Chemicals Production	Portland Cement Manufacturing: Hazardous Waste-fired
MON	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Paper and Other Webs (Surface Coating)	Sewage Sludge Incineration
Pharmaceuticals Production	Tire Production
Polymers & Resins (Excluding P&R III)	
<b>Acetophenone (98862)</b>	
Industrial Boilers	Secondary Lead Smelting
Institutional/Commercial Boilers	Tire Production
Pharmaceuticals Production	Utilities - Coal
Pulp and Paper Production (non-combustion) MACT I	
<b>Acrolein (107028)</b>	
Chlorine Production	Pulp and Paper Production (non-combustion) MACT I
Industrial Boilers	Secondary Lead Smelting
Institutional/Commercial Boilers	Stationary Internal Combustion Engines
MON	Tire Production
Polymers & Resins (Excluding P&R III)	Utilities - Coal
<b>Acrylamide (79061)</b>	
MON	Polymers & Resins (Excluding P&R III)

**Hazardous Air Pollutants and Their Associated MACT Source Categories  
(Continued)**

Paper and Other Webs (Surface Coating)	
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### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

<b>Acrylic Acid (79107)</b>	
Agricultural Chemicals Production	Pharmaceuticals Production
Chlorine Production	Polymers & Resins (Excluding P&R III)
MON	Printing/Publishing (Surface Coating)
Paper and Other Webs (Surface Coating)	
<b>Acrylonitrile (107131)</b>	
Acrylic Fibers/Modacrylic Fibers Production	Polymers & Resins (Excluding P&R III)
Agricultural Chemicals Production	Portland Cement Manufacturing: Hazardous Waste-fired
Chlorine Production	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Clay Products Manufacturing	Publicly Owned Treatment Works (POTW) Emissions
MON	Secondary Lead Smelting
Municipal Landfills	Sewage Sludge Incineration
Paper and Other Webs (Surface Coating)	Tire Production
Pharmaceuticals Production	
<b>Allyl Chloride (107051)</b>	
Chlorine Production	Polymers & Resins (Excluding P&R III)
MON	Tire Production
Pharmaceuticals Production	
<b>Aniline (62533)</b>	
Agricultural Chemicals Production	Polymers & Resins (Excluding P&R III)
Chlorine Production	Portland Cement Manufacturing: Hazardous Waste-fired
MON	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Paper and Other Webs (Surface Coating)	Tire Production
Pharmaceuticals Production	
<b>Antimony &amp; Compounds</b>	
Agricultural Chemicals Production	Primary Copper Smelting
Asphalt Roofing Manufacturing	Primary Lead Smelting
Clay Products Manufacturing	Printing/Publishing (Surface Coating)
Coke By-Product Plants	Pulp and Paper Production (combustion) MACT II
Ferroalloys Production	Secondary Aluminum Production
Industrial Boilers	Secondary Lead Smelting
Institutional/Commercial Boilers	Semiconductor Manufacturing
Iron Foundries	Sewage Sludge Incineration
Medical Waste Incinerators	Steel Foundries
MON	Utilities - Coal
Paper and Other Webs (Surface Coating)	Utility Turbines
Polymers & Resins (Excluding P&R III)	

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

<b>Arsenic &amp; Compounds (inorganic including Arsine)</b>	
Aerospace Industries	Primary Copper Smelting
Agricultural Chemicals Production	Primary Lead Smelting
Clay Products Manufacturing	Printing/Publishing (Surface Coating)
Crematories	Pulp and Paper Production (combustion) MACT II
Hazardous Waste Incineration	Secondary Aluminum Production
Industrial Boilers	Secondary Lead Smelting
Institutional/Commercial Boilers	Sewage Sludge Incineration
Iron Foundries	Steel Foundries
Medical Waste Incinerators	Utilities - Coal
MON	Utilities - Natural Gas
Municipal Waste Combustors	Utilities - Oil
Pharmaceuticals Production	Utility Turbines
Plywood/Particle Board Manufacturing	Wool Fiberglass Manufacturing
<b>Asbestos (1332214)</b>	
Asphalt Concrete Manufacturing	Chlorine Production
Asphalt Roofing Manufacturing	Paper and Other Webs (Surface Coating)
<b>Benzene (71432)</b>	
Aerospace Industries	Paper and Other Webs (Surface Coating)
Agricultural Chemicals Production	Petroleum Refineries: Other Sources Not Distinctly Listed
Asphalt Concrete Manufacturing	Pharmaceuticals Production
Asphalt Roofing Manufacturing	Polymers & Resins (Excluding P&R III)
Carbon Black Production	Portland Cement Manufacturing: Hazardous Waste-fired
Chlorine Production	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Clay Products Manufacturing	Printing/Publishing (Surface Coating)
Coke By-Product Plants	Publicly Owned Treatment Works (POTW) Emissions
Coke Ovens: Charging, Top Side, and Door Leaks	Pulp and Paper Production (combustion) MACT II
Coke Ovens: Pushing, Quenching, and Battery Stacks	Pulp and Paper Production (non-combustion) MACT I
Gasoline Distribution (Stage 1)	Secondary Lead Smelting
Hazardous Waste Incineration	Sewage Sludge Incineration
Industrial Boilers	Stationary Internal Combustion Engines
Institutional/Commercial Boilers	Stationary Turbines
Integrated Iron and Steel Manufacturing	Steel Foundries
Iron Foundries	Taconite Iron Ore Processing
Marine Vessel Loading Operations	Tire Production
Medical Waste Incinerators	Utilities - Coal

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

MON	Utilities - Natural Gas
Municipal Landfills	Utilities - Oil
Oil and Natural Gas Production	Utility Turbines
<b>Benzidine (92875)</b>	
Tire Production	
<b>Benzotrichloride (98077)</b>	
Chlorine Production	Pulp and Paper Production (non-combustion) MACT I
MON	Tire Production
<b>Benzyl Chloride (100447)</b>	
Chlorine Production	Pharmaceuticals Production
Industrial Boilers	Polymers & Resins (Excluding P&R III)
Institutional/Commercial Boilers	Tire Production
MON	Utilities - Coal
<b>Beryllium &amp; Compounds</b>	
Clay Products Manufacturing	Pulp and Paper Production (combustion) MACT II
Crematories	Sewage Sludge Incineration
Industrial Boilers	Steel Foundries
Institutional/Commercial Boilers	Utilities - Coal
Medical Waste Incinerators	Utilities - Oil
MON	Utility Boilers - Coke
Municipal Waste Combustors	Utility Turbines
Primary Copper Smelting	
<b>Biphenyl (92524)</b>	
Agricultural Chemicals Production	Pharmaceuticals Production
Carbon Black Production	Polymers & Resins (Excluding P&R III)
Chlorine Production	Rayon Production
Coke By-Product Plants	Secondary Lead Smelting
MON	Steel Foundries
Paper and Other Webs (Surface Coating)	Tire Production
Petroleum Refineries: Other Sources Not Distinctly Listed	Vegetable Oil Production
<b>Bis(2-ethylhexyl)phthalate (117817)</b>	
Agricultural Chemicals Production	Plywood/Particle Board Manufacturing
Asphalt Concrete Manufacturing	Polymers & Resins (Excluding P&R III)
Clay Products Manufacturing	Printing/Publishing (Surface Coating)
Friction Products Manufacturing	Secondary Lead Smelting
Industrial Boilers	Sewage Sludge Incineration

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

Institutional/Commercial Boilers	Tire Production
Paper and Other Webs (Surface Coating)	Utilities - Coal
Pharmaceuticals Production	
<b>Bis(chloromethyl) Ether (542881)</b>	
MON	Polymers & Resins (Excluding P&R III)
<b>Bromoform (75252)</b>	
Industrial Boilers	Tire Production
Institutional/Commercial Boilers	Utilities - Coal
<b>Cadmium &amp; Compounds</b>	
Aerospace Industries	Primary Lead Smelting
Carbon Black Production	Printing/Publishing (Surface Coating)
Clay Products Manufacturing	Pulp and Paper Production (combustion) MACT II
Crematories	Secondary Aluminum Production
Industrial Boilers	Secondary Lead Smelting
Institutional/Commercial Boilers	Sewage Sludge Incineration
Iron Foundries	Stationary Turbines
Medical Waste Incinerators	Steel Foundries
MON	Tire Production
Municipal Waste Combustors	Utilities - Coal
Other Biological Incineration	Utilities - Natural Gas
Paper and Other Webs (Surface Coating)	Utilities - Oil
Polymers & Resins (Excluding P&R III)	Utility Boilers - Coke
Primary Copper Smelting	Utility Turbines
<b>Calcium Cyanamide (156627)</b>	
MON	
<b>Captan (133062)</b>	
Agricultural Chemicals Production	MON
<b>Carbaryl (63252)</b>	
Agricultural Chemicals Production	MON
<b>Carbon Disulfide (75150)</b>	
Agricultural Chemicals Production	Municipal Landfills
Carbon Black Production	Pharmaceuticals Production
Cellophane Production	Polymers & Resins (Excluding P&R III)
Cellulose Food Casing Manufacturing	Portland Cement Manufacturing: Hazardous Waste-fired
Chlorine Production	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Clay Products Manufacturing	Publicly Owned Treatment Works (POTW) Emissions
Coke By-Product Plants	Pulp and Paper Production (non-combustion) MACT I

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

Coke Ovens: Pushing, Quenching, and Battery Stacks	Rayon Production
Friction Products Manufacturing	Secondary Lead Smelting
Industrial Boilers	Steel Foundries
Institutional/Commercial Boilers	Tire Production
MON	Utilities - Coal
<b>Carbon Tetrachloride (56235)</b>	
Agricultural Chemicals Production	Pharmaceuticals Production
Chlorine Production	Polymers & Resins (Excluding P&R III)
Clay Products Manufacturing	Pulp and Paper Production (non-combustion) MACT I
Hazardous Waste Incineration	Sewage Sludge Incineration
Medical Waste Incinerators	Tire Production
MON	Utilities - Coal
Municipal Landfills	
<b>Carbonyl Sulfide (463581)</b>	
Carbon Black Production	Municipal Landfills
Chlorine Production	Polymers & Resins (Excluding P&R III)
Coke By-Product Plants	Primary Aluminum Production
Coke Ovens: Pushing, Quenching, and Battery Stacks	Steel Foundries
MON	Tire Production
<b>Catechol (120809)</b>	
MON	Semiconductor Manufacturing
Paper and Other Webs (Surface Coating)	
<b>Chloramben (133904)</b>	
Agricultural Chemicals Production	
<b>Chlordane (57749)</b>	
MON	
<b>Chlorine (7782505)</b>	
Agricultural Chemicals Production	Plywood/Particle Board Manufacturing
Chlorine Production	Polymers & Resins (Excluding P&R III)
Clay Products Manufacturing	Portland Cement Manufacturing: Hazardous Waste-fired
Coke By-Product Plants	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Ferroalloys Production	Primary Aluminum Production
Industrial Boilers	Primary Copper Smelting
Institutional/Commercial Boilers	Primary Magnesium Refining
Iron Foundries	Printing/Publishing (Surface Coating)
Leather Tanning and Finishing Operations	Pulp and Paper Production (non-combustion) MACT I



### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

Medical Waste Incinerators	Rayon Production
MON	Semiconductor Manufacturing
Paper and Other Webs (Surface Coating)	Steel Foundries
Pharmaceuticals Production	Steel Pickling HCl Process
Phosphate Fertilizers Production	
<b>Chloroacetic Acid (79118)</b>	
MON	Polymers & Resins (Excluding P&R III)
Pharmaceuticals Production	
<b>Chlorobenzene (108907)</b>	
Agricultural Chemicals Production	Polymers & Resins (Excluding P&R III)
Chlorine Production	Portland Cement Manufacturing: Hazardous Waste-fired
Clay Products Manufacturing	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Industrial Boilers	Pulp and Paper Production (non-combustion) MACT I
Institutional/Commercial Boilers	Secondary Lead Smelting
MON	Sewage Sludge Incineration
Municipal Landfills	Steel Foundries
Paper and Other Webs (Surface Coating)	Tire Production
Pharmaceuticals Production	Utilities - Coal
<b>Chloroform (67663)</b>	
Agricultural Chemicals Production	Pharmaceuticals Production
Chlorine Production	Polymers & Resins (Excluding P&R III)
Clay Products Manufacturing	Portland Cement Manufacturing: Hazardous Waste-fired
Hazardous Waste Incineration	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Industrial Boilers	Publicly Owned Treatment Works (POTW) Emissions
Institutional/Commercial Boilers	Pulp and Paper Production (non-combustion) MACT I
Medical Waste Incinerators	Secondary Lead Smelting
MON	Sewage Sludge Incineration
Municipal Landfills	Tire Production
Paper and Other Webs (Surface Coating)	Utilities - Coal
<b>Chloromethyl Methyl Ether (107302)</b>	
MON	Polymers & Resins (Excluding P&R III)
Pharmaceuticals Production	
<b>Chloroprene</b>	
Chlorine Production	Polymers & Resins (Excluding P&R III)
MON	Tire Production
<b>Chromium &amp; Compounds</b>	
Aerospace Industries	Municipal Waste Combustors

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

Agricultural Chemicals Production	Paper and Other Webs (Surface Coating)
Asphalt Roofing Manufacturing	Plywood/Particle Board Manufacturing
Chlorine Production	Polymers & Resins (Excluding P&R III)
Chromic Acid Anodizing	Portland Cement Manufacturing: Hazardous Waste-fired
Chromium Refractories Production	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Clay Products Manufacturing	Primary Aluminum Production
Coke By-Product Plants	Primary Copper Smelting
Crematories	Printing/Publishing (Surface Coating)
Decorative Chromium Electroplating	Pulp and Paper Production (combustion) MACT II
Ferroalloys Production	Secondary Aluminum Production
Friction Products Manufacturing	Secondary Lead Smelting
Hard Chromium Electroplating	Sewage Sludge Incineration
Industrial Boilers	Stationary Turbines
Industrial Process Cooling Towers	Steel Foundries
Institutional/Commercial Boilers	Tire Production
Integrated Iron and Steel Manufacturing	Utilities - Coal
Iron Foundries	Utilities - Natural Gas
Leather Tanning and Finishing Operations	Utilities - Oil
Lime Manufacturing	Utility Boilers - Coke
Medical Waste Incinerators	Utility Turbines
Mineral Wool Production	Wool Fiberglass Manufacturing
MON	
<b>Cobalt Compounds</b>	
Aerospace Industries	Primary Copper Smelting
Clay Products Manufacturing	Printing/Publishing (Surface Coating)
Ferroalloys Production	Pulp and Paper Production (combustion) MACT II
Industrial Boilers	Sewage Sludge Incineration
Institutional/Commercial Boilers	Steel Foundries
Integrated Iron and Steel Manufacturing	Utilities - Coal
Iron Foundries	Utilities - Natural Gas
MON	Utilities - Oil
Paper and Other Webs (Surface Coating)	Utility Turbines
Polymers & Resins (Excluding P&R III)	
<b>Coke Oven Emissions</b>	
Coke Ovens: Charging, Top Side, and Door Leaks	
<b>Cresols (1319773 ) (includes o [95487], m [108394], and p [106445])</b>	

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

Agricultural Chemicals Production	Portland Cement Manufacturing: Hazardous Waste-fired
Chlorine Production	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Coke By-Product Plants	Primary Copper Smelting
MON	Pulp and Paper Production (non-combustion) MACT I
Paper and Other Webs (Surface Coating)	Steel Foundries
Petroleum Refineries: Other Sources Not Distinctly Listed	Tire Production
Polymers & Resins (Excluding P&R III)	Utilities - Coal
<b>Cumene (98828)</b>	
Agricultural Chemicals Production	Polymers & Resins (Excluding P&R III)
Asphalt Concrete Manufacturing	Portland Cement Manufacturing: Hazardous Waste-fired
Chlorine Production	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Gasoline Distribution (Stage 1)	Primary Aluminum Production
Industrial Boilers	Printing/Publishing (Surface Coating)
Institutional/Commercial Boilers	Pulp and Paper Production (non-combustion) MACT I
Iron Foundries	Secondary Lead Smelting
MON	Steel Foundries
Paper and Other Webs (Surface Coating)	Tire Production
Petroleum Refineries: Other Sources Not Distinctly Listed	Utilities - Coal
Pharmaceuticals Production	
<b>Cyanide Compounds</b>	
Agricultural Chemicals Production	MON
Carbon Black Production	Paper and Other Webs (Surface Coating)
Coke By-Product Plants	Pharmaceuticals Production
Ferroalloys Production	Primary Aluminum Production
Industrial Boilers	Printing/Publishing (Surface Coating)
Institutional/Commercial Boilers	Steel Foundries
<b>Dibutyl Phthalate (84742)</b>	
Asphalt Concrete Manufacturing	Portland Cement Manufacturing: Hazardous Waste-fired
Clay Products Manufacturing	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Friction Products Manufacturing	Printing/Publishing (Surface Coating)
MON	Secondary Lead Smelting
Paper and Other Webs (Surface Coating)	Tire Production
Plywood/Particle Board Manufacturing	Utilities - Coal
Polymers & Resins (Excluding P&R III)	
<b>Dichlorethyl Ether (111444)</b>	
Chlorine Production	Tire Production

**Hazardous Air Pollutants and Their Associated MACT Source Categories  
(Continued)**

MON	
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### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

<b>Dichlorvos (62737)</b>	
Agricultural Chemicals Production	Pharmaceuticals Production
MON	
<b>Diethanolamine (111422)</b>	
Agricultural Chemicals Production	Pharmaceuticals Production
Chlorine Production	Polymers & Resins (Excluding P&R III)
Iron Foundries	Portland Cement Manufacturing: Hazardous Waste-fired
MON	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Paper and Other Webs (Surface Coating)	Steel Foundries
<b>Diethyl Sulfate (64675)</b>	
MON	Pharmaceuticals Production
Paper and Other Webs (Surface Coating)	Polymers & Resins (Excluding P&R III)
<b>Dimethyl Phthalate (131113)</b>	
Boat Manufacturing	Pharmaceuticals Production
Clay Products Manufacturing	Polymers & Resins (Excluding P&R III)
MON	Tire Production
<b>Dimethyl Sulfate (77781)</b>	
Agricultural Chemicals Production	MON
Industrial Boilers	Paper and Other Webs (Surface Coating)
Institutional/Commercial Boilers	Pharmaceuticals Production
<b>Dimethylformamide (68122)</b>	
Pharmaceuticals Production	
<b>Dioxin/Furans as 2,3,7,8-TCDD TEQ (1746016)</b>	
Crematories	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Hazardous Waste Incineration	Pulp and Paper Production (combustion) MACT II
Industrial Boilers	Scrap or Waste Tire Incineration
Integrated Iron and Steel Manufacturing	Secondary Aluminum Production
Medical Waste Incinerators	Secondary Lead Smelting
Municipal Waste Combustors	Sewage Sludge Incineration
Other Biological Incineration	Utilities - Coal
Portland Cement Manufacturing: Hazardous Waste-fired	Utilities - Oil
<b>Epichlorohydrin (1-Chloro-2,3-epoxypropane) (106898)</b>	
Asphalt Concrete Manufacturing	Polymers & Resins (Excluding P&R III)
Chlorine Production	Portland Cement Manufacturing: Hazardous Waste-fired
MON	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Pharmaceuticals Production	Tire Production

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

<b>Ethyl Acrylate (140885)</b>	
Chlorine Production	Pharmaceuticals Production
MON	Polymers & Resins (Excluding P&R III)
Paper and Other Webs (Surface Coating)	
<b>Ethyl Carbamate (51796)</b>	
Secondary Lead Smelting	
<b>Ethyl Chloride (75003)</b>	
Chlorine Production	Pharmaceuticals Production
Industrial Boilers	Polycarbonates Production
Institutional/Commercial Boilers	Polymers & Resins (Excluding P&R III)
MON	Tire Production
Municipal Landfills	Utilities - Coal
<b>Ethylbenzene (100414)</b>	
Aerospace Industries	Petroleum Refineries: Other Sources Not Distinctly Listed
Agricultural Chemicals Production	Pharmaceuticals Production
Asphalt Concrete Manufacturing	Plywood/Particle Board Manufacturing
Asphalt Roofing Manufacturing	Polymers & Resins (Excluding P&R III)
Chlorine Production	Portland Cement Manufacturing: Hazardous Waste-fired
Clay Products Manufacturing	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Coke By-Product Plants	Printing/Publishing (Surface Coating)
Friction Products Manufacturing	Publicly Owned Treatment Works (POTW) Emissions
Gasoline Distribution (Stage 1)	Pulp and Paper Production (non-combustion) MACT I
Industrial Boilers	Secondary Lead Smelting
Institutional/Commercial Boilers	Semiconductor Manufacturing
Iron Foundries	Sewage Sludge Incineration
Mineral Wool Production	Steel Foundries
MON	Tire Production
Municipal Landfills	Utilities - Coal
Oil and Natural Gas Production	Utilities - Oil
Paper and Other Webs (Surface Coating)	
<b>Ethylene Dibromide (106934)</b>	
Industrial Boilers	Pharmaceuticals Production
Institutional/Commercial Boilers	Polymers & Resins (Excluding P&R III)
MON	Tire Production
<b>Ethylene Dichloride (75343)</b>	
Agricultural Chemicals Production	Paper and Other Webs (Surface Coating)
Chlorine Production	Pharmaceuticals Production

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

Gasoline Distribution (Stage 1)	Polymers & Resins (Excluding P&R III)
Industrial Boilers	Portland Cement Manufacturing: Hazardous Waste-fired
Institutional/Commercial Boilers	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Medical Waste Incinerators	Pulp and Paper Production (non-combustion) MACT I
MON	Sewage Sludge Incineration
Municipal Landfills	Tire Production
Other Biological Incineration	Utilities - Coal
<b>Ethylene Glycol (107211)</b>	
Agricultural Chemicals Production	Metal Coil (Surface Coating)
Asphalt Concrete Manufacturing	Metal Furniture (Surface Coating)
Asphalt Roofing Manufacturing	Mineral Wool Production
Auto and Light Duty Truck (Surface Coating)	Miscellaneous Metal Parts and Products (Surface Coating)
Carbon Black Production	MON
Chlorine Production	Paper and Other Webs (Surface Coating)
Chromium Refractories Production	Pharmaceuticals Production
Clay Products Manufacturing	Plywood/Particle Board Manufacturing
Coke By-Product Plants	Polymers & Resins (Excluding P&R III)
Ferroalloys Production	Portland Cement Manufacturing: Hazardous Waste-fired
Flat Wood Paneling (Surface Coating)	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Friction Products Manufacturing	Primary Aluminum Production
Integrated Iron and Steel Manufacturing	Printing/Publishing (Surface Coating)
Iron Foundries	Rayon Production
Large Appliance (Surface Coating)	Semiconductor Manufacturing
Metal Can (Surface Coating)	Steel Foundries
<b>Ethylene Oxide (75218)</b>	
Agricultural Chemicals Production	Paper and Other Webs (Surface Coating)
Chlorine Production	Pharmaceuticals Production
Commercial Sterilization Facilities	Polyether Polyols Production
MON	Polymers & Resins (Excluding P&R III)
<b>Ethylidene Dichloride (75343)</b>	
Municipal Landfills	Tire Production
<b>Formaldehyde (50000)</b>	
Aerospace Industries	Polymers and Resins III
Agricultural Chemicals Production	Portland Cement Manufacturing: Hazardous Waste-fired
Asphalt Roofing Manufacturing	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Chlorine Production	Printing/Publishing (Surface Coating)
Chromium Refractories Production	Pulp and Paper Production (combustion) MACT II

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

Crematories	Pulp and Paper Production (non-combustion) MACT I
Friction Products Manufacturing	Secondary Aluminum Production
Industrial Boilers	Secondary Lead Smelting
Institutional/Commercial Boilers	Sewage Sludge Incineration
Iron Foundries	Stationary Internal Combustion Engines
Leather Tanning and Finishing Operations	Stationary Turbines
Medical Waste Incinerators	Steel Foundries
Mineral Wool Production	Taconite Iron Ore Processing
MON	Utilities - Coal
Municipal Waste Combustors	Utilities - Natural Gas
Paper and Other Webs (Surface Coating)	Utilities - Oil
Pharmaceuticals Production	Utility Turbines
Plywood/Particle Board Manufacturing	Wool Fiberglass Manufacturing
Polymers & Resins (Excluding P&R III)	
<b>Glycol Ethers</b>	
Aerospace Industries	MON
Agricultural Chemicals Production	Paper and Other Webs (Surface Coating)
Asphalt Roofing Manufacturing	Pharmaceuticals Production
Auto and Light Duty Truck (Surface Coating)	Plywood/Particle Board Manufacturing
Chlorine Production	Polymers & Resins (Excluding P&R III)
Clay Products Manufacturing	Portland Cement Manufacturing: Hazardous Waste-fired
Coke By-Product Plants	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Flat Wood Paneling (Surface Coating)	Primary Aluminum Production
Friction Products Manufacturing	Printing/Publishing (Surface Coating)
Iron Foundries	Publicly Owned Treatment Works (POTW) Emissions
Large Appliance (Surface Coating)	Rayon Production
Leather Tanning and Finishing Operations	Semiconductor Manufacturing
Metal Can (Surface Coating)	Shipbuilding and Ship Repair (Surface Coating)
Metal Coil (Surface Coating)	Steel Foundries
Metal Furniture (Surface Coating)	Wood Furniture (Surface Coating)
Miscellaneous Metal Parts and Products (Surface Coating)	
<b>Heptachlor (76448)</b>	
MON	
<b>Hexachlorobenzene (118741)</b>	
Agricultural Chemicals Production	Tire Production
MON	Utilities - Coal



### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

<b>Hexachlorobutadiene (87683)</b>	
Chlorine Production	Tire Production
MON	
<b>Hexachlorocyclopentadiene (77474)</b>	
Agricultural Chemicals Production	MON
Chlorine Production	Tire Production
<b>Hexachloroethane (67721)</b>	
Agricultural Chemicals Production	MON
Chlorine Production	Tire Production
<b>Hexane (110543)</b>	
Aerospace Industries	Petroleum Refineries: Other Sources Not Distinctly Listed
Gasoline Distribution (Stage 1)	Pharmaceuticals Production
Industrial Boilers	Polyether Polyols Production
Institutional/Commercial Boilers	Pulp and Paper Production (non-combustion) MACT I
Marine Vessel Loading Operations	Secondary Lead Smelting
Municipal Landfills	Tire Production
Oil and Natural Gas Production	Utilities - Coal
<b>Hydrazine (302012)</b>	
Agricultural Chemicals Production	Pharmaceuticals Production
Chlorine Production	Polymers & Resins (Excluding P&R III)
MON	
<b>Hydrochloric Acid (Hydrogen Chloride [gas only]) (7647010)</b>	
Agricultural Chemicals Production	Phosphate Fertilizers Production
Asphalt Concrete Manufacturing	Plywood/Particle Board Manufacturing
Chlorine Production	Polymers & Resins (Excluding P&R III)
Chromium Refractories Production	Portland Cement Manufacturing: Hazardous Waste-fired
Clay Products Manufacturing	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Coke By-Product Plants	Primary Aluminum Production
Ferroalloys Production	Primary Copper Smelting
Friction Products Manufacturing	Primary Magnesium Refining
Hazardous Waste Incineration	Printing/Publishing (Surface Coating)
Industrial Boilers	Pulp and Paper Production (combustion) MACT II
Integrated Iron and Steel Manufacturing	Pulp and Paper Production (non-combustion) MACT I
Iron Foundries	Secondary Aluminum Production
Leather Tanning and Finishing Operations	Semiconductor Manufacturing
Lime Manufacturing	Sewage Sludge Incineration
Medical Waste Incinerators	Steel Foundries

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

MON	Steel Pickling HCl Process
Municipal Waste Combustors	Utilities - Coal
Paper and Other Webs (Surface Coating)	Utilities - Oil
Pharmaceuticals Production	Vegetable Oil Production
<b>Hydrogen Fluoride (Hydrofluoric Acid) (7664393)</b>	
Agricultural Chemicals Production	Paper and Other Webs (Surface Coating)
Chlorine Production	Phosphate Fertilizers Production
Chromium Refractories Production	Phosphoric Acid Manufacturing
Clay Products Manufacturing	Polymers & Resins (Excluding P&R III)
Ferroalloys Production	Primary Aluminum Production
Friction Products Manufacturing	Secondary Aluminum Production
Hydrogen Fluoride Production	Semiconductor Manufacturing
Integrated Iron and Steel Manufacturing	Steel Foundries
Iron Foundries	Utilities - Coal
Medical Waste Incinerators	Utilities - Oil
MON	
<b>Hydroquinone (123319)</b>	
Chlorine Production	Polymers & Resins (Excluding P&R III)
MON	Semiconductor Manufacturing
Paper and Other Webs (Surface Coating)	Tire Production
<b>Isophorone (78591)</b>	
Clay Products Manufacturing	Tire Production
Industrial Boilers	Utilities - Coal
Institutional/Commercial Boilers	
<b>Lead &amp; Compounds</b>	
Aerospace Industries	Polymers & Resins (Excluding P&R III)
Agricultural Chemicals Production	Portland Cement Manufacturing: Hazardous Waste-fired
Asphalt Concrete Manufacturing	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Auto and Light Duty Truck (Surface Coating)	Primary Aluminum Production
Boat Manufacturing	Primary Copper Smelting
Clay Products Manufacturing	Primary Lead Smelting
Coke By-Product Plants	Printing/Publishing (Surface Coating)
Ferroalloys Production	Pulp and Paper Production (combustion) MACT II
Friction Products Manufacturing	Secondary Aluminum Production
Gasoline Distribution (Stage 1)	Secondary Lead Smelting
Industrial Boilers	Semiconductor Manufacturing

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

Institutional/Commercial Boilers	Sewage Sludge Incineration
Integrated Iron and Steel Manufacturing	Steel Foundries
Iron Foundries	Taconite Iron Ore Processing
Lime Manufacturing	Tire Production
Medical Waste Incinerators	Utilities - Coal
MON	Utilities - Natural Gas
Municipal Waste Combustors	Utilities - Oil
Paper and Other Webs (Surface Coating)	Utility Turbines
Phosphate Fertilizers Production	Wool Fiberglass Manufacturing
<b>Lindane (58899)</b>	
Agricultural Chemicals Production	
<b>Maleic Anhydride (108316)</b>	
Agricultural Chemicals Production	Portland Cement Manufacturing: Hazardous Waste-fired
MON	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Paper and Other Webs (Surface Coating)	Printing/Publishing (Surface Coating)
Pharmaceuticals Production	Vegetable Oil Production
Polymers & Resins (Excluding P&R III)	
<b>Manganese &amp; Compounds</b>	
Agricultural Chemicals Production	Phosphate Fertilizers Production
Boat Manufacturing	Polymers & Resins (Excluding P&R III)
Chlorine Production	Primary Aluminum Production
Clay Products Manufacturing	Primary Copper Smelting
Coke By-Product Plants	Primary Lead Smelting
Ferroalloys Production	Pulp and Paper Production (combustion) MACT II
Friction Products Manufacturing	Secondary Aluminum Production
Industrial Boilers	Secondary Lead Smelting
Institutional/Commercial Boilers	Semiconductor Manufacturing
Integrated Iron and Steel Manufacturing	Sewage Sludge Incineration
Iron Foundries	Stationary Turbines
Medical Waste Incinerators	Steel Foundries
MON	Utilities - Coal
Municipal Waste Combustors	Utilities - Natural Gas
Paper and Other Webs (Surface Coating)	Utilities - Oil
Pharmaceuticals Production	Utility Turbines
<b>Mercury &amp; Compounds</b>	
Aerospace Industries	Portland Cement Manufacturing: Hazardous Waste-fired
Carbon Black Production	Portland Cement Manufacturing: Non-Hazardous Waste-fired

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

Chlorine Production	Primary Copper Smelting
Chromic Acid Anodizing	Primary Lead Smelting
Clay Products Manufacturing	Pulp and Paper Production (combustion) MACT II
Crematories	Secondary Aluminum Production
Hazardous Waste Incineration	Secondary Lead Smelting
Industrial Boilers	Sewage Sludge Incineration
Institutional/Commercial Boilers	Stationary Internal Combustion Engines
Lime Manufacturing	Stationary Turbines
Medical Waste Incinerators	Steel Foundries
MON	Utilities - Coal
Municipal Waste Combustors	Utilities - Natural Gas
Polymers & Resins (Excluding P&R III)	Utilities - Oil
	Utility Turbines
<b>Methanol (67561)</b>	
Aerospace Industries	Plywood/Particle Board Manufacturing
Agricultural Chemicals Production	Polymers & Resins (Excluding P&R III)
Chlorine Production	Polymers and Resins III
Chromium Refractories Production	Portland Cement Manufacturing: Hazardous Waste-fired
Clay Products Manufacturing	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Coke By-Product Plants	Printing/Publishing (Surface Coating)
Friction Products Manufacturing	Publicly Owned Treatment Works (POTW) Emissions
Integrated Iron and Steel Manufacturing	Pulp and Paper Production (combustion) MACT II
Iron Foundries	Pulp and Paper Production (non-combustion) MACT I
Leather Tanning and Finishing Operations	Rayon Production
Mineral Wool Production	Semiconductor Manufacturing
MON	Steel Foundries
Paper and Other Webs (Surface Coating)	Vegetable Oil Production
Pharmaceuticals Production	Wool Fiberglass Manufacturing
Phosphate Fertilizers Production	
<b>Methoxychlor (72435)</b>	
Agricultural Chemicals Production	
<b>Methyl Bromide (Bromomethane) (74839)</b>	
Agricultural Chemicals Production	Paper and Other Webs (Surface Coating)
Clay Products Manufacturing	Polymers & Resins (Excluding P&R III)
Industrial Boilers	Secondary Lead Smelting
Institutional/Commercial Boilers	Tire Production
MON	Utilities - Coal

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

<b>Methyl Chloride (74873)</b>	
Aerospace Industries	Pharmaceuticals Production
Agricultural Chemicals Production	Polymers & Resins (Excluding P&R III)
Chlorine Production	Pulp and Paper Production (non-combustion) MACT I
Clay Products Manufacturing	Secondary Lead Smelting
Industrial Boilers	Tire Production
MON	Utilities - Coal
<b>Methyl Chloroform (1,1,1-Trichloroethane) (71556)</b>	
Aerospace Industries	Municipal Landfills
Agricultural Chemicals Production	Paper and Other Webs (Surface Coating)
Asphalt Concrete Manufacturing	Pharmaceuticals Production
Asphalt Roofing Manufacturing	Phosphate Fertilizers Production
Boat Manufacturing	Plywood/Particle Board Manufacturing
Chlorine Production	Polymers & Resins (Excluding P&R III)
Chromium Refractories Production	Portland Cement Manufacturing: Hazardous Waste-fired
Clay Products Manufacturing	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Ferroalloys Production	Primary Aluminum Production
Friction Products Manufacturing	Primary Copper Smelting
Halogenated Solvent Cleaners	Printing/Publishing (Surface Coating)
Hazardous Waste Incineration	Publicly Owned Treatment Works (POTW) Emissions
Industrial Boilers	Pulp and Paper Production (non-combustion) MACT I
Institutional/Commercial Boilers	Semiconductor Manufacturing
Integrated Iron and Steel Manufacturing	Sewage Sludge Incineration
Iron Foundries	Steel Foundries
Medical Waste Incinerators	Tire Production
Mineral Wool Production	Utilities - Coal
MON	Utilities - Oil
<b>Methyl Ethyl Ketone (2-Butanone) (78933)</b>	
Aerospace Industries	Paper and Other Webs (Surface Coating)
Auto and Light Duty Truck (Surface Coating)	Pharmaceuticals Production
Boat Manufacturing	Plywood/Particle Board Manufacturing
Chlorine Production	Polymers & Resins (Excluding P&R III)
Chromium Refractories Production	Portland Cement Manufacturing: Hazardous Waste-fired
Clay Products Manufacturing	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Flat Wood Paneling (Surface Coating)	Primary Aluminum Production
Friction Products Manufacturing	Printing/Publishing (Surface Coating)
Industrial Boilers	Publicly Owned Treatment Works (POTW) Emissions

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

Institutional/Commercial Boilers	Pulp and Paper Production (combustion) MACT II
Integrated Iron and Steel Manufacturing	Pulp and Paper Production (non-combustion) MACT I
Iron Foundries	Secondary Lead Smelting
Large Appliance (Surface Coating)	Semiconductor Manufacturing
Leather Tanning and Finishing Operations	Sewage Sludge Incineration
Magnetic Tape (Surface Coating)	Shipbuilding and Ship Repair (Surface Coating)
Metal Can (Surface Coating)	Steel Foundries
Metal Coil (Surface Coating)	Tire Production
Metal Furniture (Surface Coating)	Utilities - Coal
Miscellaneous Metal Parts and Products (Surface Coating)	Vegetable Oil Production
MON	Wood Furniture (Surface Coating)
Municipal Landfills	
<b>Methyl Iodide (Iodomethane) (74884)</b>	
Clay Products Manufacturing	Secondary Lead Smelting
MON	Utilities - Coal
Pharmaceuticals Production	
<b>Methyl Isobutyl Ketone (Hexone) (108101)</b>	
Aerospace Industries	Paper and Other Webs (Surface Coating)
Agricultural Chemicals Production	Pharmaceuticals Production
Asphalt Roofing Manufacturing	Phosphate Fertilizers Production
Auto and Light Duty Truck (Surface Coating)	Plywood/Particle Board Manufacturing
Chlorine Production	Polymers & Resins (Excluding P&R III)
Coke By-Product Plants	Portland Cement Manufacturing: Hazardous Waste-fired
Flat Wood Paneling (Surface Coating)	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Friction Products Manufacturing	Primary Aluminum Production
Integrated Iron and Steel Manufacturing	Printing/Publishing (Surface Coating)
Iron Foundries	Publicly Owned Treatment Works (POTW) Emissions
Leather Tanning and Finishing Operations	Pulp and Paper Production (combustion) MACT II
Magnetic Tape (Surface Coating)	Pulp and Paper Production (non-combustion) MACT I
Metal Can (Surface Coating)	Semiconductor Manufacturing
Metal Coil (Surface Coating)	Shipbuilding and Ship Repair (Surface Coating)
Metal Furniture (Surface Coating)	Steel Foundries
Miscellaneous Metal Parts and Products (Surface Coating)	Tire Production
MON	Utilities - Coal
Municipal Landfills	Wood Furniture (Surface Coating)

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

<b>Methyl Isocyanate (624839)</b>	
Agricultural Chemicals Production	MON
Iron Foundries	Plywood/Particle Board Manufacturing
<b>Methyl Methacrylate (80626)</b>	
Agricultural Chemicals Production	Plywood/Particle Board Manufacturing
Boat Manufacturing	Polymers & Resins (Excluding P&R III)
Industrial Boilers	Portland Cement Manufacturing: Hazardous Waste-fired
Institutional/Commercial Boilers	Portland Cement Manufacturing: Non-Hazardous Waste-fired
MON	Utilities - Coal
Paper and Other Webs (Surface Coating)	
<b>Methyl tert-Butyl Ether (1634044)</b>	
Gasoline Distribution (Stage 1)	Pharmaceuticals Production
Industrial Boilers	Polymers & Resins (Excluding P&R III)
Institutional/Commercial Boilers	Tire Production
MON	Utilities - Coal
Petroleum Refineries: Other Sources Not Distinctly Listed	
<b>Methylene Chloride (75092)</b>	
Agricultural Chemicals Production	Plywood/Particle Board Manufacturing
Boat Manufacturing	Polycarbonates Production
Chlorine Production	Polymers & Resins (Excluding P&R III)
Clay Products Manufacturing	Portland Cement Manufacturing: Hazardous Waste-fired
Flexible Polyurethane Foam Fabrication Operations	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Flexible Polyurethane Foam Production	Printing/Publishing (Surface Coating)
Friction Products Manufacturing	Publicly Owned Treatment Works (POTW) Emissions
Halogenated Solvent Cleaners	Pulp and Paper Production (non-combustion) MACT I
Industrial Boilers	Secondary Lead Smelting
Institutional/Commercial Boilers	Semiconductor Manufacturing
Iron Foundries	Sewage Sludge Incineration
Medical Waste Incinerators	Spandex Production
MON	Steel Foundries
Municipal Landfills	Tire Production
Paper and Other Webs (Surface Coating)	Utilities - Coal
Pharmaceuticals Production	Utilities - Oil
<b>Methylhydrazine (60344)</b>	
Industrial Boilers	MON
Institutional/Commercial Boilers	

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

<b>N,N-Dimethylaniline (121697)</b>	
MON	Polymers & Resins (Excluding P&R III)
Paper and Other Webs (Surface Coating)	Tire Production
Pharmaceuticals Production	
<b>N-Nitrosodimethylamine (62759)</b>	
Pharmaceuticals Production	Utilities - Coal
Tire Production	
<b>N-Nitrosomorpholine (59892)</b>	
Tire Production	
<b>Nickel &amp; Compounds</b>	
Aerospace Industries	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Chromium Refractories Production	Primary Aluminum Production
Clay Products Manufacturing	Primary Copper Smelting
Coke By-Product Plants	Primary Lead Smelting
Crematories	Printing/Publishing (Surface Coating)
Ferroalloys Production	Pulp and Paper Production (combustion) MACT II
Friction Products Manufacturing	Secondary Aluminum Production
Industrial Boilers	Secondary Lead Smelting
Institutional/Commercial Boilers	Sewage Sludge Incineration
Integrated Iron and Steel Manufacturing	Stationary Turbines
Iron Foundries	Steel Foundries
Medical Waste Incinerators	Tire Production
MON	Utilities - Coal
Municipal Waste Combustors	Utilities - Natural Gas
Paper and Other Webs (Surface Coating)	Utilities - Oil
Pharmaceuticals Production	Utility Boilers - Coke
Polymers & Resins (Excluding P&R III)	Utility Turbines
Portland Cement Manufacturing: Hazardous Waste-fired	Vegetable Oil Production
<b>Nitrobenzene (98953)</b>	
MON	Portland Cement Manufacturing: Hazardous Waste-fired
Pharmaceuticals Production	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Polymers & Resins (Excluding P&R III)	Tire Production
<b>o-Anisidine (90040)</b>	
MON	Tire Production
<b>o-Toluidine (95534)</b>	
Polymers & Resins (Excluding P&R III)	Tire Production



### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

<b>p-Phenylenediamine (106503)</b>	
MON	Tire Production
Polymers & Resins (Excluding P&R III)	
<b>Parathion (56382)</b>	
Agricultural Chemicals Production	
<b>Pentachloronitrobenzene (Quintobenzene) (82688)</b>	
Agricultural Chemicals Production	Tire Production
MON	
<b>Pentachlorophenol (87865)</b>	
Agricultural Chemicals Production	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Plywood/Particle Board Manufacturing	Tire Production
Portland Cement Manufacturing: Hazardous Waste-fired	Utilities - Coal
<b>Phenol (108952)</b>	
Agricultural Chemicals Production	Polymers & Resins (Excluding P&R III)
Chlorine Production	Polymers and Resins III
Chromium Refractories Production	Portland Cement Manufacturing: Hazardous Waste-fired
Clay Products Manufacturing	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Coke By-Product Plants	Printing/Publishing (Surface Coating)
Friction Products Manufacturing	Pulp and Paper Production (combustion) MACT II
Industrial Boilers	Pulp and Paper Production (non-combustion) MACT I
Institutional/Commercial Boilers	Secondary Lead Smelting
Integrated Iron and Steel Manufacturing	Semiconductor Manufacturing
Iron Foundries	Sewage Sludge Incineration
Lime Manufacturing	Stationary Turbines
Mineral Wool Production	Steel Foundries
MON	Tire Production
Paper and Other Webs (Surface Coating)	Utilities - Coal
Petroleum Refineries: Other Sources Not Distinctly Listed	Utilities - Oil
Pharmaceuticals Production	Wool Fiberglass Manufacturing
Plywood/Particle Board Manufacturing	
<b>Phosgene (75445)</b>	
Agricultural Chemicals Production	Pharmaceuticals Production
Chlorine Production	Polymers & Resins (Excluding P&R III)
MON	

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

<b>Phosphorus (7723140)</b>	
Clay Products Manufacturing	Steel Foundries
Industrial Boilers	Utilities - Coal
MON	Utilities - Natural Gas
Phosphate Fertilizers Production	Utilities - Oil
Sewage Sludge Incineration	Utility Turbines
<b>Phthalic Anhydride (85449)</b>	
MON	Portland Cement Manufacturing: Hazardous Waste-fired
Paper and Other Webs (Surface Coating)	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Pharmaceuticals Production	Printing/Publishing (Surface Coating)
Polymers & Resins (Excluding P&R III)	Utilities - Coal
<b>Polychlorinated Biphenyls (Aroclors) (1336363)</b>	
Hazardous Waste Incineration	Other Biological Incineration
Industrial Boilers	Scrap or Waste Tire Incineration
Medical Waste Incinerators	Sewage Sludge Incineration
Municipal Landfills	Utilities - Oil
Municipal Waste Combustors	
<b>Polycyclic Organic Matter as 16-PAH</b>	
Aerospace Industries	Municipal Waste Combustors
Agricultural Chemicals Production	Paper and Other Webs (Surface Coating)
Asphalt Concrete Manufacturing	Petroleum Refineries Catalytic Cracking (Fluid and other) Units, Catalytic Reforming Units, and Sulfur Plant Units
Asphalt Roofing Manufacturing	Petroleum Refineries: Other Sources Not Distinctly Listed
Carbon Black Production	Pharmaceuticals Production
Chlorine Production	Polymers & Resins (Excluding P&R III)
Clay Products Manufacturing	Portland Cement Manufacturing: Hazardous Waste-fired
Coke By-Product Plants	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Coke Ovens: Charging, Top Side, and Door Leaks	Primary Aluminum Production
Coke Ovens: Pushing, Quenching, and Battery Stacks	Printing/Publishing (Surface Coating)
Crematories	Pulp and Paper Production (combustion) MACT II
Ferroalloys Production	Scrap or Waste Tire Incineration
Friction Products Manufacturing	Secondary Lead Smelting
Gasoline Distribution (Stage 1)	Sewage Sludge Incineration
Hazardous Waste Incineration	Stationary Internal Combustion Engines
Industrial Boilers	Stationary Turbines
Institutional/Commercial Boilers	Steel Foundries

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

Integrated Iron and Steel Manufacturing	Tire Production
Iron Foundries	Utilities - Coal
Medical Waste Incinerators	Utilities - Natural Gas
MON	Utilities - Oil
Municipal Landfills	
<b>Propionaldehyde (123386)</b>	
Chlorine Production	Polymers & Resins (Excluding P&R III)
Industrial Boilers	Pulp and Paper Production (non-combustion) MACT I
Institutional/Commercial Boilers	Secondary Lead Smelting
MON	Utilities - Coal
<b>Propoxur (Baygon) (114261)</b>	
Agricultural Chemicals Production	Polymers & Resins (Excluding P&R III)
<b>Propylene Dichloride (78875)</b>	
Agricultural Chemicals Production	Paper and Other Webs (Surface Coating)
Chlorine Production	Polymers & Resins (Excluding P&R III)
MON	Tire Production
Municipal Landfills	
<b>Propylene Oxide (75569)</b>	
Agricultural Chemicals Production	Polyether Polyols Production
Chlorine Production	Polymers & Resins (Excluding P&R III)
MON	Portland Cement Manufacturing: Hazardous Waste-fired
Paper and Other Webs (Surface Coating)	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Pharmaceuticals Production	Tire Production
<b>Quinoline (91225)</b>	
Coke By-Product Plants	Steel Foundries
MON	Utilities - Coal
Pharmaceuticals Production	
<b>Quinone (p-Benzoquinone) (106514)</b>	
MON	
<b>Selenium Compounds</b>	
Industrial Boilers	Pulp and Paper Production (combustion) MACT II
Institutional/Commercial Boilers	Sewage Sludge Incineration
MON	Steel Foundries
Paper and Other Webs (Surface Coating)	Utilities - Coal
Pharmaceuticals Production	Utilities - Oil
Primary Copper Smelting	Utility Turbines

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

<b>Styrene (100425)</b>	
Agricultural Chemicals Production	Plywood/Particle Board Manufacturing
Asphalt Concrete Manufacturing	Polymers & Resins (Excluding P&R III)
Boat Manufacturing	Portland Cement Manufacturing: Hazardous Waste-fired
Chlorine Production	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Clay Products Manufacturing	Primary Copper Smelting
Coke By-Product Plants	Publicly Owned Treatment Works (POTW) Emissions
Industrial Boilers	Pulp and Paper Production (combustion) MACT II
Institutional/Commercial Boilers	Pulp and Paper Production (non-combustion) MACT I
Iron Foundries	Secondary Lead Smelting
Mineral Wool Production	Steel Foundries
MON	Tire Production
Paper and Other Webs (Surface Coating)	Utilities - Coal
Petroleum Refineries: Other Sources Not Distinctly Listed	
<b>Styrene Oxide (96093)</b>	
MON	
<b>Tetrachloroethylene (127184)</b>	
Aerospace Industries	Pharmaceuticals Production
Agricultural Chemicals Production	Plywood/Particle Board Manufacturing
Chlorine Production	Polymers & Resins (Excluding P&R III)
Clay Products Manufacturing	Portland Cement Manufacturing: Hazardous Waste-fired
Coke By-Product Plants	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Dry Cleaning Facilities	Printing/Publishing (Surface Coating)
Friction Products Manufacturing	Publicly Owned Treatment Works (POTW) Emissions
Halogenated Solvent Cleaners	Pulp and Paper Production (non-combustion) MACT I
Industrial Boilers	Semiconductor Manufacturing
Institutional/Commercial Boilers	Sewage Sludge Incineration
Leather Tanning and Finishing Operations	Steel Foundries
Medical Waste Incinerators	Tire Production
MON	Utilities - Coal
Municipal Landfills	Utilities - Oil
Paper and Other Webs (Surface Coating)	
<b>Titanium Tetrachloride (7550450)</b>	
MON	Polymers & Resins (Excluding P&R III)
<b>Toluene (108883)</b>	
Aerospace Industries	Oil and Natural Gas Production

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

Agricultural Chemicals Production	Paper and Other Webs (Surface Coating)
Asphalt Concrete Manufacturing	Petroleum Refineries: Other Sources Not Distinctly Listed
Asphalt Roofing Manufacturing	Pharmaceuticals Production
Auto and Light Duty Truck (Surface Coating)	Phosphate Fertilizers Production
Boat Manufacturing	Plywood/Particle Board Manufacturing
Cellophane Production	Polyether Polyols Production
Chlorine Production	Polymers & Resins (Excluding P&R III)
Chromium Refractories Production	Portland Cement Manufacturing: Hazardous Waste-fired
Clay Products Manufacturing	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Coke By-Product Plants	Primary Aluminum Production
Coke Ovens: Pushing, Quenching, and Battery Stacks	Printing/Publishing (Surface Coating)
Flat Wood Paneling (Surface Coating)	Publicly Owned Treatment Works (POTW) Emissions
Friction Products Manufacturing	Pulp and Paper Production (combustion) MACT II
Gasoline Distribution (Stage 1)	Pulp and Paper Production (non-combustion) MACT I
Industrial Boilers	Secondary Lead Smelting
Institutional/Commercial Boilers	Semiconductor Manufacturing
Integrated Iron and Steel Manufacturing	Sewage Sludge Incineration
Iron Foundries	Shipbuilding and Ship Repair (Surface Coating)
Large Appliance (Surface Coating)	Spandex Production
Leather Tanning and Finishing Operations	Stationary Internal Combustion Engines
Magnetic Tape (Surface Coating)	Stationary Turbines
Marine Vessel Loading Operations	Steel Foundries
Medical Waste Incinerators	Taconite Iron Ore Processing
Metal Can (Surface Coating)	Tire Production
Metal Coil (Surface Coating)	Utilities - Coal
Metal Furniture (Surface Coating)	Utilities - Natural Gas
Mineral Wool Production	Utilities - Oil
Miscellaneous Metal Parts and Products (Surface Coating)	Vegetable Oil Production
MON	Wood Furniture (Surface Coating)
Municipal Landfills	
<b>Trichloroethylene (79016)</b>	
Aerospace Industries	Plywood/Particle Board Manufacturing
Agricultural Chemicals Production	Polymers & Resins (Excluding P&R III)
Asphalt Roofing Manufacturing	Portland Cement Manufacturing: Hazardous Waste-fired
Chlorine Production	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Clay Products Manufacturing	Printing/Publishing (Surface Coating)

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

Coke By-Product Plants	Publicly Owned Treatment Works (POTW) Emissions
Halogenated Solvent Cleaners	Pulp and Paper Production (non-combustion) MACT I
Integrated Iron and Steel Manufacturing	Secondary Lead Smelting
Iron Foundries	Semiconductor Manufacturing
Medical Waste Incinerators	Sewage Sludge Incineration
MON	Steel Foundries
Municipal Landfills	Tire Production
Paper and Other Webs (Surface Coating)	Utilities - Coal
Pharmaceuticals Production	
<b>Triethylamine (121448)</b>	
Pharmaceuticals Production	
<b>Trifluralin (1582098)</b>	
Agricultural Chemicals Production	Pharmaceuticals Production
MON	Tire Production
<b>Vinyl Acetate (108054)</b>	
Chlorine Production	Polymers & Resins (Excluding P&R III)
Clay Products Manufacturing	Portland Cement Manufacturing: Hazardous Waste-fired
Industrial Boilers	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Institutional/Commercial Boilers	Printing/Publishing (Surface Coating)
Mineral Wool Production	Tire Production
MON	Utilities - Coal
Paper and Other Webs (Surface Coating)	Utilities - Oil
Pharmaceuticals Production	
<b>Vinyl Bromide (593602)</b>	
MON	Polymers & Resins (Excluding P&R III)
<b>Vinyl Chloride (75014)</b>	
Agricultural Chemicals Production	Paper and Other Webs (Surface Coating)
Chlorine Production	Polymers & Resins (Excluding P&R III)
Hazardous Waste Incineration	Sewage Sludge Incineration
MON	Tire Production
Municipal Landfills	
<b>Vinylidene Chloride (75354)</b>	
Chlorine Production	Pharmaceuticals Production
MON	Polymers & Resins (Excluding P&R III)
Municipal Landfills	Tire Production
Paper and Other Webs (Surface Coating)	Utilities - Coal

### Hazardous Air Pollutants and Their Associated MACT Source Categories (Continued)

<b>Xylenes (1330207) (includes o [95476], m [108383], and p [106423])</b>	
Aerospace Industries	Municipal Landfills
Agricultural Chemicals Production	Oil and Natural Gas Production
Asphalt Concrete Manufacturing	Paper and Other Webs (Surface Coating)
Asphalt Roofing Manufacturing	Petroleum Refineries: Other Sources Not Distinctly Listed
Auto and Light Duty Truck (Surface Coating)	Pharmaceuticals Production
Boat Manufacturing	Plywood/Particle Board Manufacturing
Chlorine Production	Polymers & Resins (Excluding P&R III)
Clay Products Manufacturing	Polymers and Resins III
Coke By-Product Plants	Portland Cement Manufacturing: Hazardous Waste-fired
Flat Wood Paneling (Surface Coating)	Portland Cement Manufacturing: Non-Hazardous Waste-fired
Friction Products Manufacturing	Primary Aluminum Production
Gasoline Distribution (Stage 1)	Printing/Publishing (Surface Coating)
Industrial Boilers	Publicly Owned Treatment Works (POTW) Emissions
Institutional/Commercial Boilers	Pulp and Paper Production (combustion) MACT II
Integrated Iron and Steel Manufacturing	Pulp and Paper Production (non-combustion) MACT I
Iron Foundries	Secondary Lead Smelting
Large Appliance (Surface Coating)	Semiconductor Manufacturing
Leather Tanning and Finishing Operations	Sewage Sludge Incineration
Marine Vessel Loading Operations	Shipbuilding and Ship Repair (Surface Coating)
Medical Waste Incinerators	Stationary Internal Combustion Engines
Metal Can (Surface Coating)	Stationary Turbines
Metal Coil (Surface Coating)	Steel Foundries
Metal Furniture (Surface Coating)	Tire Production
Mineral Wool Production	Utilities - Oil
Miscellaneous Metal Parts and Products (Surface Coating)	Vegetable Oil Production
MON	Wood Furniture (Surface Coating)

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# APPENDIX B

## LIST OF MACT SOURCE CATEGORIES AND ASSOCIATED HAZARDOUS AIR POLLUTANTS

[NOTE: These tables include only MACT source categories for which National-level HAP emission estimates have been developed under EPA's National Toxic Inventory Development Program; these do not include all HAP emissions from all MACT sources. Source: U.S. Environmental Protection Agency, 1998. *Baseline Emissions Inventory of HAP Emissions from MACT Sources*. Prepared by the Emission Factor and Inventory Group, Research Triangle Park, North Carolina.]

Source: *Handbook for Air Toxics Emission Inventory Development, Volume I: Stationary Sources, Appendix J*, EPA-454-/B-98-002, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, November 1998.

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## List of MACT Source Categories and Associated Hazardous Air Pollutants

### MACT SOURCE CATEGORY

Acrylic Fibers/Modacrylic Fibers Production  
Acrylonitrile

#### Aerospace Industries

1,4-Dioxane (1,4-Diethyleneoxide)	Glycol Ethers	Methyl Isobutyl Ketone (Hexone)
Arsenic & Compounds (inorganic including Arsine)	Hexane	Nickel & Compounds
Benzene	Lead & Compounds	Polycyclic Organic Matter as 16-PAH
Cadmium & Compounds	Mercury & Compounds	Tetrachloroethylene
Chromium & Compounds	Methanol	Toluene
Cobalt Compounds	Methyl Chloride	Trichloroethylene
Ethylbenzene	Methyl Chloroform (1,1,1-Trichloroethane)	Xylenes (includes o, m, and p)
Formaldehyde	Methyl Ethyl Ketone (2-Butanone)	

#### Agricultural Chemicals Production

1,2,4-Trichlorobenzene	Chlorobenzene	Methanol
1,3-Butadiene	Chloroform	Methoxychlor
1,3-Dichloropropene	Chromium & Compounds	Methyl Bromide (Bromomethane)
1,4-Dichlorobenzene	Cresols (includes o,m,p)	Methyl Chloride
1,4-Dioxane (1,4-Diethyleneoxide)	Cumene	Methyl Chloroform (1,1,1-Trichloroethane)
2,4-D (2,4-Dichlorophenoxyacetic Acid)	Cyanide Compounds	Methyl Isobutyl Ketone (Hexone)
2,4-Dinitrophenol	Dichlorvos	Methyl Isocyanate
4,6-Dinitro-o-cresol (including salts)	Diethanolamine	Methyl Methacrylate
4-4'-Methylenediphenyl Diisocyanate	Dimethyl Sulfate	Methylene Chloride
4-Nitrophenol	Ethylbenzene	Parathion
Acetonitrile	Ethylene Dichloride	Pentachloronitrobenzene (Quintobenzene)
Acrylic Acid	Ethylene Glycol	Pentachlorophenol
Acrylonitrile	Ethylene Oxide	Phenol
Aniline	Formaldehyde	Phosgene
Antimony & Compounds	Glycol Ethers	Polycyclic Organic Matter as 16-PAH
Arsenic & Compounds (inorganic including Arsine)	Hexachlorobenzene	Propoxur (Baygon)
Benzene	Hexachlorocyclopentadiene	Propylene Dichloride
Biphenyl	Hexachloroethane	Propylene Oxide
Bis(2-ethylhexyl)phthalate	Hydrazine	Styrene
Captan	Hydrochloric Acid (Hydrogen Chloride [gas only])	Tetrachloroethylene
Carbaryl	Hydrogen Fluoride (Hydrofluoric Acid)	Toluene
Carbon Disulfide	Lead & Compounds	Trichloroethylene

## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Carbon Tetrachloride	Lindane	Trifluralin
Chloramben	Maleic Anhydride	Vinyl Chloride
Chlorine	Manganese & Compounds	Xylenes (includes o, m, and p)
<b>Asphalt Concrete Manufacturing</b>		
Asbestos	Epichlorohydrin (1-Chloro-2,3-epoxypropane)	Methyl Chloroform (1,1,1-Trichloroethane)
Benzene	Ethylbenzene	Polycyclic Organic Matter as 16-PAH
Bis(2-ethylhexyl)phthalate	Ethylene Glycol	Styrene
Cumene	Hydrochloric Acid (Hydrogen Chloride [gas only])	Toluene
Dibutyl Phthalate	Lead & Compounds	Xylenes (includes o, m, and p)
<b>Asphalt Roofing Manufacturing</b>		
Antimony & Compounds	Ethylene Glycol	Polycyclic Organic Matter as 16-PAH
Asbestos	Formaldehyde	Toluene
Benzene	Glycol Ethers	Trichloroethylene
Chromium & Compounds	Methyl Chloroform (1,1,1-Trichloroethane)	Xylenes (includes o, m, and p)
Ethylbenzene	Methyl Isobutyl Ketone (Hexone)	
<b>Auto and Light Duty Truck (Surface Coating)</b>		
Ethylene Glycol	Methyl Ethyl Ketone (2-Butanone)	Xylenes (includes o, m, and p)
Glycol Ethers	Methyl Isobutyl Ketone (Hexone)	
Lead & Compounds	Toluene	
<b>Baker's Yeast Manufacturing</b>		
Acetaldehyde		
<b>Boat Manufacturing</b>		
4,4'-Methylenediphenyl Diisocyanate	Methyl Chloroform (1,1,1-Trichloroethane)	Styrene
Dimethyl Phthalate	Methyl Ethyl Ketone (2-Butanone)	Toluene
Lead & Compounds	Methyl Methacrylate	Xylenes (includes o, m, and p)
Manganese & Compounds	Methylene Chloride	

## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

### Carbon Black Production

Benzene	Carbon Disulfide	Ethylene Glycol
Biphenyl	Carbonyl Sulfide	Mercury & Compounds
Cadmium & Compounds	Cyanide Compounds	Polycyclic Organic Matter as 16-PAH

### Cellophane Production

Carbon Disulfide	Toluene
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### Cellulose Food Casing Manufacturing

Carbon Disulfide
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### Chlorine Production

1,1,2,2-Tetrachloroethane	Carbonyl Sulfide	Hydrogen Fluoride (Hydrofluoric Acid)
1,1,2-Trichloroethane	Chlorine	Hydroquinone
1,1-Dimethylhydrazine	Chlorobenzene	Manganese & Compounds
1,2,4-Trichlorobenzene	Chloroform	Mercury & Compounds
1,2-Epoxybutane	Chloroprene	Methanol
1,3-Butadiene	Chromium & Compounds	Methyl Chloride
1,3-Dichloropropene	Cresols (includes o,m,p)	Methyl Chloroform (1,1,1-Trichloroethane)
1,4-Dichlorobenzene	Cumene	Methyl Ethyl Ketone (2-Butanone)
1,4-Dioxane (1,4-Diethyleneoxide)	Dichlorethyl Ether	Methyl Isobutyl Ketone (Hexone)
4,4'-Methylenedianiline	Diethanolamine	Methylene Chloride
4,4'-Methylenediphenyl Diisocyanate	Epichlorohydrin (1-Chloro-2,3-epoxypropane)	Phenol
Acetaldehyde	Ethyl Acrylate	Phosgene
Acrolein	Ethyl Chloride	Polycyclic Organic Matter as 16-PAH
Acrylic Acid	Ethylbenzene	Propionaldehyde
Acrylonitrile	Ethylene Dichloride	Propylene Dichloride
Allyl Chloride	Ethylene Glycol	Propylene Oxide
Aniline	Ethylene Oxide	Styrene
Asbestos	Formaldehyde	Tetrachloroethylene
Benzene	Glycol Ethers	Toluene
Benzotrichloride	Hexachlorobutadiene	Trichloroethylene
Benzyl Chloride	Hexachlorocyclopentadiene	Vinyl Acetate
Biphenyl	Hexachloroethane	Vinyl Chloride
Carbon Disulfide	Hydrazine	Vinylidene Chloride
Carbon Tetrachloride	Hydrochloric Acid (Hydrogen Chloride [gas only])	Xylenes (includes o, m, and p)

## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

### Chromic Acid Anodizing

#### Chromium & Compounds

#### Mercury & Compounds

### Chromium Refractories Production

#### Chromium & Compounds

Ethylene Glycol

Formaldehyde

Hydrochloric Acid (Hydrogen Chloride [gas only])

#### Hydrogen Fluoride (Hydrofluoric Acid)

Methanol

Methyl Chloroform (1,1,1-Trichloroethane)

Methyl Ethyl Ketone (2-Butanone)

#### Nickel & Compounds

Phenol

Toluene

### Clay Products Manufacturing

1,4-Dichlorobenzene

2,4-Toluene Diisocyanate

Acrylonitrile

#### Antimony & Compounds

Arsenic &amp; Compounds (inorganic including Arsine)

Benzene

#### Beryllium & Compounds

Bis(2-ethylhexyl)phthalate

#### Cadmium & Compounds

Carbon Disulfide

Carbon Tetrachloride

Chlorine

Chlorobenzene

Chloroform

#### Chromium & Compounds

#### Cobalt Compounds

Dibutyl Phthalate

Dimethyl Phthalate

Ethylbenzene

Ethylene Glycol

Glycol Ethers

Hydrochloric Acid (Hydrogen Chloride [gas only])

Hydrogen Fluoride (Hydrofluoric Acid)

Isophorone

#### Lead & Compounds

#### Manganese & Compounds

#### Mercury & Compounds

Methanol

Methyl Bromide (Bromomethane)

Methyl Chloride

Methyl Chloroform (1,1,1-Trichloroethane)

Methyl Ethyl Ketone (2-Butanone)

Methyl Iodide (Iodomethane)

Methylene Chloride

#### Nickel & Compounds

Phenol

Phosphorus

Polycyclic Organic Matter as 16-PAH

Styrene

Tetrachloroethylene

Toluene

Trichloroethylene

Vinyl Acetate

Xylenes (includes o, m, and p)

### Coke By-Product Plants

1,3-Butadiene

2,4-Dinitrophenol

#### Antimony & Compounds

Benzene

Biphenyl

Carbon Disulfide

#### Cyanide Compounds

Ethylbenzene

Ethylene Glycol

Glycol Ethers

Hydrochloric Acid (Hydrogen Chloride [gas only])

#### Lead & Compounds

Phenol

Polycyclic Organic Matter as 16-PAH

Quinoline

Styrene

Tetrachloroethylene

Toluene

## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Carbonyl Sulfide  
Chlorine

Manganese & Compounds  
Methanol

Trichloroethylene  
Xylenes (includes o, m, and p)

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## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Chromium & Compounds	Methyl Isobutyl Ketone (Hexone)	
Cresols (includes o,m,p)	Nickel & Compounds	
<hr/>		
Coke Ovens: Charging, Top Side, and Door Leaks		
Benzene	Coke Oven Emissions	Polycyclic Organic Matter as 16-PAH
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Coke Ovens: Pushing, Quenching, and Battery Stacks		
Benzene	Carbonyl Sulfide	Toluene
Carbon Disulfide	Polycyclic Organic Matter as 16-PAH	
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Commercial Sterilization Facilities		
Ethylene Oxide		
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Crematories		
Arsenic & Compounds (inorganic including Arsine)	Chromium & Compounds	Mercury & Compounds
Beryllium & Compounds	Dioxin/Furans as 2,3,7,8-TCDD TEQ	Nickel & Compounds
Cadmium & Compounds	Formaldehyde	Polycyclic Organic Matter as 16-PAH
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Decorative Chromium Electroplating		
Chromium & Compounds		
<hr/>		
Dry Cleaning Facilities		
Tetrachloroethylene		
<hr/>		
Ferroalloys Production		
Antimony & Compounds	Ethylene Glycol	Methyl Chloroform (1,1,1-Trichloroethane)
Chlorine	Hydrochloric Acid (Hydrogen Chloride [gas only])	Nickel & Compounds
Chromium & Compounds	Hydrogen Fluoride (Hydrofluoric Acid)	Polycyclic Organic Matter as 16-PAH
Cobalt Compounds	Lead & Compounds	
Cyanide Compounds	Manganese & Compounds	
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## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

### Flat Wood Paneling (Surface Coating)

Ethylene Glycol	Methyl Ethyl Ketone (2-Butanone)	Toluene
Glycol Ethers	Methyl Isobutyl Ketone (Hexone)	Xylenes (includes o, m, and p)

### Flexible Polyurethane Foam Fabrication Operations Methylene Chloride

### Flexible Polyurethane Foam Production

2,4-Toluene Diisocyanate	4-4'-Methylenediphenyl Diisocyanate	Methylene Chloride
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### Friction Products Manufacturing

1,4-Dichlorobenzene	Glycol Ethers	Methyl Isobutyl Ketone (Hexone)
Bis(2-ethylhexyl)phthalate	Hydrochloric Acid (Hydrogen Chloride [gas only])	Methylene Chloride
Carbon Disulfide	Hydrogen Fluoride (Hydrofluoric Acid)	Nickel & Compounds
Chromium & Compounds	Lead & Compounds	Phenol
Dibutyl Phthalate	Manganese & Compounds	Polycyclic Organic Matter as 16-PAH
Ethylbenzene	Methanol	Tetrachloroethylene
Ethylene Glycol	Methyl Chloroform (1,1,1-Trichloroethane)	Toluene
Formaldehyde	Methyl Ethyl Ketone (2-Butanone)	Xylenes (includes o, m, and p)

### Gasoline Distribution (Stage 1)

2,2,4-Trimethylpentane	Ethylene Dichloride	Polycyclic Organic Matter as 16-PAH
Benzene	Hexane	Toluene
Cumene	Lead & Compounds	Xylenes (includes o, m, and p)
Ethylbenzene	Methyl tert-Butyl Ether	

### Halogenated Solvent Cleaners

Methyl Chloroform (1,1,1-Trichloroethane)	Tetrachloroethylene
Methylene Chloride	Trichloroethylene

### Hard Chromium Electroplating

## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

### Chromium & Compounds

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#### Hazardous Waste Incineration

1,1,2,2-Tetrachloroethane	Chloroform	Polychlorinated Biphenyls (Aroclors)
1,1,2-Trichloroethane	Dioxin/Furans as 2,3,7,8-TCDD TEQ	Polycyclic Organic Matter as 16-PAH
Arsenic & Compounds (inorganic including Arsine)	Hydrochloric Acid (Hydrogen Chloride [gas only])	Vinyl Chloride

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## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Benzene	Mercury & Compounds	
Carbon Tetrachloride	Methyl Chloroform (1,1,1-Trichloroethane)	
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Hydrogen Fluoride Production		
Hydrogen Fluoride (Hydrofluoric Acid)		
<hr/>		
Industrial Boilers		
1,4-Dichlorobenzene	Chloroform	Methyl Chloride
2,4-Dinitrophenol	Chromium & Compounds	Methyl Chloroform (1,1,1-Trichloroethane)
2,4-Dinitrotoluene	Cobalt Compounds	Methyl Ethyl Ketone (2-Butanone)
2-Chloroacetophenone	Cumene	Methyl Methacrylate
4-Nitrophenol	Cyanide Compounds	Methyl tert-Butyl Ether
Acetaldehyde	Dimethyl Sulfate	Methylene Chloride
Acetophenone	Dioxin/Furans as 2,3,7,8-TCDD TEQ	Methylhydrazine
Acrolein	Ethyl Chloride	Nickel & Compounds
Antimony & Compounds	Ethylbenzene	Phenol
Arsenic & Compounds (inorganic including Arsine)	Ethylene Dibromide	Phosphorus
Benzene	Ethylene Dichloride	Polychlorinated Biphenyls (Aroclors)
Benzyl Chloride	Formaldehyde	Polycyclic Organic Matter as 16-PAH
Beryllium & Compounds	Hexane	Propionaldehyde
Bis(2-ethylhexyl)phthalate	Hydrochloric Acid (Hydrogen Chloride [gas only])	Selenium Compounds
Bromoform	Isophorone	Styrene
Cadmium & Compounds	Lead & Compounds	Tetrachloroethylene
Carbon Disulfide	Manganese & Compounds	Toluene
Chlorine	Mercury & Compounds	Vinyl Acetate
Chlorobenzene	Methyl Bromide (Bromomethane)	Xylenes (includes o, m, and p)
<hr/>		
Industrial Process Cooling Towers		
Chromium & Compounds		
<hr/>		
Institutional/Commercial Boilers		
2,4-Dinitrophenol	Chloroform	Methyl Ethyl Ketone (2-Butanone)
2,4-Dinitrotoluene	Chromium & Compounds	Methyl Methacrylate
2-Chloroacetophenone	Cobalt Compounds	Methyl tert-Butyl Ether
4-Nitrophenol	Cumene	Methylene Chloride

## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Acetaldehyde	Cyanide Compounds	Methylhydrazine
Acetophenone	Dimethyl Sulfate	Nickel & Compounds
Acrolein	Ethyl Chloride	Phenol
	Ethylbenzene	Polycyclic Organic Matter as 16-PAH
Antimony & Compounds		
Arsenic & Compounds (inorganic including Arsine)	Ethylene Dibromide	Propionaldehyde
Benzene	Ethylene Dichloride	Selenium Compounds
Benzyl Chloride	Formaldehyde	Styrene
Beryllium & Compounds	Hexane	Tetrachloroethylene
Bis(2-ethylhexyl)phthalate	Isophorone	Toluene
Bromoform	Lead & Compounds	Vinyl Acetate
Cadmium & Compounds	Manganese & Compounds	Xylenes (includes o, m, and p)
Carbon Disulfide	Mercury & Compounds	
Chlorine	Methyl Bromide (Bromomethane)	
Chlorobenzene	Methyl Chloroform (1,1,1-Trichloroethane)	
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Integrated Iron and Steel Manufacturing		
4-4'-Methylenediphenyl Diisocyanate	Hydrogen Fluoride (Hydrofluoric Acid)	Nickel & Compounds
Benzene	Lead & Compounds	Phenol
Chromium & Compounds	Manganese & Compounds	Polycyclic Organic Matter as 16-PAH
Cobalt Compounds	Methanol	Toluene
Dioxin/Furans as 2,3,7,8-TCDD TEQ	Methyl Chloroform (1,1,1-Trichloroethane)	Trichloroethylene
Ethylene Glycol	Methyl Ethyl Ketone (2-Butanone)	Xylenes (includes o, m, and p)
Hydrochloric Acid (Hydrogen Chloride [gas only])	Methyl Isobutyl Ketone (Hexone)	
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Iron Foundries		
1,4-Dioxane (1,4-Diethyleneoxide)	Ethylbenzene	Methyl Isobutyl Ketone (Hexone)
4-4'-Methylenediphenyl Diisocyanate	Ethylene Glycol	Methyl Isocyanate
Antimony & Compounds	Formaldehyde	Methylene Chloride
Arsenic & Compounds (inorganic including Arsine)	Glycol Ethers	Nickel & Compounds
Benzene	Hydrochloric Acid (Hydrogen Chloride [gas only])	Phenol
Cadmium & Compounds	Hydrogen Fluoride (Hydrofluoric Acid)	Polycyclic Organic Matter as 16-PAH
Chlorine	Lead & Compounds	Styrene
Chromium & Compounds	Manganese & Compounds	Toluene
Cobalt Compounds	Methanol	Trichloroethylene
Cumene	Methyl Chloroform (1,1,1-Trichloroethane)	Xylenes (includes o, m, and p)
Diethanolamine	Methyl Ethyl Ketone (2-Butanone)	

## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

### Large Appliance (Surface Coating)

Ethylene Glycol	Methyl Ethyl Ketone (2-Butanone)	Xylenes (includes o, m, and p)
Glycol Ethers	Toluene	

### Leather Tanning and Finishing Operations

Chlorine	Hydrochloric Acid (Hydrogen Chloride [gas only])	Tetrachloroethylene
Chromium & Compounds	Methanol	Toluene
Formaldehyde	Methyl Ethyl Ketone (2-Butanone)	Xylenes (includes o, m, and p)
Glycol Ethers	Methyl Isobutyl Ketone (Hexone)	

### Lime Manufacturing

Chromium & Compounds	Lead & Compounds	Phenol
Hydrochloric Acid (Hydrogen Chloride [gas only])	Mercury & Compounds	

### Magnetic Tape (Surface Coating)

Methyl Ethyl Ketone (2-Butanone)	Methyl Isobutyl Ketone (Hexone)	Toluene
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### Marine Vessel Loading Operations

Benzene	Toluene
Hexane	Xylenes (includes o, m, and p)

### Medical Waste Incinerators

1,1,2,2-Tetrachloroethane	Chromium & Compounds	Methyl Chloroform (1,1,1-Trichloroethane)
Antimony & Compounds	Dioxin/Furans as 2,3,7,8-TCDD TEQ	Methylene Chloride
Arsenic & Compounds (inorganic including Arsine)	Ethylene Dichloride	Nickel & Compounds
Benzene	Formaldehyde	Polychlorinated Biphenyls (Aroclors)
Beryllium & Compounds	Hydrochloric Acid (Hydrogen Chloride [gas only])	Polycyclic Organic Matter as 16-PAH
Cadmium & Compounds	Hydrogen Fluoride (Hydrofluoric Acid)	Tetrachloroethylene
Carbon Tetrachloride	Lead & Compounds	Toluene
Chlorine	Manganese & Compounds	Trichloroethylene
Chloroform	Mercury & Compounds	Xylenes (includes o, m, and p)

### Metal Can (Surface Coating)

## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Ethylene Glycol Glycol Ethers	Methyl Ethyl Ketone (2-Butanone) Methyl Isobutyl Ketone (Hexone)	Toluene Xylenes (includes o, m, and p)
Metal Coil (Surface Coating) Ethylene Glycol Glycol Ethers	Methyl Ethyl Ketone (2-Butanone) Methyl Isobutyl Ketone (Hexone)	Toluene Xylenes (includes o, m, and p)
Metal Furniture (Surface Coating) Ethylene Glycol Glycol Ethers	Methyl Ethyl Ketone (2-Butanone) Methyl Isobutyl Ketone (Hexone)	Toluene Xylenes (includes o, m, and p)
Mineral Wool Production 4,4'-Methylenediphenyl Diisocyanate Chromium & Compounds Ethylbenzene Ethylene Glycol	Formaldehyde Methanol Methyl Chloroform (1,1,1-Trichloroethane) Phenol	Styrene Toluene Vinyl Acetate Xylenes (includes o, m, and p)
Miscellaneous Metal Parts and Products (Surface Coating) Ethylene Glycol Glycol Ethers	Methyl Ethyl Ketone (2-Butanone) Methyl Isobutyl Ketone (Hexone)	Toluene Xylenes (includes o, m, and p)
MON 1,1,2,2-Tetrachloroethane 1,1,2-Trichloroethane 1,1-Dimethylhydrazine 1,2,4-Trichlorobenzene 1,2-Propylenimine (2-Methylaziridine) 1,3-Butadiene 1,3-Dichloropropene 1,4-Dichlorobenzene 1,4-Dioxane (1,4-Diethyleneoxide) 2,4-D (2,4-Dichlorophenoxyacetic Acid) 2,4-Dinitrophenol 2,4-Dinitrotoluene	Catechol Chlordane Chlorine Chloroacetic Acid Chlorobenzene Chloroform Chloromethyl Methyl Ether Chloroprene Chromium & Compounds Cobalt Compounds Cresols (includes o,m,p) Cumene	Methanol Methyl Bromide (Bromomethane) Methyl Chloride Methyl Chloroform (1,1,1-Trichloroethane) Methyl Ethyl Ketone (2-Butanone) Methyl Iodide (Iodomethane) Methyl Isobutyl Ketone (Hexone) Methyl Isocyanate Methyl Methacrylate Methyl tert-Butyl Ether Methylene Chloride Methylhydrazine

### **List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)**

2,4-Toluene Diisocyanate	Cyanide Compounds	N,N-Dimethylaniline
2-Nitropropane	Dibutyl Phthalate	Nickel & Compounds
3,3'-Dichlorobenzidene	Dichlorethyl Ether	Nitrobenzene
4,4'-Methylenedianiline	Dichlorvos	o-Anisidine
4,6-Dinitro-o-cresol (including salts)	Diethanolamine	p-Phenylenediamine
4,4'-Methylenediphenyl Diisocyanate	Diethyl Sulfate	Pentachloronitrobenzene (Quintobenzene)
4-Nitrophenol	Dimethyl Phthalate	Phenol

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# List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

5/31/01

CHAPTER 1 - INTRODUCTION

Acetaldehyde	Dimethyl Sulfate	Phosgene
Acetamide	Epichlorohydrin (1-Chloro-2,3-epoxypropane)	Phosphorus
Acetonitrile	Ethyl Acrylate	Phthalic Anhydride
Acrolein	Ethyl Chloride	Polycyclic Organic Matter as 16-PAH
Acrylamide	Ethylbenzene	Propionaldehyde
Acrylic Acid	Ethylene Dibromide	Propylene Dichloride
Acrylonitrile	Ethylene Dichloride	Propylene Oxide
Allyl Chloride	Ethylene Glycol	Quinoline
Aniline	Ethylene Oxide	Quinone (p-Benzoquinone)
Antimony & Compounds	Formaldehyde	Selenium Compounds
Arsenic & Compounds (inorganic including Arsine)	Glycol Ethers	Styrene
Benzene	Heptachlor	Styrene Oxide
Benzotrichloride	Hexachlorobenzene	Tetrachloroethylene
Benzyl Chloride	Hexachlorobutadiene	Titanium Tetrachloride
Beryllium & Compounds	Hexachlorocyclopentadiene	Toluene
Biphenyl	Hexachloroethane	Trichloroethylene
Bis(chloromethyl) Ether	Hydrazine	Trifluralin
Cadmium & Compounds	Hydrochloric Acid (Hydrogen Chloride [gas only])	Vinyl Acetate
Calcium Cyanamide	Hydrogen Fluoride (Hydrofluoric Acid)	Vinyl Bromide
Captan	Hydroquinone	Vinyl Chloride
Carbaryl	Lead & Compounds	Vinylidene Chloride
Carbon Disulfide	Maleic Anhydride	Xylenes (includes o, m, and p)
Carbon Tetrachloride	Manganese & Compounds	
Carbonyl Sulfide	Mercury & Compounds	

## Municipal Landfills

1,1,2,2-Tetrachloroethane	Ethylbenzene	Polycyclic Organic Matter as 16-PAH
Acrylonitrile	Ethylene Dichloride	Propylene Dichloride
Benzene	Ethylidene Dichloride	Tetrachloroethylene
Carbon Disulfide	Hexane	Toluene
Carbon Tetrachloride	Methyl Chloroform (1,1,1-Trichloroethane)	Trichloroethylene
Carbonyl Sulfide	Methyl Ethyl Ketone (2-Butanone)	Vinyl Chloride
Chlorobenzene	Methyl Isobutyl Ketone (Hexone)	Vinylidene Chloride
Chloroform	Methylene Chloride	Xylenes (includes o, m, and p)
Ethyl Chloride	Polychlorinated Biphenyls (Aroclors)	



## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

### Municipal Waste Combustors

Acetaldehyde	Dioxin/Furans as 2,3,7,8-TCDD TEQ	Mercury & Compounds
Arsenic & Compounds (inorganic including Arsine)	Formaldehyde	Nickel & Compounds
Beryllium & Compounds	Hydrochloric Acid (Hydrogen Chloride [gas only])	Polychlorinated Biphenyls (Aroclors)
Cadmium & Compounds	Lead & Compounds	Polycyclic Organic Matter as 16-PAH
Chromium & Compounds	Manganese & Compounds	

### Oil and Natural Gas Production

2,2,4-Trimethylpentane	Ethylbenzene	Toluene
Benzene	Hexane	Xylenes (includes o, m, and p)

### Other Biological Incineration

Acetaldehyde	Dioxin/Furans as 2,3,7,8-TCDD TEQ	Polychlorinated Biphenyls (Aroclors)
Cadmium & Compounds	Ethylene Dichloride	

### Paper and Other Webs (Surface Coating)

1,1,2-Trichloroethane	Cumene	Methyl Ethyl Ketone (2-Butanone)
1,4-Dioxane (1,4-Diethyleneoxide)	Cyanide Compounds	Methyl Isobutyl Ketone (Hexone)
2,4-Toluene Diisocyanate	Dibutyl Phthalate	Methyl Methacrylate
Acetaldehyde	Diethanolamine	Methylene Chloride
Acetonitrile	Diethyl Sulfate	N,N-Dimethylaniline
Acrylamide	Dimethyl Sulfate	Nickel & Compounds
Acrylic Acid	Ethyl Acrylate	Phenol
Acrylonitrile	Ethylbenzene	Phthalic Anhydride
Aniline	Ethylene Dichloride	Polycyclic Organic Matter as 16-PAH
Antimony & Compounds	Ethylene Glycol	Propylene Dichloride
Asbestos	Ethylene Oxide	Propylene Oxide
Benzene	Formaldehyde	Selenium Compounds
Biphenyl	Glycol Ethers	Styrene
Bis(2-ethylhexyl)phthalate	Hydrochloric Acid (Hydrogen Chloride [gas only])	Tetrachloroethylene
Cadmium & Compounds	Hydrogen Fluoride (Hydrofluoric Acid)	Toluene
Catechol	Hydroquinone	Trichloroethylene
Chlorine	Lead & Compounds	Vinyl Acetate
Chlorobenzene	Maleic Anhydride	Vinyl Chloride
Chloroform	Manganese & Compounds	Vinylidene Chloride
Chromium & Compounds	Methanol	Xylenes (includes o, m, and p)

## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Cobalt Compounds	Methyl Bromide (Bromomethane)	
Cresols (includes o,m,p)	Methyl Chloroform (1,1,1-Trichloroethane)	
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Petroleum Refineries Catalytic Cracking (Fluid and other) Units, Catalytic Reforming Units, and Sulfur Plant Units		
Polycyclic Organic Matter as 16-PAH		
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Petroleum Refineries: Other Sources Not Distinctly Listed		
2,2,4-Trimethylpentane	Ethylbenzene	Styrene
Benzene	Hexane	Toluene
Biphenyl	Methyl tert-Butyl Ether	Xylenes (includes o, m, and p)
Cresols (includes o,m,p)	Phenol	
Cumene	Polycyclic Organic Matter as 16-PAH	
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Pharmaceuticals Production		
1,1,2-Trichloroethane	Dichlorvos	Methyl Ethyl Ketone (2-Butanone)
1,2-Epoxybutane	Diethanolamine	Methyl Iodide (Iodomethane)
1,2-Propylenimine (2-Methylaziridine)	Diethyl Sulfate	Methyl Isobutyl Ketone (Hexone)
1,4-Dioxane (1,4-Diethyleneoxide)	Dimethyl Phthalate	Methyl tert-Butyl Ether
Acetonitrile	Dimethyl Sulfate	Methylene Chloride
Acetophenone	Dimethylformamide	N,N-Dimethylaniline
Acrylic Acid	Epichlorohydrin (1-Chloro-2,3-epoxypropane)	N-Nitrosodimethylamine
Acrylonitrile	Ethyl Acrylate	Nickel & Compounds
Allyl Chloride	Ethyl Chloride	Nitrobenzene
Aniline	Ethylbenzene	Phenol
Arsenic & Compounds (inorganic including Arsine)	Ethylene Dibromide	Phosgene
Benzene	Ethylene Dichloride	Phthalic Anhydride
Benzyl Chloride	Ethylene Glycol	Polycyclic Organic Matter as 16-PAH
Biphenyl	Ethylene Oxide	Propylene Oxide
Bis(2-ethylhexyl)phthalate	Formaldehyde	Quinoline
Carbon Disulfide	Glycol Ethers	Selenium Compounds
Carbon Tetrachloride	Hexane	Tetrachloroethylene
Chlorine	Hydrazine	Toluene
Chloroacetic Acid	Hydrochloric Acid (Hydrogen Chloride [gas only])	Trichloroethylene
Chlorobenzene	Maleic Anhydride	Triethylamine
Chloroform	Manganese & Compounds	Trifluralin
Chloromethyl Methyl Ether	Methanol	Vinyl Acetate

### List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Cumene	Methyl Chloride	Vinylidene Chloride
Cyanide Compounds	Methyl Chloroform (1,1,1-Trichloroethane)	Xylenes (includes o, m, and p)

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## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

### Phosphate Fertilizers Production

Chlorine	Manganese & Compounds	Phosphorus
Hydrochloric Acid (Hydrogen Chloride [gas only])	Methanol	Toluene
Hydrogen Fluoride (Hydrofluoric Acid)	Methyl Chloroform (1,1,1-Trichloroethane)	
Lead & Compounds	Methyl Isobutyl Ketone (Hexone)	

### Phosphoric Acid Manufacturing

Hydrogen Fluoride (Hydrofluoric Acid)

### Plywood/Particle Board Manufacturing

4-4'-Methylenediphenyl Diisocyanate	Formaldehyde	Methylene Chloride
Acetaldehyde	Glycol Ethers	Pentachlorophenol
Arsenic & Compounds (inorganic including Arsine)	Hydrochloric Acid (Hydrogen Chloride [gas only])	Phenol
Bis(2-ethylhexyl)phthalate	Methanol	Styrene
Chlorine	Methyl Chloroform (1,1,1-Trichloroethane)	Tetrachloroethylene
Chromium & Compounds	Methyl Ethyl Ketone (2-Butanone)	Toluene
Dibutyl Phthalate	Methyl Isobutyl Ketone (Hexone)	Trichloroethylene
Ethylbenzene	Methyl Isocyanate	Xylenes (includes o, m, and p)
Ethylene Glycol	Methyl Methacrylate	

### Polycarbonates Production

Ethyl Chloride	Methylene Chloride
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### Polyether Polyols Production

Ethylene Oxide	Propylene Oxide
Hexane	Toluene

### Polymers & Resins (Excluding P&R III)

1,1,2,2-Tetrachloroethane	Chlorine	Methanol
1,1-Dimethylhydrazine	Chloroacetic Acid	Methyl Bromide (Bromomethane)
1,2-Epoxybutane	Chlorobenzene	Methyl Chloride
1,2-Propylenimine (2-Methylaziridine)	Chloroform	Methyl Chloroform (1,1,1-Trichloroethane)

### **List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)**

1,3-Butadiene	Chloromethyl Methyl Ether	Methyl Ethyl Ketone (2-Butanone)
1,3-Dichloropropene	Chloroprene	Methyl Isobutyl Ketone (Hexone)
1,4-Dioxane (1,4-Diethyleneoxide)	Chromium & Compounds	Methyl Methacrylate
2,4,6-Trichlorophenol	Cobalt Compounds	Methyl tert-Butyl Ether
2,4-D (2,4-Dichlorophenoxyacetic Acid)	Cresols (includes o,m,p)	Methylene Chloride

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# List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

2,4-Dinitrophenol	Cumene	N,N-Dimethylaniline
2,4-Toluene Diisocyanate	Dibutyl Phthalate	Nickel & Compounds
4,4'-Methylenebis(2-chloroaniline)	Diethanolamine	Nitrobenzene
4,4'-Methylenedianiline	Diethyl Sulfate	o-Toluidine
4,4'-Methylenediphenyl Diisocyanate	Dimethyl Phthalate	p-Phenylenediamine
Acetaldehyde	Epichlorohydrin (1-Chloro-2,3-epoxypropane)	Phenol
Acetonitrile	Ethyl Acrylate	Phosgene
Acrolein	Ethyl Chloride	Phthalic Anhydride
Acrylamide	Ethylbenzene	Polycyclic Organic Matter as 16-PAH
Acrylic Acid	Ethylene Dibromide	Propionaldehyde
Acrylonitrile	Ethylene Dichloride	Propoxur (Baygon)
Allyl Chloride	Ethylene Glycol	Propylene Dichloride
Aniline	Ethylene Oxide	Propylene Oxide
Antimony & Compounds	Formaldehyde	Styrene
Benzene	Glycol Ethers	Tetrachloroethylene
Benzyl Chloride	Hydrazine	Titanium Tetrachloride
Biphenyl	Hydrochloric Acid (Hydrogen Chloride [gas only])	Toluene
Bis(2-ethylhexyl)phthalate	Hydrogen Fluoride (Hydrofluoric Acid)	Trichloroethylene
Bis(chloromethyl) Ether	Hydroquinone	Vinyl Acetate
Cadmium & Compounds	Lead & Compounds	Vinyl Bromide
Carbon Disulfide	Maleic Anhydride	Vinyl Chloride
Carbon Tetrachloride	Manganese & Compounds	Vinylidene Chloride
Carbonyl Sulfide	Mercury & Compounds	Xylenes (includes o, m, and p)

## Polymers and Resins III

Formaldehyde	Phenol
Methanol	Xylenes (includes o, m, and p)

## Portland Cement Manufacturing: Hazardous Waste-fired

1,1,2,2-Tetrachloroethane	Dibutyl Phthalate	Methyl Isobutyl Ketone (Hexone)
1,1,2-Trichloroethane	Diethanolamine	Methyl Methacrylate
1,2,4-Trichlorobenzene	Dioxin/Furans as 2,3,7,8-TCDD TEQ	Methylene Chloride
1,4-Dichlorobenzene	Epichlorohydrin (1-Chloro-2,3-epoxypropane)	Nickel & Compounds
2-Nitropropane	Ethylbenzene	Nitrobenzene
Acetonitrile	Ethylene Dichloride	Pentachlorophenol
Acrylonitrile	Ethylene Glycol	Phenol
Aniline	Formaldehyde	Phthalic Anhydride
Benzene	Glycol Ethers	Polycyclic Organic Matter as 16-PAH
Carbon Disulfide	Hydrochloric Acid (Hydrogen Chloride [gas only])	Propylene Oxide
Chlorine	Lead & Compounds	Styrene

## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Chlorobenzene	Maleic Anhydride	Tetrachloroethylene
Chloroform	Mercury & Compounds	Toluene
Chromium & Compounds	Methanol	Trichloroethylene
Cresols (includes o,m,p)	Methyl Chloroform (1,1,1-Trichloroethane)	Vinyl Acetate
Cumene	Methyl Ethyl Ketone (2-Butanone)	Xylenes (includes o, m, and p)

### Portland Cement Manufacturing: Non-Hazardous Waste-fired

1,1,2,2-Tetrachloroethane	Dibutyl Phthalate	Methyl Isobutyl Ketone (Hexone)
1,1,2-Trichloroethane	Diethanolamine	Methyl Methacrylate
1,2,4-Trichlorobenzene	Dioxin/Furans as 2,3,7,8-TCDD TEQ	Methylene Chloride
1,4-Dichlorobenzene	Epichlorohydrin (1-Chloro-2,3-epoxypropane)	Nickel & Compounds
2-Nitropropane	Ethylbenzene	Nitrobenzene
Acetonitrile	Ethylene Dichloride	Pentachlorophenol
Acrylonitrile	Ethylene Glycol	Phenol
Aniline	Formaldehyde	Phthalic Anhydride
Benzene	Glycol Ethers	Polycyclic Organic Matter as 16-PAH
Carbon Disulfide	Hydrochloric Acid (Hydrogen Chloride [gas only])	Propylene Oxide
Chlorine	Lead & Compounds	Styrene
Chlorobenzene	Maleic Anhydride	Tetrachloroethylene
Chloroform	Mercury & Compounds	Toluene
Chromium & Compounds	Methanol	Trichloroethylene
Cresols (includes o,m,p)	Methyl Chloroform (1,1,1-Trichloroethane)	Vinyl Acetate
Cumene	Methyl Ethyl Ketone (2-Butanone)	Xylenes (includes o, m, and p)

### Primary Aluminum Production

Carbonyl Sulfide	Glycol Ethers	Methyl Ethyl Ketone (2-Butanone)
Chlorine	Hydrochloric Acid (Hydrogen Chloride [gas only])	Methyl Isobutyl Ketone (Hexone)
Chromium & Compounds	Hydrogen Fluoride (Hydrofluoric Acid)	Nickel & Compounds
Cumene	Lead & Compounds	Polycyclic Organic Matter as 16-PAH

## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Cyanide Compounds	Manganese & Compounds	Toluene
Ethylene Glycol	Methyl Chloroform (1,1,1-Trichloroethane)	Xylenes (includes o, m, and p)
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Primary Copper Smelting		
Antimony & Compounds	Cobalt Compounds	Methyl Chloroform (1,1,1-Trichloroethane)
Arsenic & Compounds (inorganic including Arsine)	Cresols (includes o,m,p)	Nickel & Compounds
Beryllium & Compounds	Hydrochloric Acid (Hydrogen Chloride [gas only])	Selenium Compounds
Cadmium & Compounds	Lead & Compounds	Styrene
Chlorine	Manganese & Compounds	
Chromium & Compounds	Mercury & Compounds	
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Primary Lead Smelting		
Antimony & Compounds	Lead & Compounds	Nickel & Compounds
Arsenic & Compounds (inorganic including Arsine)	Manganese & Compounds	
Cadmium & Compounds	Mercury & Compounds	
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Primary Magnesium Refining		
Chlorine	Hydrochloric Acid (Hydrogen Chloride [gas only])	
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Printing/Publishing (Surface Coating)		
1,4-Dioxane (1,4-Diethyleneoxide)	Cumene	Methyl Ethyl Ketone (2-Butanone)
2-Nitropropane	Cyanide Compounds	Methyl Isobutyl Ketone (Hexone)
4-4'-Methylenediphenyl Diisocyanate	Dibutyl Phthalate	Methylene Chloride
Acrylic Acid	Ethylbenzene	Nickel & Compounds
Antimony & Compounds	Ethylene Glycol	Phenol
Arsenic & Compounds (inorganic including Arsine)	Formaldehyde	Phthalic Anhydride
Benzene	Glycol Ethers	Polycyclic Organic Matter as 16-PAH
Bis(2-ethylhexyl)phthalate	Hydrochloric Acid (Hydrogen Chloride [gas only])	Tetrachloroethylene
Cadmium & Compounds	Lead & Compounds	Toluene
Chlorine	Maleic Anhydride	Trichloroethylene
Chromium & Compounds	Methanol	Vinyl Acetate
Cobalt Compounds	Methyl Chloroform (1,1,1-Trichloroethane)	Xylenes (includes o, m, and p)
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Publicly Owned Treatment Works (POTW) Emissions



### List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Acrylonitrile

Benzene

Carbon Disulfide

Methanol

Methyl Chloroform (1,1,1-Trichloroethane)

Methyl Ethyl Ketone (2-Butanone)

Tetrachloroethylene

Toluene

Trichloroethylene

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## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Chloroform	Methyl Isobutyl Ketone (Hexone)	Xylenes (includes o, m, and p)
Ethylbenzene	Methylene Chloride	
Glycol Ethers	Styrene	
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<b>Pulp and Paper Production (combustion) MACT II</b>		
Acetaldehyde	Dioxin/Furans as 2,3,7,8-TCDD TEQ	Methyl Isobutyl Ketone (Hexone)
Antimony & Compounds	Formaldehyde	Nickel & Compounds
Arsenic & Compounds (inorganic including Arsine)	Hydrochloric Acid (Hydrogen Chloride [gas only])	Phenol
Benzene	Lead & Compounds	Polycyclic Organic Matter as 16-PAH
Beryllium & Compounds	Manganese & Compounds	Selenium Compounds
Cadmium & Compounds	Mercury & Compounds	Styrene
Chromium & Compounds	Methanol	Toluene
Cobalt Compounds	Methyl Ethyl Ketone (2-Butanone)	Xylenes (includes o, m, and p)
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<b>Pulp and Paper Production (non-combustion) MACT I</b>		
1,1,2-Trichloroethane	Chloroform	Methyl Ethyl Ketone (2-Butanone)
1,2,4-Trichlorobenzene	Cresols (includes o,m,p)	Methyl Isobutyl Ketone (Hexone)
Acetaldehyde	Cumene	Methylene Chloride
Acetophenone	Ethylbenzene	Phenol
Acrolein	Ethylene Dichloride	Propionaldehyde
Benzene	Formaldehyde	Styrene
Benzotrichloride	Hexane	Tetrachloroethylene
Carbon Disulfide	Hydrochloric Acid (Hydrogen Chloride [gas only])	Toluene
Carbon Tetrachloride	Methanol	Trichloroethylene
Chlorine	Methyl Chloride	Xylenes (includes o, m, and p)
Chlorobenzene	Methyl Chloroform (1,1,1-Trichloroethane)	
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<b>Rayon Production</b>		
Biphenyl	Chlorine	Glycol Ethers
Carbon Disulfide	Ethylene Glycol	Methanol
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<b>Scrap or Waste Tire Incineration</b>		
Dioxin/Furans as 2,3,7,8-TCDD TEQ	Polychlorinated Biphenyls (Aroclors)	Polycyclic Organic Matter as 16-PAH
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## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

### Secondary Aluminum Production

Antimony & Compounds	Dioxin/Furans as 2,3,7,8-TCDD TEQ	Lead & Compounds
Arsenic & Compounds (inorganic including Arsine)	Formaldehyde	Manganese & Compounds
Cadmium & Compounds	Hydrochloric Acid (Hydrogen Chloride [gas only])	Mercury & Compounds
Chromium & Compounds	Hydrogen Fluoride (Hydrofluoric Acid)	Nickel & Compounds

### Secondary Lead Smelting

1,1,2,2-Tetrachloroethane	Chlorobenzene	Methyl Chloride
1,3-Butadiene	Chloroform	Methyl Ethyl Ketone (2-Butanone)
1,3-Dichloropropene	Chromium & Compounds	Methyl Iodide (Iodomethane)
Acetaldehyde	Cumene	Methylene Chloride
Acetophenone	Dibutyl Phthalate	Nickel & Compounds
Acrolein	Dioxin/Furans as 2,3,7,8-TCDD TEQ	Phenol
Acrylonitrile	Ethyl Carbamate (Urethane)	Polycyclic Organic Matter as 16-PAH
Antimony & Compounds	Ethylbenzene	Propionaldehyde
Arsenic & Compounds (inorganic including Arsine)	Formaldehyde	Styrene
Benzene	Hexane	Toluene
Biphenyl	Lead & Compounds	Trichloroethylene
Bis(2-ethylhexyl)phthalate	Manganese & Compounds	Xylenes (includes o, m, and p)
Cadmium & Compounds	Mercury & Compounds	
Carbon Disulfide	Methyl Bromide (Bromomethane)	

### Semiconductor Manufacturing

1,2,4-Trichlorobenzene	Hydrogen Fluoride (Hydrofluoric Acid)	Methylene Chloride
Antimony & Compounds	Hydroquinone	Phenol
Catechol	Lead & Compounds	Tetrachloroethylene
Chlorine	Manganese & Compounds	Toluene
Ethylbenzene	Methanol	Trichloroethylene
Ethylene Glycol	Methyl Chloroform (1,1,1-Trichloroethane)	Xylenes (includes o, m, and p)
Glycol Ethers	Methyl Ethyl Ketone (2-Butanone)	
Hydrochloric Acid (Hydrogen Chloride [gas only])	Methyl Isobutyl Ketone (Hexone)	

### Sewage Sludge Incineration

1,1,2,2-Tetrachloroethane	Chloroform	Methylene Chloride
1,4-Dichlorobenzene	Chromium & Compounds	Nickel & Compounds
Acetaldehyde	Cobalt Compounds	Phenol

## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Acetonitrile	Dioxin/Furans as 2,3,7,8-TCDD TEQ	Phosphorus
Acrylonitrile	Ethylbenzene	Polychlorinated Biphenyls (Aroclors)
Antimony & Compounds	Ethylene Dichloride	Polycyclic Organic Matter as 16-PAH
Arsenic & Compounds (inorganic including Arsine)	Formaldehyde	Selenium Compounds
Benzene	Hydrochloric Acid (Hydrogen Chloride [gas only])	Tetrachloroethylene
Beryllium & Compounds	Lead & Compounds	Toluene
Bis(2-ethylhexyl)phthalate	Manganese & Compounds	Trichloroethylene
Cadmium & Compounds	Mercury & Compounds	Vinyl Chloride
Carbon Tetrachloride	Methyl Chloroform (1,1,1-Trichloroethane)	Xylenes (includes o, m, and p)
Chlorobenzene	Methyl Ethyl Ketone (2-Butanone)	
Shipbuilding and Ship Repair (Surface Coating)		
Glycol Ethers	Methyl Isobutyl Ketone (Hexone)	Xylenes (includes o, m, and p)
Methyl Ethyl Ketone (2-Butanone)	Toluene	
Spandex Production		
2,4-Toluene Diisocyanate	Methylene Chloride	Toluene
Stationary Internal Combustion Engines		
1,3-Butadiene	Benzene	Polycyclic Organic Matter as 16-PAH
Acetaldehyde	Formaldehyde	Toluene
Acrolein	Mercury & Compounds	Xylenes (includes o, m, and p)
Stationary Turbines		
Acetaldehyde	Formaldehyde	Phenol
Benzene	Manganese & Compounds	Polycyclic Organic Matter as 16-PAH
Cadmium & Compounds	Mercury & Compounds	Toluene
Chromium & Compounds	Nickel & Compounds	Xylenes (includes o, m, and p)
Steel Foundries		
1,1,2-Trichloroethane	Cresols (includes o,m,p)	Methyl Ethyl Ketone (2-Butanone)
2,4-Dinitrophenol	Cumene	Methyl Isobutyl Ketone (Hexone)
4-4'-Methylenediphenyl Diisocyanate	Cyanide Compounds	Methylene Chloride
Antimony & Compounds	Diethanolamine	Nickel & Compounds

## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Arsenic & Compounds (inorganic including Arsine)	Ethylbenzene	Phenol
Benzene	Ethylene Glycol	Phosphorus
Beryllium & Compounds	Formaldehyde	Polycyclic Organic Matter as 16-PAH
Biphenyl	Glycol Ethers	Quinoline
Cadmium & Compounds	Hydrochloric Acid (Hydrogen Chloride [gas only])	Selenium Compounds
Carbon Disulfide	Hydrogen Fluoride (Hydrofluoric Acid)	Styrene
Carbonyl Sulfide	Lead & Compounds	Tetrachloroethylene
Chlorine	Manganese & Compounds	Toluene
Chlorobenzene	Mercury & Compounds	Trichloroethylene
Chromium & Compounds	Methanol	Xylenes (includes o, m, and p)
Cobalt Compounds	Methyl Chloroform (1,1,1-Trichloroethane)	
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Steel Pickling HCl Process		
Chlorine	Hydrochloric Acid (Hydrogen Chloride [gas only])	
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Taconite Iron Ore Processing		
Benzene	Lead & Compounds	
Formaldehyde	Toluene	
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Tire Production		
1,1,2,2-Tetrachloroethane	Benzotrichloride	Methyl Bromide (Bromomethane)
1,1,2-Trichloroethane	Benzyl Chloride	Methyl Chloride
1,2,4-Trichlorobenzene	Biphenyl	Methyl Chloroform (1,1,1-Trichloroethane)
1,2-Dibromo-3-chloropropane	Bis(2-ethylhexyl)phthalate	Methyl Ethyl Ketone (2-Butanone)
1,3-Butadiene	Bromoform	Methyl Isobutyl Ketone (Hexone)
1,4-Dichlorobenzene	Cadmium & Compounds	Methyl tert-Butyl Ether
1,4-Dioxane (1,4-Diethyleneoxide)	Carbon Disulfide	Methylene Chloride
2,2,4-Trimethylpentane	Carbon Tetrachloride	N,N-Dimethylaniline
2,4,5-Trichlorophenol	Carbonyl Sulfide	N-Nitrosodimethylamine
2,4,6-Trichlorophenol	Chlorobenzene	N-Nitrosomorpholine
2,4-Dinitrophenol	Chloroform	Nickel & Compounds
2,4-Dinitrotoluene	Chloroprene	Nitrobenzene
2-Chloroacetophenone	Chromium & Compounds	o-Anisidine
3,3'-Dichlorobenzidine	Cresols (includes o,m,p)	o-Toluidine
3,3'-Dimethoxybenzidine	Cumene	p-Phenylenediamine
3,3'-Dimethylbenzidine	Dibutyl Phthalate	Pentachloronitrobenzene (Quintobenzene)
4,4'-Methylenebis(2-chloroaniline)	Dichlorethyl Ether	Pentachlorophenol

### List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

4,4'-Methylenedianiline	Dimethyl Phthalate	Phenol
4,6-Dinitro-o-cresol (including salts)	Epichlorohydrin (1-Chloro-2,3-epoxypropane)	Polycyclic Organic Matter as 16-PAH
4-Aminobiphenyl	Ethyl Chloride	Propylene Dichloride
4-Dimethylaminoazobenzene	Ethylbenzene	Propylene Oxide
4-Nitrobiphenyl	Ethylene Dibromide	Styrene
4-Nitrophenol	Ethylene Dichloride	Tetrachloroethylene
Acetaldehyde	Ethylidene Dichloride	Toluene

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## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Acetonitrile	Hexachlorobenzene	Trichloroethylene
Acetophenone	Hexachlorobutadiene	Trifluralin
Acrolein	Hexachlorocyclopentadiene	Vinyl Acetate
Acrylonitrile	Hexachloroethane	Vinyl Chloride
Allyl Chloride	Hexane	Vinylidene Chloride
Aniline	Hydroquinone	Xylenes (includes o, m, and p)
Benzene	Isophorone	
Benzidine	Lead & Compounds	
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Utilities - Coal		
1,1,2-Trichloroethane	Cresols (includes o,m,p)	Methyl Isobutyl Ketone (Hexone)
1,3-Dichloropropene	Cumene	Methyl Methacrylate
2,4-Dinitrotoluene	Dibutyl Phthalate	Methyl tert-Butyl Ether
2-Chloroacetophenone	Dioxin/Furans as 2,3,7,8-TCDD TEQ	Methylene Chloride
Acetaldehyde	Ethyl Chloride	N-Nitrosodimethylamine
Acetophenone	Ethylbenzene	Nickel & Compounds
Acrolein	Ethylene Dichloride	Pentachlorophenol
Antimony & Compounds	Formaldehyde	Phenol
Arsenic & Compounds (inorganic including Arsine)	Hexachlorobenzene	Phosphorus
Benzene	Hexane	Phthalic Anhydride
Benzyl Chloride	Hydrochloric Acid (Hydrogen Chloride [gas only])	Polycyclic Organic Matter as 16-PAH
Beryllium & Compounds	Hydrogen Fluoride (Hydrofluoric Acid)	Propionaldehyde
Bis(2-ethylhexyl)phthalate	Isophorone	Quinoline
Bromoform	Lead & Compounds	Selenium Compounds
Cadmium & Compounds	Manganese & Compounds	Styrene
Carbon Disulfide	Mercury & Compounds	Tetrachloroethylene
Carbon Tetrachloride	Methyl Bromide (Bromomethane)	Toluene
Chlorobenzene	Methyl Chloride	Trichloroethylene
Chloroform	Methyl Chloroform (1,1,1-Trichloroethane)	Vinyl Acetate
Chromium & Compounds	Methyl Ethyl Ketone (2-Butanone)	Vinylidene Chloride
Cobalt Compounds	Methyl Iodide (Iodomethane)	

## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

### Utilities - Natural Gas

Arsenic & Compounds (inorganic including Arsine)	Formaldehyde	Phosphorus
Benzene	Lead & Compounds	Polycyclic Organic Matter as 16-PAH
Cadmium & Compounds	Manganese & Compounds	Toluene
Chromium & Compounds	Mercury & Compounds	
Cobalt Compounds	Nickel & Compounds	

### Utilities - Oil

Acetaldehyde	Formaldehyde	Phenol
Arsenic & Compounds (inorganic including Arsine)	Hydrochloric Acid (Hydrogen Chloride [gas only])	Phosphorus
Benzene	Hydrogen Fluoride (Hydrofluoric Acid)	Polychlorinated Biphenyls (Aroclors)
Beryllium & Compounds	Lead & Compounds	Polycyclic Organic Matter as 16-PAH
Cadmium & Compounds	Manganese & Compounds	Selenium Compounds
Chromium & Compounds	Mercury & Compounds	Tetrachloroethylene
Cobalt Compounds	Methyl Chloroform (1,1,1-Trichloroethane)	Toluene
Dioxin/Furans as 2,3,7,8-TCDD TEQ	Methylene Chloride	Vinyl Acetate
Ethylbenzene	Nickel & Compounds	Xylenes (includes o, m, and p)

### Utility Boilers - Coke

Beryllium & Compounds	Chromium & Compounds
Cadmium & Compounds	Nickel & Compounds

### Utility Turbines

Antimony & Compounds	Chromium & Compounds	Mercury & Compounds
Arsenic & Compounds (inorganic including Arsine)	Cobalt Compounds	Nickel & Compounds
Benzene	Formaldehyde	Phosphorus
Beryllium & Compounds	Lead & Compounds	Selenium Compounds
Cadmium & Compounds	Manganese & Compounds	

### Vegetable Oil Production

2,4-Toluene Diisocyanate	Maleic Anhydride	Toluene
4,4'-Methylenediphenyl Diisocyanate	Methanol	Xylenes (includes o, m, and p)
Biphenyl	Methyl Ethyl Ketone (2-Butanone)	



## List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Hydrochloric Acid (Hydrogen Chloride [gas only])

Nickel & Compounds

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List of MACT Source Categories and Associated Hazardous Air Pollutants (Continued)

Wood Furniture (Surface Coating)		
Glycol Ethers	Methyl Isobutyl Ketone (Hexone)	Xylenes (includes o, m, and p)
Methyl Ethyl Ketone (2-Butanone)	Toluene	
<hr/>		
Wool Fiberglass Manufacturing		
Arsenic & Compounds (inorganic including Arsine)	Formaldehyde	Methanol
Chromium & Compounds	Lead & Compounds	Phenol
<hr/>		

# APPENDIX C

## OVERVIEW OF REFERENCE MATERIALS

Source: *Handbook for Criteria Pollutant Inventory Development: A Beginner's Guide for Point and Area Sources, Appendix F.* EPA-454-/R-99-037, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, September 1999.

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## OVERVIEW OF REFERENCE MATERIALS

### Aerometric Information Retrieval System (AIRS)

The Aerometric Information Retrieval System (AIRS) is a computer-based repository of information about airborne pollution. The Airs Facility Subsystem (AFS) contains emissions, compliance data, and permit data for stationary sources. AFS data is used primarily by states in preparation of State Implementation Plans (SIPs) and SIP inventories. Types of data stored in AFS include:

- Facility name, location, and SIC code;
- Stack parameters;
- Process-specific operating schedule;
- SCC codes;
- Annual process rate, and fuel parameters; and
- Annual emissions estimates for criteria pollutants.

AFS is used by some states as a repository of HAP emissions and facility specific data. Some states update HAP information in AFS regularly on an annual basis or whenever changes occur to a facility or its operation. Currently there is **NO** mandatory requirement by EPA for states to report HAP emissions in AFS.

If data in AFS are going to be used for HAP inventory preparation purposes, it is important to understand the appropriate applications and limitations of the data. The completeness of the data in AIRS for a given state can be evaluated by determining the extent of HAP and source category coverage. For example, states may elect to report HAP emissions in AFS only for certain regions or nonattainment areas in the state; thus, not reporting a complete inventory of HAP emissions for the entire state.

In regard to HAP coverage, it is important to consider the reporting thresholds that states have for HAP emissions. Some states require facilities to quantify and report speciated HAP emissions for any HAP emitted beyond a certain threshold. However, some states only require facilities to simply identify, but not quantify, those HAPs that are emitted beyond the requirement threshold.

It is important to know the basis of the HAP emissions in AFS--whether they are reported as actual, potential (controlled or uncontrolled), permitted, or measured emissions. Depending on

the emission type, emissions may be entered in AFS on a plant or segment level. Knowing the emission type and level that a state uses for reporting data will assist in downloading data from AFS. Manuals may be downloaded from the Internet at <http://www.epa.gov/ttn/chief/>.

AFS can also be used to identify facilities that are subject to a MACT standard; however, this can only be done for states that designate facilities that are subject to a MACT standard. AFS allows states to report information pertaining to MACT standards, such as indicating the MACT category that applies to a facility and the MACT compliance status (whether the facility is in compliance with the MACT standard). Although reporting MACT standard information in AFS is voluntary, this information may be used to assist in MACT floor determination. If MACT information is not available in AFS, SCC codes can be used to determine the MACT that may apply to a facility.

The AIRS database resides on EPA's mainframe computer system and is not a publicly available database that can be accessed from the web. In order to retrieve information directly from AIRS, you need to obtain an account on the EPA mainframe computer system and pay the applicable computer usage charges. Information about obtaining a computer account is available by calling 1-800-334-2405 (toll free) or 919-541-7862.

### **AIRSWeb**

The AIRSWeb gives access to air pollution data for the entire United States. AIRSWeb is a collection of the most significant AIRS data elements. AIRSWeb "Source Reports" display estimates of annual emissions of criteria pollutants from individual point sources, and number of sources and total pollutant emissions by industry. Specifically, there are six Source Reports that can be generated from AIRSWeb:

- **Ranking:** Lists each source in order of its pollutant emissions, ranking them from largest to smallest;
- **Compliance:** Indicates whether each source is complying with regulations governing air pollutant emissions;
- **Address:** The name and address of each source plus additional descriptive information;
- **Count:** The number of sources and total air pollutant emissions for each geographic area (county, state, or EPA region);
- **SIC:** The number of sources and total air pollutant emissions for each SIC; and



- Year: The number of sources that submitted emissions estimates for each calendar year (indicates how recent are the data).

AIRSWeb data collection is refreshed monthly, usually on the first Tuesday. AIRSWeb reports can be accessed on the World Wide Web at <http://www.epa.gov/airswweb/sources.htm>.

### **National Toxics Inventory**

The 1993 National Toxics Inventory (NTI) database contains county-level air toxics data for the 188 HAPs for hundreds of major, area, and mobile source categories. Source categories included in the NTI are classified by SIC codes, SCC codes, AMS codes, or hybrid NTI category codes.

Specifically, the data contained in the NTI includes annual emissions at the state and county levels. The NTI air toxics data are compiled from a variety of sources including:

- CAA-mandated studies including Section 112(c)(6) and Section 112(k);
- State air toxics programs;
- TRI data;
- Data generated in support of the MACT standards program; and
- Industry and trade group data.

Data elements included in the NTI database are:

- FIPS state code;
- FIPS county code;
- Source category code and description;
- Pollutant code and description; and
- Total state and county-level emissions.

Some of the limitations of the 1993 NTI are that the inventory does not directly contain facility-specific data. Most of the emissions estimates were developed using a top-down approach. However, some of the raw data used to compile the inventory such as TRI and MACT data, and some state and local inventory data were facility-specific.

While the NTI does not provide direct procedural guidance, the emissions data and background documentation for emission calculations used in preparing it can be helpful to you in preparing your own air toxics inventory. The *1996 Periodic Inventory Guidance* document includes this information and can be downloaded from CHIEF web page at <http://www.epa.gov/ttn/chief/>.

NTI is a work-in-progress and is currently being updated to a 1996 base year, and efforts are underway to incorporate facility-specific, major source inventory data for the 1996 base year. NTI data can be downloaded off the World Wide Web through EPA's Web site at <http://www.epa.gov/ttn/chief/nti/index.html>.

### **The NET Database**

The National Emissions Trends (NET) system is a national repository database compiled by EPA and includes EPA's latest estimates of national emissions for criteria pollutants. Non-criteria pollutants included in the inventory are HAPs, PM<sub>2.5</sub>, and ammonia. Estimates are contained in the inventory for the years 1900 to 1996, with increasing levels of detail in the more recent years.

The 1996 NET inventory includes state-submitted inventory data generated for the Ozone Transport Assessment Group (OTAG) and Grand Canyon Visibility Transport Commissions (GCVTC) and other inventory services. The NET inventory, does not necessarily include state data for any particular source or pollutant. However, EPA intends to provide statewide 1996 emissions inventory data on a county level basis to every state in the country.

The NET inventory can be used as a starting point in compiling a statewide air toxics inventory because the inventory includes some HAP emissions. Moreover, the NET inventory can be used to compile an initial list of emission sources in the state. Additional information on the NET inventory can be obtained through the CHIEF's Emissions Inventory Web site at <http://www.epa.gov/ttn/chief/net/index.html> or from the Info CHIEF Help Desk at: (919) 541-1000.

### **Dun and Bradstreet Million Dollar Database**

D&B Million Dollar Database provides information on over 1,000,000 U.S. leading public and private businesses. Company information includes name, address (including county), and industry information with up to 24 individual 8-digit SICs. The database also allows you to search for specific companies, or find companies within a specific industry group. Access to these databases is available on a subscription basis. Company data is updated every 60 days. The database can be accessed on the World Wide Web at <http://www.dnb.com/>.

### **Toxic Release Inventory**

The EPA's Toxic Release Inventory (TRI) is a compilation of information about toxic chemicals used, manufactured, stored, treated, transported, or released into the environment. EPA stores TRI data in the Toxics Release Inventory System (TRIS). The TRI chemical list currently includes 579 individually-listed chemicals and 28 chemical categories. Some of the information included in the TRI database includes:

- Type of chemicals released into the local environment during the preceding year; and
- Quantity of each chemical that went into the air, water, and land in a particular year.

TRI data are best used when combined with information from other sources because of the following limitations associated with the TRI data:

- TRI covers only a subset of industrial sources. Non-industrial sources such as dry cleaners or automobile service stations are not covered in TRI;
- Only provides facility estimates reported as either stack or fugitive emissions; no breakout at the process level;
- Many point sources may not be required to report data to TRIS. Facilities must meet all of the following criteria in order to report data to TRIS;
  - Facilities that conduct manufacturing operations with SIC codes 20 through 39;
  - Facilities that have 10 or more full-time employees or their equivalent;
  - Facilities that manufacture, process, or otherwise use EPCRA Section 313 chemicals at the following thresholds: 25,000 lb/yr for manufacturing and processing, or 100,000 lb/yr otherwise used.
- TRI data are self-reported by the emitting facilities and reported releases may have been based upon estimation techniques rather than direct monitoring or testing, and therefore may not represent an accurate amount of release;
- TRI does not require a listing of all chemicals released, and thus, many releases go unreported. Moreover, chemicals may be added or deleted from the list. The EPCRA Information Hotline at (800) 535-0202 will provide up-to-date information on the status of the changes; and
- Five of the 188 HAPs are currently not required to be reported in TRI. These HAPs are: 2,2,4-trimethylpentane (540-84-1); 2,3,7,8-tetrachlorodibenzo-p-dioxin (1746-01-6); DDE (3547-04-4); coke oven emissions; and radionuclides.

TRI can be searched by pollutant, SIC, facility name, or location. Updated TRI lists of chemicals can be downloaded off the World Wide Web through EPA's Office of Pollution Prevention and Toxics Web site at <http://www.epa.gov/opptintr/tri/chemical.htm>. TRI reports are available in public libraries or can be downloaded off the World Wide Web at <http://www.epa.gov/tri/>. The TRI database can also be searched online through the Right-To-Know Network (RTK NET) at <http://www.rtk.net/trisearch.html>.

### **Toxic Release Inventory Reporting Form R Guidance**

Title III, Section 313 Release Reporting Guidance documents contain information to help industries comply with the reporting requirements of Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 and Section 6607 of the Pollution Prevention Act of 1990. These manuals are intended to supplement the *Toxic Chemical Release Inventory Reporting Form R and Instruction*.

EPCRA Section 313 reporting requirements are discussed and the information needed to determine if an EPCRA 313 report must be prepared for a specific facility is presented. This discussion includes the definitions and lists required to make this decision. Threshold determination is explained in detail, including the step-by-step procedure with examples to clarify the process.

Detailed instructions for estimating releases are presented in each document. Again, a step-by-step approach is presented and illustrated with examples of the concepts presented and the calculations required. Industry-specific information includes a list of the commonly used EPCRA Section 313 chemicals; an overview of the industry processes; identification of appropriate chemical activities and reporting thresholds; methods for estimating quantities of chemicals released or otherwise managed; and discussion of common reporting errors.

The list of current TRI documents can be found in the reporting instructions that are sent to the facilities every year. Or, they can be obtained by calling EPA's Toxic Release Inventory Branch at (202) 260-3943.

The guidance documents that have been produced include:

- Monofilament fiber manufacture;
- Printing operations;
- Electrodeposition of organic coatings;
- Spray application of organic coatings;

- Semiconductor manufacture;
- Formulation of aqueous solutions;
- Electroplating operations;
- Textile dyeing;
- Presswood and laminated wood products manufacturing;
- Roller, knife, and gravure coating operations;
- Paper and paperboard production;
- Leather tanning and finishing processes;
- Wood preserving;
- Rubber production and compounding;
- Estimating releases and waste treatment efficiencies;
- Metal fabrication industry; and
- Food processors.

The following documents were updated in 1997 and can be obtained from the TRI Web site at [www.epa.gov/tri/](http://www.epa.gov/tri/):

- Metal mining;
- Coal mining;
- RCRA Subtitle CTSD facilities and solvent recovery;
- Petroleum distribution;
- Electric generation; and
- Chemical distribution.

The following documents are being updated:

- Food processing;
- Metal fabrication;
- Electroplating;
- Semiconductors;
- Paper and paperboard;
- Printing operations;
- Spray application of organic coatings;
- Textiles;
- Rubber production;
- Electrodeposition;
- Presswood;
- Monofilament mfg;
- Roller, knife and gravure;
- Leather; and
- Wood preservation.

In addition, the following documents are being written:

- Smelting operations;
- Welding operations; and
- Incidental manufacture/byproducts.

# APPENDIX D

## LIST OF EMISSION ESTIMATION MODELS AND EMISSION FACTOR RESOURCES (Current as of March 2001)

Source: *Handbook for Criteria Pollutant Inventory Development: A Beginner's Guide for Point and Area Sources, Appendix G.* EPA-454-/R-99-037, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, September 1999.

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## List of Emission Factor Resources

### Landfill Gas Emissions Model (Version 2.01)

The Landfill Gas Emissions Model was developed by the Clean Air Technology Center (CATC). The model can be used to estimate emission rates for methane, carbon dioxide, nonmethane organic compounds, and individual toxic air pollutants from landfills. The system allows the user to enter specific information regarding the characteristics and capacity of an individual landfill and to project the emissions of methane, CO, nonmethane organic compounds, and individual HAPs over time using the Scholl Canyon decay model for landfill gas production estimation. The Scholl Canyon Model is a first-order decay equation that uses site-specific characteristics for estimating the gas generation rate. In the absence of site-specific data, the program provides conservative default values. The user also may tailor decay rate characteristics on an individual basis. An integrated decay rate constant calculator is provided for landfills that may be operating a gas recovery system to allow more accurate assessments of decay attributes. Outputs may be reviewed in either tabular or graphical forms. A help system is also provided with information on the model operation as well as details on assumptions and defaults used by the system. For additional information contact the EPA's Air Pollution Prevention and Control Division at (919) 541-2709. The model can be downloaded from the World Wide Web through EPA's TTN Web site at <http://www.epa.gov/ttn/catc/products.html#software>.

### TANKS

TANKS is a Windows-based computer software program that computes estimates of VOC emissions from fixed- and floating-roof storage tanks based on the emission estimation procedures from Chapter 7 of *AP-42*, plus recent updates from the American Petroleum Institute. The TANKS program employs a chemical database of over 100 organic liquids and meteorology data from over 250 cities in the United States. The user may add new chemicals and cities to their version of the database. The tank types addressed in the program include vertical and horizontal fixed roof tanks, and internal and external floating roof tanks. The tank contents can consist of single-component liquid or a multicomponent mixture. TANKS is available through the EPA's TTN Web site at <http://www.epa.gov/ttn/chief/software/tanks/index.html>.

### WATER9

WATER9 is a Windows based computer program and consists of analytical expressions for estimating air emissions of individual waste constituents in wastewater collection, storage, treatment, and disposal facilities; a database listing many of the organic compounds; and procedures for obtaining reports of constituent fates, including air emissions and treatment effectiveness. WATER9 is available through the EPA's TTN Web site at <http://www.epa.gov/ttn/chief/software/water/>.

## **CHEMDAT8**

CHEMDAT8 is a Lotus 1-2-3 spreadsheet that includes analytical models for estimating emissions from treatment, storage and disposal facility (TSDF) processes. The original models include disposal impoundments, closed landfills, land treatment facilities, and aeration and nonaeration impoundment processes.

The models in CHEMDAT8 can be applied to other types of TSDF processes besides those contained in the original design. The nonaerated impoundment model in CHEMDAT8 can estimate emissions from storage surface impoundments and open-top wastewater treatment tanks. The CHEMDAT8 aerated impoundment model may be used for predicting emissions from surface treatment impoundments and aerated wastewater treatment tanks. The land treatment model in CHEMDAT8 can estimate emissions from land treatment soil, open landfills, and wastepiles. Emissions from an oil film surface in a land treatment facility or an oil film on surface impoundments can be predicted via the oil film model in CHEMDAT8. When a CHEMDAT8 model is not available to predict emissions, the equations shown in the reports that provide the background to the model can be used to perform hand calculations of emissions.

This eighth version of the CHEMDAT spreadsheet contains several major operational modifications. In CHEMDAT8, the user can select a subset of target compounds for investigation. The user can also specify which TSDF processes are to be considered during a session. These two selections improve the efficiency of CHEMDAT8 relative to some of the earlier versions by minimizing storage requirements as well as actual loading and execution time.

Default input parameters in the CHEMDAT8 diskette demonstrate example calculations. However, the input parameters can be changed to reflect different TSDF characteristics and then recalculate emissions under these modified conditions. The list of 60 compounds currently in CHEMDAT8 can be augmented by an additional 700 chemicals. Procedures for introducing data for additional compounds into CHEMDAT8 are described in the supporting documentation report. CHEMDAT8 is available through the EPA's TTN Web site at <http://www.epa.gov/ttn/chief/software/water/water8.html>

## **PM Calc**

PM Calc is a computer software developed by EPA to estimate PM<sub>2.5</sub> emissions. PM Calc is applicable to point sources and requires the user to input uncontrolled emissions (either total particulate or PM<sub>10</sub>) for each source, the source category classification (SCC) and the type of control device, if any. The program will then calculate controlled emissions for PM<sub>2.5</sub> and PM<sub>10</sub> for each point source. PM Calc is available through the EPA's TTN Web site at <http://www.epa.gov/ttn/chief/software/pmcalc/>

## **Compilation of Air Pollutant Emission Factors (AP-42)**

The primary reference for criteria pollutant emission factors for industrial sources is *AP-42* (EPA, 2000b). EPA is continuously updating *AP-42* to include available emission factors for the most common emission source categories.

The extent of completeness and detail of the emission information in *AP-42* is determined by the information available from published references. Emissions from some processes are better documented than others. For example, several emission factors may be listed for the production of one substance: one factor for each of a number of steps in the production process such as neutralization, drying, distillation, and other operations. However, because of less extensive information, only one emission factor may be given for production facility releases for another substance, though emissions are probably produced during several intermediate steps. There may be more than one emission factor for the production of a certain substance because differing production processes may exist, or because different control devices may be used. Therefore, it is necessary to look at more than just the emission factor for a particular application and to observe details in the text and in table footnotes of *AP-42*.

Each *AP-42* emission factor is given a rating from A through E, with A being the best. A factor's rating is a general indication of the reliability, or robustness, of that factor. This rating is assigned based on the estimated reliability of the tests used to develop the factor and on both the amount and the representative characteristics of those data. Because ratings are subjective and only indirectly consider the inherent scatter among the data used to calculate factors, the ratings should be seen only as approximations. A rating should be considered an indicator of the accuracy and precision of a given factor being used to estimate emissions from a large number of sources. This indicator is largely a reflection of the professional judgment of *AP-42* authors and reviewers concerning the reliability of any estimates derived with these factors.

The fact that an emission factor for a pollutant or process is not available from EPA does not imply that the Agency believes the source does not emit that pollutant or that the source should not be inventoried, but it is only that EPA does not have enough data to provide any advice. *AP-42* must be considered work-in-progress. Up-to-date sections of *AP-42* can be downloaded off the World Wide Web through OAQPS' TTN Web site at <http://www.epa.gov/ttn/chief/ap42/index.html>. *AP-42* is also available through *Fax CHIEF* automated fax document delivery service, through the *Air CHIEF* CD-ROM, and in hard copy from the Government Printing Office (202) 512-1800.

### **Factor Information Retrieval (FIRE) Data System**

FIRE is a database management system containing:

- EPA's recommended emission estimation factors for criteria pollutants and HAPs;
- Information about industries, their emitting processes, and chemicals emitted;

- All EPA point and area SCCs through September 2000;
- Easy access to emission factors obtained from *AP-42*, *L&E* series documents, factors derived from state-reported test data, and factors taken from literature searches;
- Each emission factor entry includes comments about its development, in terms of the calculation methods and/or source conditions, as well as the references where the data were obtained. The emission factor entry also includes a data quality rating;
- Capability for users to browse through records in the database or to select specific emission factors by source category name or source classification code (SCC), by pollutant name or CAS number, or by control device type or code.

FIRE Version 6.23 (released November 2000) is a user-friendly, menu-driven Windows® program that can run under Windows® Version 3.1, 95 or Windows® NT. FIRE can be downloaded off the World Wide Web through OAQPS' TTN Web site at <http://www.epa.gov/ttn/chief/software/fire/>. FIRE is also available on the Air CHIEF, a compact disc read-only memory (CD-ROM) and can be obtained by calling the Info CHIEF Help Desk at (919) 541-1000.

### **Air Clearinghouse for Inventories and Emission Factors (Air CHIEF) CD-ROM**

Air CHIEF CD-ROM format, gives access to air emission data specific to estimating the types and quantities of pollutants that may be emitted from a wide variety of sources. Updated annually, Air CHIEF offers thousands of pages contained in some of EPA's most widely used documents. This most recent version of Air CHIEF contains many enhancements, such as linking between related documents, Web links directly to the CHIEF Web site for easy access to the most recent updates, and enhanced full-CD searching. The Adobe Acrobat® software included on the CD allows for easy browsing of all information or locating specific information by conducting keyword searches by pollutant, source category, SCC, or SIC code. Some of the databases included on Air CHIEF version 8.0 are: (1) *AP-42*; (2) *L&E* documents; (3) *EIIP* documents; (4) *AP-42* background files; and (5) FIRE version 6.23. Also included on Air CHIEF are the installable copies of these software programs: BEIS, WATER8, CHEMDAT8, CHEM9, Landfill Model, and SPECIATE.

Air CHIEF version 8.0 is available for distribution for free from the Info CHIEF Help Desk. Call the Help Desk at (919)541-1000, or send an email to [info.chief@epa.gov](mailto:info.chief@epa.gov).

## APPENDIX E

### LIST OF L&E DOCUMENTS (<http://www.epa.gov/ttn/chief/le/index.html>) (Current as of March 2001)

Source: *Handbook for Criteria Pollutant Inventory Development: A Beginner's Guide for Point and Area Sources, Appendix H.* EPA-454-/R-99-037, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, September 1999.

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### List of *L&E* Documents

<b>Substance</b>	<b>EPA Publication Number</b>	<b>Available On Line?</b>
Acrylonitrile	EPA-450/4-84-007a	YES
Arsenic	EPA-454/R-98-013	YES
Benzene	EPA-454/R-98-011	YES
Butadiene	EPA-454/R-96-008	YES
Cadmium	EPA-454/R-93-040	YES
Carbon Tetrachloride	EPA-450/4-84-007b	YES
Chlorobenzene (update)	EPA-454/R-93-044	YES
Chloroform	EPA-450/4-84-007c	YES
Chromium (supplement)	EPA-450/2-89-002	YES
Chromium	EPA-450/4-84-007g	YES
Cyanide Compounds	EPA-454/R-93-041	YES
Dioxins and Furans	EPA-454/R-97-003	YES
Epichlorohydrin	EPA-450/4-84-007j	YES
Ethylene Dichloride	EPA-450/4-84-007d	YES
Ethylene Oxide	EPA-450/4-84-007i	YES
Formaldehyde	EPA-450/4-91-012	YES
Lead	EPA-454/R-98-006	YES
Manganese	EPA-450/4-84-007h	NO
Mercury	EPA-453/R-97-012	YES
Methyl Chloroform	EPA-454/R-93-045	YES
Methyl Ethyl Ketone	EPA-454/R-93-046	YES
Methylene Chloride	EPA-454/R-93-006	YES
Nickel	EPA-450/4-84-007f	YES
Organic Liquid Storage Tanks	EPA-450/4-88-004	NO
Perchloroethylene and Trichloroethylene	EPA-450/2-89-013	YES
Phosgene	EPA-450/4-84-007i	YES
Polychlorinated Biphenyls (PCBs)	EPA-450/4-84-007n	NO
Polycyclic Organic Matter (POM)	EPA-454/R-98-014	YES
Styrene	EPA-454/R-93-011	YES
Toluene	EPA-454/R-93-047	YES

**List of *L&E* Documents (Continued)**

<b>Substance</b>	<b>EPA Publication Number</b>	<b>Available On Line?</b>
Vinylidene Chloride	EPA-450/4-84-007k	YES
Xylenes	EPA-454/R-93-048	YES

# APPENDIX F

## GUIDANCE ON HOW TO CONDUCT SCREENING STUDIES

Source: *Handbook for Criteria Pollutant Inventory Development: A Beginner's Guide for Point and Area Sources, Appendix M.* EPA-454-/R-99-037, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, September 1999.

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## ELEMENTS

An emission inventory questionnaire mail-out has three basic elements: the cover letter, the questionnaire instructions, and the questionnaire itself. The questionnaire format and content depends on the detail of the inventory and the ultimate use of the data. All of these components, when considered together, make up the questionnaire package.

### Cover Letter

The cover letter is a key to the emission inventory, because it introduces the purpose of the questionnaire and is the initial contact with the recipient. If the cover letter does not command attention, the attached questionnaire may be discarded or filed away and not considered a top priority. This could make the number of companies requiring recontact by agency personnel increase dramatically.

The cover letter should include the following:

- Applicable regulations, if any, that require the recipient to respond;
- Confidentiality provisions, if applicable;
- The purpose of the questionnaire;
- A respectful request for cooperation in filling out the questionnaire;
- Due date for the return of completed questionnaires;
- A state or local agency contact name and telephone number to answer questions; and
- Rationale for asking for what may appear to the source to be redundant information.

The cover letter should be as short and direct as possible. The most successful return rates for questionnaires have been the ones having the strongest legal statements. Therefore, states/local agencies requiring source registration to obtain construction or operating permits may obtain better source cooperation.

A strong statement about existing and applicable regulations which require a recipient to respond to the questionnaire is the agency's most powerful tool for maximizing the return rate. The statement should be placed prominently in the beginning or at the top of the cover letter. It should cite any applicable regulations or proposed regulations and specify penalties for noncompliance.

Another important item to include in a cover letter to ensure a high return rate is the due date. The final due date should be included in the cover letter so that it will not be overlooked by those who do not read instructions. The due date may be specified either as a stated date or as a period of time after the recipient receives the questionnaire. The first approach is more specific, and gives the recipient a definite deadline. With the latter approach however, the questionnaire mailing can be staggered without having to reprint the due dates listed on the cover letter. The agency should record each due date so it will be clear when follow-up letters or phone calls may need to begin for tardy respondents.

### **Questionnaire Instructions**

General information that affects the whole questionnaire may be included first on the instruction page. For example, if the questionnaire is “open-ended” (i.e., asks the recipient to list every toxic compound from every emission source), it should be clear that the respondent should use chemical compound names or preferably CAS numbers and not just industrial trade names. Also, it may be helpful to point out that not all questions, sections, or pages may apply to every industry, as in a source category specific directed questionnaire. If the questions are designed for direct coding to computer input, the general instructions should explain how to enter numbers properly. In addition to explaining how to complete the questionnaire, the general instructions should indicate the specific year, or other appropriate period of time, for which all data are required.

Some agencies have utilized production/use questionnaires which basically just ask sources to identify whether each substance is purchased, used, or produced, followed by a more detailed questionnaire targeted to specific industries. Some agencies include minimum usage or emissions levels specified on an attached list as part of the instructions.

### **Questionnaire Design**

There are several ways to design a questionnaire. Of utmost importance when designing a questionnaire is that the format suits the needs of the agency and attains correct responses and maintains a good agency-industry working relationship.

Several approaches can be taken in designing the questionnaire which, in turn, will effect the format of the questionnaire. The approaches that can be used include: open vs. closed-ended, emission-based vs. chemical use, permit related, and general vs. industry-specific. In order for an agency to decide which approach to use, it needs to be familiar with some of the impacts of each approach.

Each agency should tailor their inventory package according to their agency's individual needs. Many times, the examples are a combination of approaches. For instance, in one case a general design questionnaire was sent to various manufacturers and process industries, and later, industry specific questionnaires were sent to a small subset of the original recipients. In still another case a



screening study was first done to narrow down the number of sources to be inventoried and indicated the design needs of the final questionnaire to be sent out. Later, a second questionnaire was sent.

The following sections explain the advantages and disadvantages of various type questionnaire designs. These are not necessarily mutually exclusive.

### Open-Ended Approach

The open-ended approach does not target specific source types or a limited group of compounds. The open-ended approach asks the respondent to list any compound that they emit. It does not provide a checklist of compounds. Therefore, with an open-minded approach a much larger number of contacts will be necessary. This approach has several similarities to a screening study:

- Less time and effort in questionnaire design;
- Responses may be less detailed;
- More responses may be inaccurate or trade names (not chemical compound names) may be listed; and
- Some sources may report no air toxic emissions.

### Closed-Ended Approach

The closed-ended approach is a more direct approach, which usually provides a limited list of compounds with the questionnaire. Some agencies' list lists of toxic compounds are becoming rather extensive and use of CAS numbers is widespread. This approach requires more design time up from (e.g. screening studies, modeling analyses). However, the benefits are that the resulting number of sources contacted can be greatly reduced and the quality and detail of the data received are usually better.

### Emissions-Based Approach

Emissions-based questionnaires request information often included in annual volatile organic compound (VOC) or particulate matter emissions inventories.

The agency may request permitted or potential emissions per source and/or actual emissions, average emissions, or emissions per day. They may also specify emissions per hour (or time interval) for specific compounds. In many cases some of this information can be collected for the majority of sources from the established criteria emission inventory records. The agency may also ask for emergency episode emissions, fugitive emissions, and information from excluded criteria emission inventory sources.

### Chemical Use Approach

Chemical use questionnaires are directed toward lists of specific compounds and ask for process input information and Material Safety Data Sheets (MSDS). The Material Safety Data Sheets include the needed species composition data and should be requested where available, for any approach used. The agency can require the source to contact the suppliers of chemicals they use, if MSDS are not available. The agency can use these data to make emissions estimates if information is also provided on daily use, process operating parameters, and efficiency of the control equipment.

### General Approach

This type of questionnaire may be used as input to simple screening models to determine if a particular source is a potential problem and if further, more detailed source, emissions, and modeling data are required. A list of chemicals is provided and the sources must access it if it emits any of the listed compounds. These questionnaires may list minimum levels for each compound addressed. Such questionnaires may also be used in conjunction with several source specific questionnaires. The general questionnaire may also be sent to a variety of manufacturing or industrial process facilities not covered by the source specific questionnaires.

### Industry-Specific Approach

These are very detailed questionnaires that may include emissions information from process vents, fugitive equipment leaks, equipment openings, raw material/product storage and handling, secondary waste treatment, and liquid spills. Questionnaires of this type are usually focused on a handful of very large, singularly important point sources. A great deal of pre-screening effort would be required for industry-specific questionnaires, and a great deal of effort would also be required of the recipient in filling out the questionnaire. More effort would be required per source for the agency to properly interpret the response. However, this level of detail is probably the next best thing to actual source testing in estimating emissions. This technique may also prove useful in targeting particular sources the agency determines may or may not need to conduct source tests.

### Tiered Approach

In the tiered or staggered mail-out approach, a cover letter and screening study type questionnaire are used, followed later by more detailed questionnaires sent to a select number or type of sources. A phone survey may be conducted by the agency prior to the screening study to narrow the number of facilities to send the screening study questionnaire or the detailed questionnaire. Whether the phone survey is conducted before or after the screening study questionnaire is sent depends on the number and type of facilities in the inventory area.

A good example would be dry cleaning establishments. The state manufacturing guide may list 100 dry cleaners in a certain city. However, after a phone survey the agency found that 75 percent of these locations are only drop-off and pick service centers. By conducting the phone screening, it was obvious that no questionnaires were necessary for those service centers. A more detailed questionnaire was sent to the remaining 25 dry cleaners. This benefitted both the agency by not having to review unnecessary forms, and the excluded service centers by not wasting their time completing unnecessary forms. Phone screening may not always be an efficient use of agency time, depending on the individual agency needs or types of industries included.

Another approach is to first send an open-ended questionnaire or general questionnaire, followed by later designed industry specific (by source type) questionnaire, followed-up by phone calls to clarify data and/or source tests or inspections.

## **OTHER CONSIDERATIONS**

Other considerations when developing a questionnaire are more related to strategy for maximizing accuracy and minimizing cost and time involved to conduct an inventory. These include discussions of the importance of the following:

- Asking the right questions;
- Maximizing return rates;
- Providing for facility confidentiality of trade secrets;
- Outlining what questions are applicable for particular source categories;
- Designing question/answer style and format to decrease confusion or misrepresentation;
- Providing written instructions for answers (especially units of measurement) with computer coding format instructions if necessary; and
- Developing a data quality assurance procedure.

Some of these considerations are clearly technical in nature, but they need to be incorporated with administrative and procedural considerations for the whole effort to be the most efficient.

### **The Right Questions**

A successful questionnaire obtains the right answers to the right questions for the particular agency while maintaining a good working relationship with the recipients. Duplication of

information already available through permit files may not be needed if the number of sources included in the survey is few and the information is easily extracted from other sources. However, for large survey efforts, it may be too time consuming for agency personnel to extract needed available information and thus, some duplication of effort on the part of the sources cannot be avoided. If the sources being sent questionnaires are the same as included in the criteria pollutant inventory, all information which the agency already has about the recipient's facility, such as mailing address, SIC number, UTM coordinates, emission point numbers, etc., should be preprinted on the questionnaire. The agency could use a window envelope to expose the facility name and address and avoid making additional mailing labels.

### **The Return Rate**

The return rate of a questionnaire depends on several factors. The first impression of the recipient, the simplicity of the questionnaire, and conveying the importance of returning the questionnaire are all important factors affecting the return rate.

#### Minimize Questionnaire Length

The recipient's first impression will be based on the size of the questionnaire. It should be as brief as possible. Unfortunately, it may be impossible for the forms and accompanying instructions for a large listing of toxic compounds or source categories to be brief. So, the next best approach may be to design the forms in such a way to make the pages as uncluttered and readable as possible leaving ample room for answers.

#### Maximizing Return Rates

Staggered mailing is particularly important for very large inventories, because 1000 or more questionnaires returned simultaneously may be too difficult to process at one time. Staggered return uses the agency's limited manpower and resources more economically. Questionnaires can easily become lost or damaged if they are not processed expediently by the agency, and this may be less likely to occur if the staggered mailing approach is used.

Each respondent should have an equal amount of time to respond to questionnaires when using the same format and approach especially if there is a penalty for late responses. But this must depend on equal complexity of the information required by questionnaires. Obviously more time will be needed for a large source to complete a source specific questionnaire than a simple screening survey or a general information questionnaire with, for example 20 compounds versus 200 compounds. Therefore, the time period allowed for completion of emission inventories require more planning than criteria pollutant inventories. The time period should be long enough so that the respondent is not overly rushed and short enough that the respondent does not procrastinate in responding.

Another good approach for a large inventory is to classify the mailings according to priority chemicals, source type, source size, county locations, or simply a source name (alphabetical) staggered approach. In this way, all of the questionnaires will not be returned at the same time. Each questionnaire should be reviewed as soon as possible after it is received. When this approach is used for a selected small number of sources at the beginning of the update, the agency can predict the manpower and resources it will take to complete the full-blown inventory effort. They may find they do not in fact have the manpower to conduct the type of inventory they want. They can instead rethink and replan their approach or request additional manpower to complete the inventory.

### **Confidentiality**

Confidentiality can be established in one of several ways. The simplest is a box to be checked to request confidentiality for all information other than emissions data given in the questionnaire. Justification for the request would be given by the recipient on a separate sheet. In this way each piece of confidential information can be keyed as such.

Another approach would be for the industry to submit one full questionnaire and one “sanitized” questionnaire that would be available for public review.

The main advantage to this approach is that it clearly indicates the request to the agency. It also alerts the agency to look for supplementary supporting information. If the questionnaire is converted to computer input, a check in the confidentiality box can be programmed as a command to store all information in a limited access data file.

The disadvantages of this approach are that it does not provide confidentiality for only specific pieces of information and that it may be too easy to use. It should be used only for recipients who are anticipated to be deeply concerned about confidentiality. This judgment is best handled by the appropriate agency officials. A better method may be to require the industry to highlight each and every answer it deems confidential.

A more complex method for establishing confidentiality involves the assignment of a survey number to each questionnaire; this number would also be printed on the general information page. The agency director would detach the general information page from the returned questionnaire and store it in a locked file. Since all identification is presented on the general information page, no one would be able to associate the information on the question pages with a specific facility. If necessary, a facility could be identified by locating the survey number in the locked file of general information pages. This consideration is especially important if the agency subcontracts to a private consultant for the interpretation and transcription of the information. If the information is computerized, the identification information could be entered into a separate limited access file.

Each agency should be versed in their local laws to ascertain that the concealment of identification is not forbidden (the public access to records varies among states).

A system which allows for partial confidentiality could be established in the cover letter using a paragraph similar to the following:

*Any proprietary information, which you believe is of a confidential nature, should be identified in a supplementary letter with applicable data in the questionnaire marked with the word CONFIDENTIAL. A brief explanation in your letter for the desired confidentiality should be included.*

This system indicates clearly to the agency which information is confidential and which is not. It also alerts the agency to look for supplementary supporting information with each returned questionnaire that is marked anywhere with the word “CONFIDENTIAL.” However, unless the marking is very clear, this system can become tedious and inefficient.

### **Applicability and Clarity of Questions**

Several factors in the design of the question section can determine the efficiency of the mailing and affect the return rate as well. First, there should be a clear statement from which the respondent can determine whether the questionnaire is applicable to his facility. Second, the questions should be well-arranged and easy to answer.

A clear statement of applicability serves several purposes. If the questionnaire is applicable, the statement reinforces the necessity of compliance. If the questionnaire is not applicable and recipient can easily determine it as such, he may be more cooperative in the future when the questionnaire does apply to him. A maximum return rate for non-applicable respondents is important because the agency will not have to waste time and money for follow-up and know up front which facilities are not being inventoried.

The use of a check box for applicability will help the agency distinguish between questionnaires that are not applicable and the ones that are returned without any response. Examples of statements of applicability are provided below.

- If this equipment was used at least five (5) days last year, check this box and complete the questionnaire.
- If this equipment was not used at least five (5) days last year, check this box and return this form.
- If this equipment has been removed, check this box and return this form.
- If any compound used on the attached table is less than the minimum level listed, check this box and return this form.

Statements of non-applicability at the beginning of each page or section can be used as an alternative or supplement to a general statement of applicability. Colored pages may be used to designate different sections of the questionnaire. By supplying a check box, the agency can discriminate between pages that were forgotten and pages that were not applicable.

### **Complexity and Questionnaire Format**

As mentioned earlier, the questions must be well-arranged and easy to answer. Brevity enhances the rate of return. The agency can usually reduce the bulk of the question section by designing industry-specific questionnaires instead of general questionnaires. Industry-specific questionnaires are designed specifically for one particular type of industry, as opposed to general questionnaires applicable to a whole group of industries. For example, it may be better to send an industry-specific questionnaire to a dry cleaning establishment and a multipage, general questionnaire to an organic solvent user.

The consideration of questionnaire format, however, must be balanced against the level of resources available to the agency conducting the inventory. It takes more money and manpower to design, mail out, and interpret industry-specific questionnaires than it does general questionnaires. Processing of industry-specific questionnaires is also more complex because the format of each questionnaire will vary. Furthermore, it is possible to send an inappropriate industry-specific questionnaire to a facility. On the other hand, general questions may be preferable if the agency's resources are limited or if the agency is unfamiliar with many of the sources. Inventories for specific pollutants may be most advantageously conducted with general questionnaires. Furthermore, general questionnaires may be more appropriate for large or complex facilities that are difficult to characterize. Most of these facilities will have engineers available to translate their process and emission information onto the forms.

If a general questionnaire must be used, it is important to provide a statement of applicability for each page. In addition, questionnaires that are organized so that all information about each emission point can be provided on one page are usually easier to fill out than questionnaires that have separate pages for process, emissions, control equipment, and stack information (subject-by-subject). For this reason, source-by-source questionnaires are usually considered the better format. However, if the questions are arranged by subject, industry-specific questionnaires can be designed by simply selecting the subject pages that apply to each industry. Then only a few supplementary pages of questions that are unique to an industry must then be formulated.

Another method that can minimize the level of effort required from the recipient, and therefore enhance the return rate, concerns the format of the questions. Multiple choice questions are the easiest type for recipients to answer. Many questions can easily be formatted as multiple choice. For example, a question that asks the recipient to describe or name the type of control device used can be improved by supplying a list of conceivable control devices and asking the recipient to put a check next to the appropriate answer. When needed, multiple choice questions can include the choice "other" with a blank beside it for entering out-of-the-ordinary controls. Other questions,

such as those that require exact numerical answers, can only be answered appropriately with a written response. If there are repetitive questions, the recipient could be asked to make a copy of a questionnaire for each point source or substance being inventoried.

### **Clarity of Instructions**

To be considered accurate, questionnaire responses must provide both the descriptive information desired and the correct numerical data. Every effort must be made not to confuse the recipient. Therefore, it is important to provide clear, complete instructions to decrease the chances of error in the responses. Instructions should be as concise as necessary. Units of measurement, method of calculations and conversions, and code number instructions should be put on the questionnaire itself and not explained in the instructions. This enables the recipient to read through instructions expediently without becoming caught up in too much detail.

In conclusion, general instructions should be as precise as possible. Some of the most effective questionnaire instructions are those which explain in detail how to answer each question. If a particular question requires special clarification, it is best to note special instructions on the same page as the question rather than print them on a separate instruction page.

The following types of information should be included when asking detailed questions:

- Specific Responses--printing the type of units wanted for an answer right next to the answer space. Using the multiple choice format;
- Samples--providing completed samples with the instructions for process flow, schematic and plant layout diagrams. Sample diagrams help the recipient to visualize what is expected; they are easiest to interpret if they are adjacent to the instructions;
- Standardized Forms--providing standardized forms when periodic inventory updates are performed. Regular recipients will eventually learn how to provide the correct responses. This is one condition under which a single generalized form for all facilities is efficient;
- Emissions Estimates--instructions for the inclusion of estimation methods used. Examples of estimation methods include: material balance, emission factors, source test results, models, and engineering judgments.

### **Final Considerations**

After a questionnaire is designed, it is good quality assurance procedure to check its effectiveness. This can be accomplished using a limited pilot mailing followed by site visits. This procedure provides a check on the effectiveness of the particular questionnaire package and its applicability



to different sources. A final possibility that may improve industry-agency relations would be to include a few questions at the end of the questionnaire or on a separate page for industry suggestions for future questionnaires or questions such as the following:

- Were the questions clear?
- Approximately how long did it take to complete the form?
- Were the questions applicable to your company?
- If you called for help and/or agency clarification, did we adequately respond?
- Was the time allowed after receiving the questionnaire adequate? If not, why?
- Please provide additional comments, if any.

This type of addition may indicate to the recipients a true concern to minimize industry paperwork, or at least the desire to work with industry to improve future questionnaires.

## **FOLLOW-UP PROCEDURES**

Follow-up can be as important or more important than the planning and effort expended in questionnaire design. The accuracy and completeness of responses must be checked and tabulated, and entered into a computer. Depending on how thorough the questionnaire instructions were explained with the mail-out, and whether deadlines were identified in the cover letter, a second major effort may be required to contact recipients who are delinquent in responding or to clarify items such as emissions units or estimates of control efficiencies. Some second effort can be expected, either for clarification of answers or for non-response. The following sections discuss the importance of such follow-up procedures such as data quality checks, the use of on-site inspections, and recontacting sources. Questionnaire revisions are also discussed.

### **Quality Control of Data**

All the questionnaires should be checked by engineers, chemists, or experienced environmental scientists to determine if the data provided are reasonable. It is helpful to ask for process flow and plant layout diagrams to aid in the interpretation of data. In addition, the best quality check would be performed by engineers or scientists who have worked in or are familiar with the industry. Finally, for similar processes and chemicals, total emissions can be compared against each other or checked against appropriate emissions factors to determine reasonableness. The extent that detailed checks can be done depends on the resources available to the agency, the number of sources included in the inventory, and the use of the data. It is suggested to recontact

a higher percentage of respondents that considered their usage lower than specified yearly amount, or as having no toxic emissions when their SIC code would suggest otherwise. Perhaps they only misunderstood the way the instructions were worded, or know their chemicals by a trade name instead of chemical composition. In any event, a follow-up call may increase the accuracy of the inventory.

### **On-Site Inspections**

For certain sources, it may be appropriate to consider plant visits if more specific information needs to be obtained for a particular program purpose, although this approach can become resource intensive and time consuming. Another approach is to do a preliminary screening and visit a very small percentage of facilities as part of a data quality control procedure. Also, it may be wise to visit a representative sample of respondents that checked the “not applicable” box, especially if the agency determines from cross referencing SIC codes, that the source has a potential to emit air toxic compounds.

Another less resource intensive approach may be to inspect the facility to check emission responses during the next regularly scheduled air compliance inspection. Most agencies periodically inspect major facilities within their jurisdiction. The problems that can be encountered using this approach is that air inspectors may need additional training before such inspections, because most regular air inspections involve criteria pollutants, or at the most select pollutants associated with NESHAPs or NSPS.

### **Recontacting Sources**

The return rate for the questionnaires can be increased by recontacting recipients that are delinquent in responding either by letter or by phone. This recontact reminds them that they will not be forgotten and may be subject to fine, and that a response is necessary. For other companies that may be confused by some of the questions, recontact provides them with a less embarrassing way to ask questions. This interaction is the most effective while the questionnaire is being initially completed, rather than having to return questionnaires to the industries for corrections. Using a pilot mailing will help get an idea of the average time recipients take to respond and how many recipients will need to be recontacted. In addition, a pilot mailing can provide an overview of the effectiveness of the questionnaire before the final mailing is done. Unnecessary recontacts should be minimized to avoid the possibility of some firms becoming uncooperative. Inventory efforts, after all, are not a one-time need. Yearly updates may be necessary.

### **Revising the Questionnaire**

The process of revising the questionnaire should be an evolving process. With each mail-out or updating of the inventory, the questionnaire or instructions for completing the questionnaire can be fine tuned or redirected to meet the developing program needs. But, as mentioned before,

industry will become familiar with questionnaire format that is not changed drastically from mailing to mailing. So, a carefully considered initial design is the best approach, and will reduce time needed for follow-up.

Some changes can be expected, such as:

- Promulgation of new regulations, stricter source registration requirements, or changes in reporting requirements;
- More EPA approved emission factors or more available stack test data;
- Increases in the number and types of compounds included;
- Changes in format of questions when agency installs or changes its data handling system; and
- Changes in control technology and/or control equipment efficiency.

Other changes may be made because of the widespread occurrence of wrong responses to a particular question. Still another kind of revision, but one that has much impact, are changes in various aspects of the inventory process, such as:

- Addition or deletion of the use of screening questionnaires;
- Changes in the cover letter, instructions or confidentiality provisions;
- Changes in the type of questionnaire, such as a change from open-ended to industry-specific questionnaires;
- Changes in the ways that the agency intends to use the data; and
- Changes in agency budgets and/or resources and manpower available for inventory efforts.

Perhaps the best way to proceed is not to plan in terms of needed emission inventory questionnaire revisions, but to continually focus on needed improvements, whatever the reasons turn out to be.

**Sample Survey Forms for the Dry Cleaning Industry**

Name of Facility: \_\_\_\_\_

Street Address: \_\_\_\_\_

City/State: \_\_\_\_\_

Contact Person: \_\_\_\_\_

Telephone Number: \_\_\_\_\_

—

**Please check the appropriate box describing your operation.**

1. Solvent Used	Amount Purchased Annually (gallons)
<input type="checkbox"/> PERC (Perchloroethylene)	_____
<input type="checkbox"/> Petroleum (Stoddard Solvent)	_____
<input type="checkbox"/> Other Petroleum Solvents	_____
<input type="checkbox"/> CFC-113 (Trichlorofluoroethane)	_____
<input type="checkbox"/> TCA (1,1,1-Trichloroethane)	_____
<input type="checkbox"/> Other	_____

### Sample Survey Forms for the Dry Cleaning Industry (Continued)

For each machine at your facility, please provide the following information:

Machine Type	Load Capacity (pounds of garments)	Estimated Solvent Use Per Load (gallons of solvent)	Controls in Place
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

For your entire facility, please estimate the amount of solvent sent for off-site disposal or recycling:

Solvent Type	Estimated (gallons/year)
PERC (Perchloroethylene)	_____
Petroleum Solvents:	_____
_____	_____
_____	_____
TCA (1,1,1 -Trichloroethane)	_____
CFC-113 (Trichlorofluoroethane)	_____
Other (please specify):	_____
_____	_____
_____	_____

For your facility, please estimate the average days per week and hours per day that dry cleaning equipment is operating:

\_\_\_\_\_ days per week \_\_\_\_\_ hours per day

Please list the number of employees at this facility:

\_\_\_\_\_ employees

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# APPENDIX G

## LIST OF EIIP PREFERRED AND ALTERNATIVE METHODS BY SOURCE CATEGORY (Current as of March 2001)

Source: *Handbook for Criteria Pollutant Inventory Development: A Beginner's Guide for Point and Area Sources, Appendix C.* EPA-454-/R-99-037, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, September 1999.

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**Table 1. List of EIIP Preferred and Alternative Methods  
by Source Category (Point Sources )**

Source Category	Estimation Methods, Preferred (P) or Alternative (A)						
	Material Balance	Emission Factors	Source Testing	CEM Data	Emission Models/ Predictive Monitoring <sup>a</sup>	Fuel Analysis	Engineering Calculations
Aircraft Manufacturing, Surface Coating	P, A	A	P, A		A		
Appliances, Surface Coating	P, A	A	P, A		A		
Automobiles and Light-duty Trucks, Surface Coating	P, A	A	P, A		A		
Automobile Refinishing, Surface Coating	P, A	A	P, A		A		
Equipment Leaks		A	A		P		
Flat Wood Product Manufacturing, Surface Coating	P, A	A	P, A		A		
Heavy-duty Truck Manufacturing, Surface Coating	P, A	A	P, A		A		
Hot-Mix Asphalt Plants		P	P	A	A	P	
Magnet Wire, Surface Coating	P, A	A	P, A		A		
Metal Cans, Surface Coating	P, A	A	P, A		A		
Metal Coil, Surface Coating	P, A	A	P, A		A		

**Table 1. List of EIIP Preferred and Alternative Methods  
by Source Category (Point Sources ) (Continued)**

Source Category	Estimation Methods, Preferred (P) or Alternative (A)						
	Material Balance	Emission Factors	Source Testing	CEM Data	Emission Models/ Predictive Monitoring <sup>a</sup>	Fuel Analysis	Engineering Calculations
Metal Furniture, Surface Coating	P, A	A	P, A		A		
Miscellaneous Metal Parts, Surface Coating	P, A	A	P, A		A		
Oil & Gas Field Production & Processing		P, A	A	A	P		
Paint and Ink Manufacturing	A	P, A	A		P		
Paper Coating, Surface Coating	P, A	A	P, A		A		
Plastic Products Manufacturing	P, A	A	P, A		A		
Plastic Parts, Surface Coating	P, A	A	P, A		A		
Secondary Metal Processing		P, A	P, A	P, A			
Semiconductor Manufacturing	P	A	P, A				A
Ships, Surface Coating	P, A	A	P, A		A		
Wastewater Collection and Treatment	A	A	A		P		A

**Table 1. List of EIIP Preferred and Alternative Methods  
by Source Category (Point Sources ) (Continued)**

Source Category	Estimation Methods, Preferred (P) or Alternative (A)						
	Material Balance	Emission Factors	Source Testing	CEM Data	Emission Models/ Predictive Monitoring <sup>a</sup>	Fuel Analysis	Engineering Calculations
Wood Furniture, Surface Coating	P, A	A	P, A		A		

<sup>a</sup> Predictive emission monitoring is an estimation method where emissions are correlated to process parameters based on demonstrated correlations.

Reference: *Emission Inventory Improvement Program Preferred and Alternative Methods*.  
Volume I, Introduction to the EIIP, and Volume II, Point Sources.

**Table 2. List of EIIP Preferred and Alternative Methods  
by Source Category (Area Sources)**

Source Category	Estimation Methods, Preferred (P) or Alternative (A)					
	Survey	Material Balance	Emission Factors	Top-Down Approach		
				Per-employee or Per-capita Emission Factors	Allocation of National Level Activity	Emission Estimation Models
Architectural Surface Coating	P	P		A	A	
Asphalt Paving	P, A	P	A			
Autobody Refinishing	P	P		A	A	
Consumer Solvents	A			P, A		
Dry Cleaning	P	P	P	A		
Gasoline Distribution, Stage I	P, A		P, A		A	
Gasoline Distribution, Stage II	P		P, A		A	P, A
Graphic Arts	P			A	A	
Industrial Surface Coating				P, A		
Landfills	P			A		P, A
Marine Vessel Loading, Ballasting and Transit	P		P			
Open Burning	P	A	P			

**Table 2. List of EIIP Preferred and Alternative Methods  
by Source Category (Area Sources) (Continued)**

Source Category	Estimation Methods, Preferred (P) or Alternative (A)					
	Survey	Material Balance	Emission Factors	Top-Down Approach		
				Per-employee or Per-capita Emission Factors	Allocation of National Level Activity	Emission Estimation Models
Pesticide Use, Agriculture	P, A	A	P, A			
Pesticide Use, NonAgriculture (Municipal, Commercial and Consumer)	P			A		
Residential Wood Combustion	P		P, A		A	
Solvent Cleaning	P, A		P	A	A	
Traffic Paints	P	P	P, A	A	A	

Reference: *Emission Inventory Improvement Program Preferred and Alternative Methods*.  
Volume III, Area Sources.

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# APPENDIX H

## POINT SOURCES EXAMPLE CALCULATIONS

Source: *Handbook for Criteria Pollutant Inventory Development: A Beginner's Guide for Point and Area Sources, Appendix D.* EPA-454-/R-99-037, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, September 1999.

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**Example 1-- Coal-fired Industrial Boiler (Emission Factors and Temporal Allocation)**

This example illustrates the procedures to calculate emissions from an industrial boiler firing anthracite coal.

**Assumed Operating Parameters**

Coal type: Anthracite  
Annual coal consumption: 928,000 tons per year (tpy)  
Ash content of coal: 7 percent  
Sulfur content of coal: 1.87 percent

Seasonal throughput fractions: Winter = 50%;  
Spring = 20%;  
Summer = 10%;  
Fall = 20%

Particulate emissions are controlled with a 75 percent efficient cyclone  
Sulfur oxides emissions are controlled with a 93 percent efficient limestone injection system.

Boiler Type: Traveling grate stoker

**AP-42 Emission Factors**

Section 1.2 of *AP-42* provides emission factors for pollutants from anthracite coal combustion in stoker fired boilers:

Total organic compounds (TOC): = 0.3 lb/ton (Table 1.2-6)  
Particulate matter (PM): = 0.8A lb/ton for PM-filterable and 0.08A lb/ton for PM-condensable where A is the ash content of coal in weight percent (Table 1.2-3)  
Lead (Pb): = 8.9E-03 lb/ton (Table 1.2-3)  
Nitrogen oxides (NO<sub>x</sub>): = 9 lb/ton (Table 1.2-1)  
Sulfur dioxide (SO<sub>2</sub>): = 39S lb/ton where S is the weight percent of sulfur in the coal (Table 1.2-1)  
Carbon monoxide (CO): = 0.6 lb/ton (Table 1.2-2)

### **Example 1-- Coal-fired Industrial Boiler (Emission Factors and Temporal Allocation) (Continued)**

#### Estimating Uncontrolled Emissions

The general equation for estimating uncontrolled emissions of TOC, Pb, NO<sub>x</sub>, CO, and CO<sub>2</sub> from anthracite coal combustion in boilers is as follows:

$$\text{Boiler Emissions} = \text{Annual Coal Consumption} \times \text{Emission Factor}$$

$$\begin{aligned} \text{TOC} &= 928,000 \text{ tons/year} \times 0.3 \text{ lb/ton} = 278,400 \text{ lb/year} = 139.2 \text{ tpy} \\ \text{Pb} &= 928,000 \text{ tons/year} \times 8.9\text{E-}03 \text{ lb/ton} = 8,259 \text{ lb/year} = 4.1 \text{ tpy} \\ \text{NO}_x &= 928,000 \text{ tons/year} \times 9 \text{ lb/ton} = 8,352,000 \text{ lb/year} = 4,176 \text{ tpy} \\ \text{CO} &= 928,000 \text{ tons/year} \times 0.6 \text{ lb/ton} = 556,800 \text{ lb/year} = 278 \text{ tpy} \end{aligned}$$

The general equation for estimating uncontrolled emissions of PM from anthracite coal combustion in boilers is as follows:

$$\begin{aligned} \text{PM Emissions} &= \text{Annual Coal Consumption} \times (\text{Emission Factor} \times \text{Coal Ash Content}) \\ \text{PM-Filterable} &= 928,000 \text{ tons/year} \times (0.8 \text{ lb/ton} \times 7) = 51,968 \text{ lb/year} \\ &= 25.98 \text{ tpy} \\ \text{PM-Condensable} &= 928,000 \text{ tons/year} \times (0.08 \text{ lb/ton} \times 7) = 5196.80 \text{ lb/year} \\ &= 2.598 \text{ tpy} \\ \text{Total PM} &= 25.98 \text{ tpy} + 2.598 \text{ tpy} = 28.58 \text{ tpy} \end{aligned}$$

The general equation for estimating uncontrolled emissions of SO<sub>2</sub> from anthracite coal combustion in boilers is as follows:

$$\begin{aligned} \text{SO}_2 \text{ Emissions} &= \text{Annual Coal Consumption} \times (\text{Emission Factor} \times \text{Coal Sulfur Content}) \\ \text{SO}_2 &= 928,000 \text{ tons/year} \times (39 \text{ lb/ton} \times 1.87) = 676,790.4 \text{ lb/year} \\ &= 338.4 \text{ tpy} \end{aligned}$$

**Example 1-- Coal-fired Industrial Boiler (Emission Factors and Temporal Allocation) (Continued)**Estimating Controlled Emissions

Particulate emissions are controlled with a 75 percent efficient cyclone and SO<sub>2</sub> emissions are controlled with a 93 percent efficient limestone injection system. The general equation for estimating controlled emissions of PM and SO<sub>2</sub> is as follows:

$$\text{Controlled Emissions} = \text{Uncontrolled Emissions} \times (1 - \text{Efficiency}/100)$$

$$\begin{aligned} \text{Total PM} &= 28.58 \text{ tpy} \times (1 - 75/100) = 28.58 \text{ tpy} \times (0.25) = 7.15 \text{ tpy} \\ \text{SO}_2 &= 338.4 \text{ tpy} \times (1 - 93/100) = 338.4 \text{ tpy} \times (0.07) = 23.7 \text{ tpy} \end{aligned}$$

Temporal Allocation of PM Emissions

The general equation for estimating seasonal emissions is as follows:

$$\text{Seasonal emissions} = \text{Seasonal throughput fraction} \times \text{annual emissions}$$

Therefore:

$$\begin{aligned} \text{Winter emissions of PM} &= 0.5 \times 7.15 \text{ tpy} = 3.575 \text{ tons} \\ \text{Spring emissions of PM} &= 0.2 \times 7.15 \text{ tpy} = 1.43 \text{ tons} \\ \text{Summer emissions of PM} &= 0.1 \times 7.15 \text{ tpy} = 0.715 \text{ tons} \\ \text{Fall emissions of PM} &= 0.2 \times 7.15 \text{ tpy} = 1.43 \text{ tons} \end{aligned}$$

### **Example 2--Natural Gas And Number 6 Fuel Oil Fired Industrial Boiler Emissions (Emission Factors)**

This example illustrates the use of *AP-42* emissions factors to estimate emissions from a small industrial boiler firing natural gas and Number 6 fuel oil.

#### Assumed Operating Parameters

##### *Natural Gas*

Annual Consumption: 99,885 MMBtu/year  
 Heating Value: 1,032 Btu/scf  
 Usage: 81% of the time

##### *#6 Oil*

Annual Consumption: 147,983 gal/year  
 Heating Value: 150,000 Btu/gal  
 Sulfur Content: 1 percent  
 Nitrogen Content: 0.4 percent  
 Usage: 19% of the time

#### AP-42 Emission Factors

Sections 1.3 and 1.4 of *AP-42* provide emission factors for pollutants from industrial boilers firing Number 6 fuel oil and natural gas, respectively.

##### *Natural Gas*

PM-Filterable:  $1.9 \text{ lb}/10^6 \text{ scf}$  (Table 1.4-2)  
 PM-Condensable:  $5.7 \text{ lb}/10^6 \text{ scf}$  (Table 1.4-2)  
 $\text{SO}_x$ :  $0.6 \text{ lb}/10^6 \text{ scf}$  as  $\text{SO}_2$  (Table 1.4-2)  
 $\text{NO}_x$  as  $\text{NO}_2$ :  $100 \text{ lb}/10^6 \text{ scf}$  as  $\text{NO}_2$  (Table 1.4-1)  
 CO:  $84 \text{ lb}/10^6 \text{ scf}$  (Table 1.4-1)  
 TOC:  $11 \text{ lb}/10^6 \text{ scf}$  (Table 1.4-2)

##### *Number 6 Fuel Oil*

All emission factors for Number 6 fuel oil are obtained from Table 1.3-1 in *AP-42* (except as noted) for boilers with firing rate less than 100 million Btu/hr:

CO:  $5 \text{ lb}/10^3 \text{ gal}$   
 Nonmethane Volatile Organics:  $0.28 \text{ lb}/10^3 \text{ gal}$  [Table 1.3-3]  
 Methane Volatile Organics:  $1 \text{ lb}/10^3 \text{ gal}$  [Table 1.3-3]  
 $\text{NO}_x$  as  $\text{NO}_2$ :  $[20.54 + (104.39 \times N)] \text{ lb}/10^3$  where N is the weight percent of nitrogen in the oil  
 $\text{NO}_2$  emission factor =  $20.54 + (104.39 \times 0.4) = 62.3 \text{ lb}/10^3 \text{ gal}$



### Example 2--Natural Gas And Number 6 Fuel Oil Fired Industrial Boiler Emissions (Emission Factors) Continued

Particulate Matter (PM):	[9.19(S) + 3.22] lb/10 <sup>3</sup> gal where S is the weight percent of sulfur in the oil PM emission factor = [9.19(1) + 3.22] lb/10 <sup>3</sup> gal = 12.41 lb/10 <sup>3</sup> gal
Sulfur Oxides as SO <sub>2</sub> :	157(S) lb/10 <sup>3</sup> gal where S is the weight percent of sulfur in the oil SO <sub>2</sub> emission factor = 157(1) = 157 lb/10 <sup>3</sup> gal
Sulfur Oxides as SO <sub>3</sub> :	2(S) lb/10 <sup>3</sup> gal where S is the weight percent of sulfur in the oil SO <sub>3</sub> emission factor = 2(1) = 2 lb/10 <sup>3</sup> gal

#### Estimating Uncontrolled Emissions by Fuel Type

##### *Natural Gas*

The general equation for estimating natural gas consumption in scf/year is as follows:

$$\begin{aligned}\text{Annual Consumption} &= \frac{\text{Annual Heat Input}}{\text{Natural Gas Heating Value}} \\ &= \frac{99,885 \times 10^6 \text{ Btu/year}}{1,032 \text{ Btu/scf}}, \quad 96.8 \times 10^6 \text{ scf/year}\end{aligned}$$

The general equation for estimating uncontrolled emissions from natural gas combustion is as follows:

$$\text{Natural Gas Emissions} = \text{Annual Gas Consumption} \times \text{Emission Factor}$$

PM-Filterable =	96.8x10 <sup>6</sup> scf/year x 1.9 lb/10 <sup>6</sup> scf = 184 lb/year = 0.09 tpy
PM-Condensable =	96.8x10 <sup>6</sup> scf/year x 5.7 lb/10 <sup>6</sup> scf = 552 lb/year = 0.28 tpy
SO <sub>x</sub> =	96.8x10 <sup>6</sup> scf/year x 0.6 lb/10 <sup>6</sup> scf = 58 lb/year = 0.03 tpy
NO <sub>x</sub> =	96.8x10 <sup>6</sup> scf/year x 100 lb/10 <sup>6</sup> scf = 9,680 lb/year = 4.8 tpy
CO =	96.8x10 <sup>6</sup> scf/year x 84 lb/10 <sup>6</sup> scf = 8,132 lb/year = 4.07 tpy
TOC =	96.8x10 <sup>6</sup> scf/year x 11 lb/10 <sup>6</sup> scf = 1,064.8 lb/year = 0.53 tpy

Total PM emissions from the combustion of natural gas is given by the following equation:

$$\begin{aligned}\text{Total PM Emissions} &= \text{PM-Filterable} + \text{PM-Condensable} \\ &= 0.09 \text{ tpy} + 0.28 \text{ tpy} = 0.37 \text{ tpy}\end{aligned}$$

### Example 2--Natural Gas And Number 6 Fuel Oil Fired Industrial Boiler Emissions (Emission Factors) (Continued)

#### Number 6 Fuel Oil

The general equation for estimating uncontrolled emissions from Number 6 fuel oil combustion in an industrial boiler is as follows:

$$\text{Number 6 Fuel Oil Emissions} = \text{Annual Fuel Oil Consumption} \times \text{Emission Factor}$$

PM	=	147,983 gal/year x 12.41 lb/10 <sup>3</sup> gal = 1,836 lb/year = 0.92 tpy
SO <sub>x</sub> as SO <sub>2</sub>	=	147,983 gal/year x 157 lb/10 <sup>3</sup> gal = 23,233 lb/year = 11.6 tpy
SO <sub>x</sub> as SO <sub>3</sub>	=	147,983 gal/year x 2 lb/10 <sup>3</sup> gal = 296 lb/year = 0.15 tpy
NO <sub>x</sub> as NO <sub>2</sub>	=	147,983 gal/year x 62.3 lb/10 <sup>3</sup> gal = 9,219 lb/year = 4.6 tpy
CO	=	147,983 gal/year x 5 lb/10 <sup>3</sup> gal = 740 lb/year = 0.37 tpy
Nonmethane Volatile Organics	=	147,983 gal/year x 0.28 lb/10 <sup>3</sup> gal = 41.44 lb/year = 0.021 tpy
Methane Volatile Organics	=	147,983 gal/year x 1 lb/10 <sup>3</sup> gal = 148 lb/year = 0.074 tpy

Total SO<sub>x</sub> emissions from the combustion of Number 6 fuel oil is given by the following equation:

$$\text{SO}_x \text{ Emissions} = \text{SO}_2 \text{ emissions} + \text{SO}_3 \text{ emissions} = 11.6 + 0.15 = 11.75 \text{ tpy}$$

Total Volatile Organic emissions from the combustion of Number 6 fuel oil is given by the following equation:

Total Organic Emissions	=	Nonmethane Volatile Organics + Methane Volatile Organics
	=	0.021 tpy + 0.074 tpy = 0.095 tpy

#### Estimating Total Uncontrolled Emissions

$$\text{Total Emissions} = \text{Natural Gas Emissions} + \text{Number 6 Fuel Oil Emissions}$$

Total PM	=	0.37 tpy + 0.92 tpy = 1.29 tpy
Total SO <sub>x</sub>	=	0.03 tpy + 11.75 tpy = 11.78 tpy
Total NO <sub>x</sub>	=	4.8 tpy + 4.6 tpy = 9.4 tpy
Total CO	=	4.07 tpy + 0.37 tpy = 4.44 tpy
Total TOC	=	0.53 tpy + 0.095 tpy = 0.625 tpy

**Example 3--Copper Coil Manufacturing (Mass Balance)**

This example illustrates the use of material (mass) balances as a method for estimating emissions from a metal rolling unit that processes copper coil. Prior to a rolling step, copper coil is sprayed with oil for lubrication and heat dispersion. After rolling, the copper coil is sent to an annealer which has been shown to destroy 85 percent of the oil during the heat treatment of the copper coil. Negligible amounts of oil remain on the copper coil after annealing. The oil is assumed to be 100 percent VOC. The VOC emissions associated with this process occur from volatilization of lubricating oil during its application prior to rolling as well as the undestroyed oil exhausted from the annealer.

Assumed Operating Parameters

Mass of copper coil processed:	5,000 kg
Mass of copper coil and oil sent to annealer:	5,075 kg
Mass of lubricating oil sprayed onto the copper:	3,000 kg
Mass of lubricating oil recovered:	2,800 kg

Estimating Emissions

The general formula to complete a material balance is represented by:

$$\text{Input} + \text{Generation} - \text{Output} - \text{Consumption} = \text{Accumulation}$$

where:

Input:	mass entering the process
Generation:	mass produced in the process
Output:	mass exiting the process
Consumption:	mass consumed in the process
Accumulation:	mass that builds up within the process

For this example, the parameters listed above are described as:

Input:	mass of lubricating oil applied (3,000 kg)
Generation:	not applicable/no material generation (0 kg)
Output:	mass of oil lost as an emission
Consumption:	mass of oil destroyed in the annealer
Accumulation:	mass of lubricating oil recovered (2,800 kg)

The estimate for the Consumption parameter is calculated from the mass of copper coil processed, the mass of copper coil and oil sent to the annealer, and the oil destruction efficiency as it is exposed to high temperatures in the annealer.

**Example 3--Copper Coil Manufacturing (Mass Balance) (Continued)**

$$\begin{aligned}\text{Consumption} &= (\text{mass of coil/oil to annealer} - \text{mass of coil processed}) \times 85 \text{ percent} \\ &= (5,075 \text{ kg} - 5,000 \text{ kg}) \times 0.85 \\ &= 64 \text{ kg oil destroyed in the annealer}\end{aligned}$$

After simplifying the material balance formula, the estimate of the Output (emissions) from this process is:

$$\text{Input} - \text{Output} - \text{Consumption} = \text{Accumulation}$$

Or:

$$\text{Output} = \text{Input} - \text{Consumption} - \text{Accumulation}$$

$$\text{Output} = 3,000 \text{ kg} - 64 \text{ kg} - 2,800 \text{ kg}$$

$$\text{Output} = 136 \text{ kg}$$

The VOC emissions associated with this process are thus 136 kg oil per 5,000 kg of copper coil processed, or 0.027 kg oil per kg of copper coil processed.

**Example 4-- Paint Manufacturing (Source Test Data)**

This example illustrates the use of source test data to estimate process emissions from a spray booth at a paint manufacturing facility. The materials emitted from the spray booth stack are assumed to be 100 percent VOC.

Assumed Operating Parameters

Stack flow rate:	50,000 scm/hr
Average measured VOC concentration from stack:	0.005 kg VOC/scm
Spray booth annual operation:	2,080 hr/year

Estimating Emissions

Since the source testing provided a VOC concentration and the average stack exhaust flow rate, the concentration can be converted to a mass flow rate:

$$\begin{aligned}\text{Mass Flow rate} &= \text{volumetric flow rate} \times \text{concentration} \\ &= 50,000 \text{ scm/hr} \times 0.005 \text{ kg VOC/scm} \\ &= 250 \text{ kg VOC/hr}\end{aligned}$$

The annual VOC emissions can then be estimated using the mass flow rate and the annual hours of operation for the paint spray booth:

$$\begin{aligned}\text{Emissions} &= \text{mass flow rate} \times \text{annual hours operation} \\ &= 250 \text{ kg VOC/hr} \times 2,080 \text{ hr/yr} \\ &= 520,000 \text{ kg VOC/yr or 520 metric tons}\end{aligned}$$

**Example 5 -- Boiler Emissions (Source Testing)**

This example illustrates the procedure to estimate lead emissions from a boiler using stack testing results.

Assumed Operating Parameters

The results of these stack sampling test runs show that the average concentration of lead (Pb) in the stack gas is 0.0005 pound per dry standard cubic feet (lb/dscf) and the average stack gas volumetric flow rate is 51,700 dry standard cubic feet per minute (dscf/min). The boiler operates 5,840 hours per year, and is equipped with a multicyclone.

Calculating Pb Emissions

The Pb emission rate is calculated as follows:

$$\begin{aligned}\text{Pb Emission Rate} &= \text{Pb concentration} \times \text{stack gas flow rate} \\ &= 0.0005 \text{ lb/dscf} \times 51,700 \text{ dscf/min} \times 60 \text{ min/hr} \\ &= 1,551 \text{ lb/hr}\end{aligned}$$

$$\text{Annual Pb Emissions} = 1,551 \text{ lb/hr} \times 5,840 \text{ hr/yr} \times 1 \text{ ton}/2,000 \text{ lb} = 4,528 \text{ tpy}$$

**Example 6--Boiler Emissions (CEM Data)**

This example illustrates how average SO<sub>2</sub> emissions can be calculated based on raw CEM data.

Assumed Operating Parameters

Example CEM output for a boiler burning fuel oil is provided in the following table:

Period	O <sub>2</sub> (%V)	SO <sub>2</sub> (ppmv)	Stack Gas Flow Rate (dscfm)
11:00	2.1	1,004.0	155,087
11:15	2.0	1,100.0	155,943
11:30	2.1	1,050.0	155,087
11:45	1.9	1,070.0	154,122
12:00	1.9	1,070.0	156,123
Average	2.0	1,058.8	155,272

HHV: Fuel heating value: 18,000 Btu/lb

SO<sub>2</sub>: Molecular weight: 64 lb/lb-mole

V: Molar volume: 385.5 ft<sup>3</sup>/lb-mole at 68°F and 1 atm

Q<sub>f</sub>: Mass fuel throughput: 46,000 lb/hr

OpHrs: Total annual hours of operation: 5,400 hours

Calculating Hourly Emissions of SO<sub>2</sub>

$$E_{\text{SO}_2} = \frac{(C \times \text{MW} \times Q \times 60)}{(V \times 10^6)}$$

Where:

C: Parts per million by volume dry air (ppmvd)

MW: Molecular weight in lb/lb-mole

Q: Flow rate in dry standard cubic feet per minute (dscfm)

V: molar volume in cubic feet (ft<sup>3</sup>)/lb-mole

**Example 6--Boiler Emissions (CEM Data) (Continued)**

$$E_{SO_2} = \frac{1,058.8 \times 64 \times 155,272 \times 60}{385.5 \times 10^6} = 1,637 \text{ lb/hr}$$

Calculating Heat Input

$$H_{in} = \frac{(Q_f \times HHV)}{(10^6)}$$

$$H_{in} = \frac{46,000 \times 18,000}{10^6} = 828 \text{ MMBtu/hr}$$

Developing SO<sub>2</sub> Emission factors

An SO<sub>2</sub> emission factor expressed as lb/MMBtu is calculated as follows:

$$EF_{SO_2} = \frac{E_{SO_2}}{H_{in}} = \frac{1,637 \text{ lb/hr}}{828 \text{ MMBtu/hr}} = 1.98 \text{ lb/MMBtu}$$

Calculating Annual SO<sub>2</sub> Emissions

Annual SO<sub>2</sub> Emissions = hourly SO<sub>2</sub> emissions × O<sub>p</sub>Hrs

$$= \frac{(1,637 \text{ lb/hr} \times 5,400 \text{ hrs})}{(2,000 \text{ lb/ton})} = 4,419 \text{ tons per year}$$



**Example 7--Boiler Emissions (Fuel Analysis)**

This example illustrates how SO<sub>2</sub> emissions from fuel combustion can be calculated using fuel analysis results.

Assumed Operating Parameters

Sulfur content of fuel: 1% by weight  
 Fuel throughput: 5,000 lb/hr  
 Hours of operation: 8,760 hours/year

Calculating SO<sub>2</sub> emissions:

The basic equation in fuel analysis emission calculation is:

$$E = Q_f \times \text{pollutant concentration in fuel} \times (MW_p/MW_f)$$

Where:

$Q_f$  = Throughput of fuel in lb/hr  
 $MW_p$  = Molecular weight of pollutant emitted (lb/lb-mole)  
 $MW_f$  = Molecular weight of pollutant in fuel (lb/lb-mole)

In this example,  $MW_p = 32 + (16 \times 2) = 64$  lb/lb-mole  
 $MW_f = 32$  lb/lb-mole

Therefore,  $E_{SO_2} = 5,000 \text{ lb/hr} \times 0.01 \times (64/32)$

$$= 100 \text{ lb/hr}$$

$$= 100 \text{ lb/hr} \times 8,760 \text{ hr/yr} \times \frac{1 \text{ ton}}{2,000 \text{ lbs}}$$

$$= 438 \text{ tons/year of SO}_2$$

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# APPENDIX I

## CONTACTS

Source: *Handbook for Criteria Pollutant Inventory Development: A Beginner's Guide for Point and Area Sources, Appendix P.* EPA-454-/R-99-037, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, September 1999.

EIIP, Volume I, Chapter 1, Appendix C, *Introduction to Stationary Point Source Emission Inventory Development.* July 1997.

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**APPENDIX II**

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## **APPENDIX I2**

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# APPENDIX J

## CLEARING UP THE RULE EFFECTIVENESS CONFUSION

Source: *Handbook for Criteria Pollutant Inventory Development: A Beginner's Guide for Point and Area Sources, Appendix B.* EPA-454-/R-99-037, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, September 1999.

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## Clearing Up the Rule Effectiveness Confusion

### Introduction

Since its formation, EPA has been implementing rules and regulations that require states to reduce the amount of pollution being emitted into the atmosphere. Achieving the air quality anticipated by implementing a particular rule has not always been successful despite imposition of numerous emission controls. In 1987 EPA acknowledged that existing air quality regulations were not resulting in sufficient emission reductions to reach acceptable levels of air quality. The November 24, 1987 Federal Register said “The EPA believes that one reason ozone levels have not declined as much as expected is that reductions from national and local control measures have not been as high as expected.”<sup>1</sup> This Federal Register further stated that “the effectiveness (i.e., the ratio of actual reductions to expected reductions expressed as a percentage) of some rules is much lower than 100 percent.” To correct or compensate for the lower than anticipated amount of reductions, the Federal Register notice stated that “for both new and existing rules, EPA proposes to allow States to assume not more than 80 percent of full effectiveness unless adequate higher levels are adequately demonstrated.” Said another way, “we don’t believe your rule will get as much reduction as you think it will.” This under-performance can result from:

- Some sources not implementing (or not implementing all the time) controls required by the rule;
- Some sources not installing sufficient control equipment to achieve required emission rate;
- Some sources operating installed control equipment at less than rated control efficiency;
- New source being introduced into the local area covered by the rule.

Any of these situations could result in attainment year emissions being higher than anticipated. Even though an individual source’s emission rate is reduced to that specified in a state rule, the overall reduction within the state may not be as great because of the above considerations.

The 1987 Federal Register<sup>1</sup> defines “effectiveness” as:

$$\text{Effectiveness} = \frac{\text{Actual Reductions}}{\text{Expected Reductions}} \quad (1)$$

For complete compliance to occur, effectiveness must equal 100 percent. This Federal Register recognizes however, that effectiveness is usually not 100 percent. To adjust for non-compliance, the Federal Register limits the amount of reduction that a state can anticipate. This forces policy

planners to account for less than complete compliance. For example, if an agency implemented a rule to reduce emissions by 100 tpy (expected reduction), the Federal Register suggests that the actual reduction will not be as great as the expected reduction (Equation 1). For the 100 tpy goal to be met (i.e., “effectiveness” to be 100 percent), the actual reduction in Equation 1 must be modified as follows:

$$\text{Effectiveness} = \frac{\text{Reduction Target} \times (\text{Empirical Factor})}{\text{Expected Reduction}} \quad (2)$$

Where:

Expected Reduction = Emission reduction required as estimated by modeling to meet air quality standard

In this example, Equation 2 becomes:

$$100\% = \frac{\text{Reduction Target} \times 0.8}{100}$$

Solving for Reduction target: Reduction target = 125 tpy

Policy makers then develop control strategies based on this Reduction target value. If an agency implements a rule to reduce emissions by 100 tpy, the policy makers must target a 125 tpy reduction to be able to achieve the needed 100 tpy. Note that the results of equation 2 do not reflect the accuracy of the emission estimates, but only adjust for the past history of complying with a new rule.

The 1992 Federal Register<sup>2</sup> defines rule effectiveness as:

$$\text{Rule Effectiveness (RE)} = \frac{\text{Actual Reduction}}{\text{Expected Reduction}} \quad (3)$$

Where:

Actual reduction = (base year emissions) - (current year emission estimates)

In Equation 3, the new term “RE” is an indicator that compares the amount of actual emission reduction to the expected reduction. This metric is useful to decision makers as they evaluate how well their policies are achieving the intended goals or how effective the rule is in achieving expected reductions. For example, assume an agency modeling exercise indicated that 100 tpy

reduction is needed in 10 years to be able to reach attainment status. Also assume the base year inventory is 200 tpy. If a 50 tpy reduction is achieved 5 years into the implementation period, then the RE =  $(200 - 150)/100 = 50$  percent. At the end of 10 years, if the entire 100 tpy has been removed, then the RE =  $(200 - 100)/100 = 100$  percent.

Introducing the factors contained in these equations acknowledges the reality that, in an imperfect world, a rule intended to reduce emissions and improve air quality does not always work as planned. Equation 2 offers, for planning purposes, an empirical solution to this problem while Equation 3 measures the effectiveness of the solution after controls are implemented. The empirical approach assumes that only 80 percent (or higher if an agency can substantiate) of the required control will be achieved. To offset this shortfall, additional controls are needed. This concept was further supported in the April 16, 1992 Federal Register.<sup>2</sup> Under III(A)(2)(a)(2) it is stated that “one hundred percent rule effectiveness is the ability of a regulatory program to achieve all the emission reductions at all sources at all times.” The “extra” controls in Equation 2 compensate for parts of the air quality strategy that are not completely implemented “at all of the sources all of the time”.

As the air quality control community became more sophisticated, it realized that other causes could be contributing to the inability to reach acceptable air quality levels. Two areas of concern are the accuracy of air quality model predictions (air quality modeling issues will not be addressed in this discussion) and the accuracy of the emission inventory accounting process (quantity of emissions represented in the inventory). Policy makers use emission estimates to help develop new rules that will cause the removal of a specified quantity of pollutant. They assume that removing this amount of pollutant will lead to acceptable air quality. The amount to be removed is usually selected as a result of various air quality modeling exercises. If the initial quantity of emissions used in the model calculations is incorrect, then the amount of pollutant to be reduced, as calculated by the model, may also be incorrect.

To offset an assumed underestimate of emissions, states are required to apply a compensation factor to facility control device efficiency values. This action has the effect of reducing the assumed efficiency of the control device (a reasonable assumption since control equipment may fail, be off line due to equipment maintenance, and process upsets occur) and increasing individual source emission estimates. This factor, also called Rule Effectiveness, has a default value of 80 percent.

Very few sources measure their emissions directly using continuous emission monitors (CEM). Uncontrolled emissions at sources not monitored by CEMs are estimated using the following equation:

$$\text{Emissions} = \text{Emission Factor} \times \text{Activity Data} \quad (4)$$

If RE is used, the equation to calculate emissions from a facility containing a control device becomes:

$$\text{Emissions} = \text{Emission Factor} \times \text{Activity Data} \times (1 - \text{CE} \times \text{RE}) \quad (5)$$

Where:

CE = manufacturer stated control efficiency

The definition of RE in Equations 3 and in Equation 5 are very different. Equation 3 provides policy makers with a method to measure the amount of reduction at a point in time and judge the success of a particular rule. Equation 5 adjusts individual facility estimates to compensate for assessment techniques that do not account for all emissions. Even though the philosophy behind the emission adjustments is different in each case, the same term - RE, is used for both situations.

### Why Confusion Exists

In 1992, EPA issued “Guidelines for Estimating and Applying Rule Effectiveness for Ozone/CO State Implementation Plan Base Year Inventories.”<sup>3</sup> Under section 1.2 the document states “The appropriate method for determining and using RE depends upon the purpose for the determination: compliance program or inventory. RE discussed outside the particular purpose may be generically referred to as control effectiveness. The following three common uses for a control effectiveness estimate have historically been called rule effectiveness:

- Identifying and addressing weakness in control strategies and regulations related to compliance and enforcement activities (more accurately call *Compliance Effectiveness*);
- Defining or redefining the control strategy necessary to achieve the required emissions reductions designated in the CAAA (more accurately called *Program or SIP Design Effectiveness*); and
- Improving the accuracy or representativeness of emission estimates across a nonattainment area (hereafter called *Rule Effectiveness*)” (3)

“The inventory RE is an adjustment to estimated emissions data to account for the emissions underestimates due to compliance failures and the inability of most inventory techniques to include these failures in an emission estimate. The RE adjustment accounts for known underestimates due to noncompliance with existing rules, control equipment downtime or operating problems and process upsets. The result is a better estimate of expected emission reductions and control measure effectiveness in future years”.<sup>3</sup>

Previous paragraphs provide definitions of Compliance effectiveness and Rule effectiveness and try to make a distinction between the two. Despite these distinctions, the second sentence of the preceding paragraph inadvisely combines concepts of both rule noncompliance and the problem of overestimating collection efficiency of control equipment. Even though there is a recognition that the two situations are different, the RE term is used interchangeably in each of these examples.

Rule Effectiveness Guidance: Integration of Inventory, Compliance, and Assessment Applications was issued in January 1994.<sup>4</sup> In the Introduction, the document states that “Rule Effectiveness (RE) is a generic term for identifying and estimating the uncertainty in emission estimates caused by failures and uncertainties in emission control programs. It is a measure of the extent to which a rule actually achieves its desired emission reductions.” Implying a second definition, the Introduction further states that “rule effectiveness accounts for identifiable emission underestimates due to factors including noncompliance with existing rules, control equipment downtime, operating and maintenance problems, and upsets.” As was previously noted, the RE term is again used in different contexts within the same section of the same document.

This Guidance document contributes further to the confusion by using apparently different definitions of rule effectiveness.<sup>4</sup> The Glossary defines Rule Effectiveness as “a generic term for identifying and estimating the uncertainties in emission estimates caused by failures and uncertainties in emission control programs. Literally, it is the extent to which a rule achieves the desired emission reductions.”

Based on past history it is understandable that, over time, the inventory community has used RE to describe different situations and often interchanging the definitions during the same discussion. The RE definition has evolved, taking on slightly different meanings, depending on the group using the term and the program to which it is being applied. Confusion results because the inventory community often uses the term RE without indicating the context in which it is being applied. Mangat, in a paper presented at an emission inventory conference in 1992 and in a subsequent EIIP paper, recognized that dissimilar definitions were being used and tried to explain the differences.<sup>5, 6</sup>

### Solutions to the Confusion

RE is currently being used to describe and solve unrelated problems. In one case it is being used to address the failure of control equipment to operate at its stated efficiency for 100 percent of the time. In the second case RE is being used to address the failure of people to implement a rule with the required vigor.

Applying an adjustment factor is a valid approach in each of these situations. Unfortunately, the same term (RE) is used to describe and address both cases. The inventory community does not need more jargon. However, a solution to the current dilemma is to abandon the RE name and replace it with two distinctive terms, each describing specifically the situation in which it applies.

Separate definitions should allow those interested in measuring how well a rule is achieving its intended reductions to determine those results. Those interested in adjusting actual emission estimates to compensate for upsets, downtime, etc could also meet their needs. Each new term is described below.

The **Practical Compliance Index (PCI)** is to be used by those in policy positions to measure how well a rule is achieving its intended results. The PCI is a measure of the extent to which a rule actually accomplishes its desired emission reductions. For example, if a new rule has a PCI of 80 percent, it has caused 80 percent of the needed emission reductions to occur. A 100 percent of the expected reductions did not (has not) occurred because not all facilities implemented controls mandated by the rule, some facilities did not control at the emission rate required by the rule, or unanticipated growth occurred in the area. Additionally, policy makers using historical PCI values can develop realistic control strategies for their area.

The **Operational Adjustment Factor (OAF)** is to be used to adjust control efficiency ratings of control devices. Adjustments are necessary due to control equipment down time, subpar control device operations, and process upsets. Current methods of estimating emissions do not account for these situations. The OAF will not be used to adjust emission factors, activity data, or direct measurement of emissions.

#### How to Apply a PCI and an OAF

##### **PCI**

Air quality modeling is performed to support new rule development. Models are run to determine how much pollutant should be removed from the air to reach an acceptable ambient air quality concentration level. When the new rule is implemented, a strategy is developed, based on model results, that describes the sources to be controlled and the acceptable emission rate of each source.

The Practical Compliance Index (PCI) provides policy makers with two tools. The Index measures how well the control strategy is progressing toward reaching the air quality goal. The PCI is calculated by:

$$\text{PCI} = \frac{(\text{Base Year Emission Estimate}) \& (\text{Current Year Emission Estimate})}{\text{Expected Reduction}} \quad (6)$$

The PCI measures progress toward meeting the new emission target in the designated attainment year. PCI can be calculated periodically to provide policy makers with information on how the policy is being implemented and the extent of compliance with new control requirements.

Past experience has shown that, even if after a new rule is fully implemented, the ambient air quality level still exceeds the standard. One reason for this failure is lack of compliance with a new rule. Policy makers can use this information to increase the likelihood that future emission targets will be met. This can be done by using an empirically derived factor is used to adjust Equation 6. Even though the air quality modeling indicates a certain number of tons of pollutant are needed to be removed to reach the standard, practical experience shows that, without additional emphasis, this target will not be reached. The compensation factor in Equation 6a offsets this lack of compliance. If the goal is to achieve a 100 percent PCI, then Equation 6 becomes:

$$PCI = \frac{\text{Reduction Target} \times \text{Compensation Factor}}{\text{Expected Reduction}} \quad (6a)$$

Where:

Compensation factor has a default value of 80 percent

The denominator is the amount of reduction necessary, as calculated by air quality modeling, to achieve acceptable ambient air pollutant levels. By setting the PCI to 1 (100 percent) and solving for the Reduction target in the numerator, policy makers will know how much pollutant reduction should be targeted for their control strategies. The compensation factor is analogous to the definition of RE in Equation 3. Guidance currently being used to calculate a RE factor can be used to estimate the compensation factor in Equation 6a.

## OAF

An inventory is composed of data that are used to estimate emissions. It contains information on control efficiencies of the devices connected to the processes being inventoried. Actual emissions are estimated either from direct measurements of the source or from calculations using variables contained in the inventory. The most common approach to estimating emissions is to select an emission factor associated with a process and combine it with the activity (thruput) of the operations. This amount is adjusted by the control efficiency of the devices attached to the process. The final product is an estimate of pollutant emitted to the atmosphere. Actual emissions are calculated by:

$$\text{Actual Emissions} = (\text{Emission Factor})_{\text{unctl}} \times (\text{Activity Data}) \times (1 - \text{Control Efficiency} \times \text{OAF}) \quad (7)$$

There are several inaccuracies associated with this approach. Even though the precision of the emission factor or activity estimate may be poor, there is usually no quantifiable bias associated with these values. However, because of operational process upsets, down time of the control device, and maintenance of the control equipment, overall control efficiency of the devices attached to the process is not as great as stated by the manufacturers. This introduces a bias into

the emission estimating process that is known qualitatively, but is not accounted for in the inventory.

Equation 7 assumes there is no bias in the emission factor or activity data and that the control device operates at 100 percent of its design efficiency all the time the process is running. To reflect reality, control efficiency should be adjusted for process upsets and control device downtime. Equation 7 then becomes:

$$\text{Actual Emissions} = (\text{Emission Factor})_{\text{unctl}} \times (\text{Activity Data}) \times (1 - \text{Control Efficiency} \times \text{OAF}) \quad (8)$$

$$\text{Where: OAF} = 1 - \frac{(\text{Tons by \& passing control device})}{[\text{Tons Collected (tpy)}] \% [\text{Tons by \& passing cor}]}$$

The OAF is determined by examining operating records for a control device or family of devices. The amount of time it is operating, the number of process upsets, and the quantity of pollutant that bypasses the control device during these periods can be used to create the OAF.

Recently, some emission rates are being combined with process control efficiencies to form an emission factor that consists of a process-control device combination. Equation 8a is used when the emission factor incorporates control efficiency.

$$\text{Actual Emissions} = (\text{Emission Factor})_{\text{ctl}} \times (\text{Activity Data}) \times (1/\text{CE} - \text{OAF}) \quad (8a)$$

### Summary

The emission inventory community has been using RE for almost a decade. Even though the term has been used interchangeably in totally different applications, the distinctions have been poorly understood. New terminology proposed in this paper should correct this problem. The PCI measures the degree to which a rule is being implemented (by measuring the amount of actual reduction and comparing it to the expected reduction). It is based on historical results from past rule implementation efforts or from recent surveys that indicate the degree of compliance to be expected. The PCI compensates for the failure of people to fully implement a rule.

The OAF is a function of control equipment efficiency, the adequacy of equipment maintenance, equipment reliability, and the stability of a process. This information is available from records maintained at each facility. The OAF compensates for the failure of equipment to perform at its stated capacity.



Next Steps

- Determine how this proposed approach affects existing data;
- Determine how existing guidance must be changed to reflect new approach;
- Decide what to do about previously reported data that has RE applied; and
- Develop new guidance explaining use of PCI and OAF.

References

1. Federal Register, Vol. 52, No. 226, Tuesday, November 24, 1987, p45059.
2. Federal Register, Vol. 57, No. 74, Part III, Thursday, April 16, 1992.
3. "Guidelines for Estimating and Applying Rule Effectiveness for ozone/CO State Implementation Plan Base year Inventories," November 1992, EPA-452/R-92-010
4. "Rule Effectiveness Guidance: Integration of Inventory, Compliance, and Assessment Applications," January 1994, EPA-452/4-94-001.
5. "Developing Present and Future Year Emissions Inventories Using Rule Effectiveness Factors", presented at the International Conference and course, Emission Inventory Issues, Durham, NC, October 1992.
6. "Emission Inventories and Proper Use of Rule Effectiveness,"  
*[http://www.epa.gov/ttn/chief/eiip/committee/point\\_sources/pointsrc.html](http://www.epa.gov/ttn/chief/eiip/committee/point_sources/pointsrc.html)*, draft report, October 1998.

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# APPENDIX K

## OPTIONS FOR DATA REPORTING

Source: *Handbook for Criteria Pollutant Inventory Development: A Beginner's Guide for Point and Area Sources, Appendix I.* EPA-454-/R-99-037, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, September 1999.

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## Options for Data Reporting

You can submit your data to EPA using one of several data transfer options. The appropriate data transfer method is identified during the planning stage of the inventory process, based on the end use of the inventory and availability of resources.

At this time the NET Input Format and the AIRS/AFS are equally viable options for submitting the point source data. The NET Input Format is the preferred option for submitting area data. You should keep in mind that information technology is a rapidly changing field, and electronic reporting of inventory data is an evolving issue. Refer to the EPA Data Submission page at <http://www.epa.gov/ttn/chief/ei/eisubmit.html> for updates on emissions reporting.

Four options are available for data reporting:

- **Aerometric Information Retrieval System/Aerometric Information Retrieval Facility Subsystem (AIRS/AFS)** - AIRS is a computer-based system for the storage and retrieval of ambient air quality monitoring data and emissions and compliance data for individual facilities. AFS contains emissions, compliance, and permit data for point sources regulated or tracked by federal, state, and local air pollution agencies.

This is the option that has been used for transferring SIP and annual emission inventory data to EPA. This option may be used to transfer **only point source data**. State and local agencies can upload industrial facility data directly to AIRS/AFS. EPA will extract the point source data submitted to AIRS/AFS and translate it into a format compatible with storage in the EPA National Emissions Trends (NET) database. You can find more information on the use of this option on the World Wide Web at <http://www.epa.gov/airsdata>.

For states that submit point source data via AIRS/AFS, it is necessary to use one of the other data transfer options to submit area, mobile, and biogenic data. Note, However, that the emissions component of AIRS/AFS will be phased out by the end of September, 2000, and the data transferred to the NET format. You should consult the AIRS/AFS Web site at <http://www.epa.gov/ttn/airs/afs/index.html> for the latest memos and information on the plans to migrate the emissions component of AIRS/AFS to the NET database.

- **NET Input Format** - The NET is an Oracle database that contains emission estimates of carbon monoxide, nitrogen oxides, sulfur dioxide, volatile organic compounds, particulate matter, lead, hazardous air pollutants, and ammonia from point, area, nonroad mobile, onroad mobile, and biogenic sources. The Emission

Factor and Inventory Group is redesigning its NET database in Oracle using the EIIP Phase I Data Model as one of the primary design criteria.

The NET Input Format creates relational, normalized data sets which conform to the relational standards and structure of the NET Oracle database. The flexibility of the format design enables it to be mapped to a wide variety of alternative database structures (e.g., state/local systems, EPA systems). By avoiding duplication of data, the data set(s) created in this format are optimized in terms of the file space and the time it takes for electronic transfer to EPA.

**EFIG will process and load the NET input files into its NET database system.**

You should note that point source data submitted to the NET will **not** be transferred to AFS. If you are interested in obtaining the EPA's new NET Oracle database structure, contact the Technical Support Center at 800-334-2405 or 919-541-7862 for additional details.

- **EIIP EDI X12** - The EIIP Data management Committee has developed a data transfer format using existing electronic data interchange (EDI) X12 standards. The EDI data exchange standard is a nonproprietary standard created and maintained by the American National Standards Institute (ANSI) X12 committee. This format is described in EIIP Volume VII, *Data Management*. The EDI data transfer procedure may be available to state/local agencies through EPA assistance. If your agency would like to use this option, contact the Technical Support Center at 800-334-2405 or 919-541-7862 to obtain advice on how to proceed.

Agencies choosing to use this option will need to develop an application interface and procure an EDI translator, or use a translator provided by the EIIP/EDI data transfer demonstration. The standardized format generated by this approach will be loaded by EPA into the NET database system. The EIIP/EDI procedure allows an agency to submit their point, area, mobile, and biogenic information in a single file.

While the EIIP successfully tested the use of EDI through its prototype demonstration, the EPA is determining how to best establish and support EDI data transfer procedures across the Agency. To learn more about the EDI data transfer technique and the results of the EIIP prototype demonstration, see the EIIP Data Management Committee, Procedures Documents page at [www.epa.gov/ttn/chief/eiip/](http://www.epa.gov/ttn/chief/eiip/).

- **Direct Source Reporting** - Point sources may already be reporting electronic emissions inventory data to EPA as part of Title IV or regional NO<sub>x</sub> trading programs. For example, electricity-generating units subject to Title IV Acid Rain

monitoring and reporting provisions must report continuous emission monitoring (CEM) data to EPA in a specified electronic data reporting (EDR) format. Submission of this data will not fulfill reporting requirements for ozone, PM, or regional haze SIP inventory submittal, but EPA recognizes this as a viable data option where reporting requirements overlap.

To avoid duplication of efforts, EPA envisions that the emissions data submitted directly to EPA from the source will be:

- Transferred to EPA's NET database; or
- Made available to the states for incorporation into their emissions inventories, which will then entered into the NET database.

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# APPENDIX L

## SAMPLE QC CHECKLIST

Source: *Handbook for Criteria Pollutant Inventory Development: A Beginner's Guide for Point and Area Sources, Appendix N*. EPA-454-/R-99-037, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, September 1999.

EIIP, Volume I, Chapter 1, Appendix D, *Introduction to Stationary Point Source Emission Inventory Development*. July 1997.

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Inventory Identification \_\_\_\_\_

Assessed By \_\_\_\_\_ Date \_\_\_\_\_

Provide the information requested along with the corresponding resource document [ref] or data. After completing the checklist, indicate the actions to be taken, deadline for completion, and date the actions are completed.

**SOURCE CATEGORY:**

Defined before data collection? [ref] _____	Yes	No
Were definitions adhered to during data collection?	Yes	No
Inclusive of all listed pollutants? [ref] _____	Yes	No

\_\_\_\_\_

**POINT SOURCE CUTOFFS:**

Identified during data collection? [ref] _____	Yes	No
Documented and reported to people involved in area source inventory?	Yes	No

_____	_____
Report ID	Date

**SURVEY RESULTS:**

Was the response rate determined? _____ rate	Yes	No
Was the percentage of missing information per returned survey estimated? _____	Yes	No
percent		

**EMISSIONS CALCULATIONS VERIFICATIONS:**

Were nonreactive VOC emissions excluded from each source category emissions estimates? [ref] _____	Yes	No
EPA recommended estimation methodology used?	Yes	No
_____		
_____		
_____		
Emissions calculations checked? _____ checked by _____ date _____	Yes	No
Are equations explicitly shown? [ref] _____	Yes	No

**REASONABLENESS CHECKS:**

Were magnitudes of calculated emissions compared with other source categories? Identify second source reference or reference location of data in file. [ref] _____	Yes	No
Were magnitudes compared with national/state ranks of source categories? _____	Yes	No
_____ compared by _____ date _____		
Were other inventories and/or national averages compared to AIRS? List other inventories or reference data in master file.	Yes	No
Were findings reported and documented?	Yes	No

**SOURCE DATA:**

Were area source activity data reliability verified using available data sources? _____		
_____ verified by _____ date _____	Yes	No
Are emissions factor sources documented? _____ where _____	Yes	No
Are local emission factors within national range? [ref] _____	Yes	No
Were facilities whose emissions and activity levels are known compared against generic emission factors to check emission factor reasonableness? _____	Yes	No
_____ compared by _____ date _____ project file no. _____		
Are assumptions documented for scaling-up source category emissions and seasonal adjustment factor corrections? [ref] _____	Yes	No
Were point sources subtracted from area source emissions estimates? [ref] _____	Yes	No
Are point source corrections to area source emission estimates documented in the category calculations? [ref] _____	Yes	No

Use the worksheet on page 3 of 3 to record the actions to be taken in response to any problems found. Set a deadline for the completion of the action and indicate when the actions are implemented.

**INTERNAL SOURCE CATEGORY CONSISTENCY  
AND ACCURACY QUALITY CONTROL CHECKS (Continued)**

<b>Actions To Be Taken</b>	<b>Deadline</b>	<b>Completion Date</b>

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# APPENDIX M

## QA/QC PROCEDURES

Source: *Handbook for Criteria Pollutant Inventory Development: A Beginner's Guide for Point and Area Sources, Section 4.4.* EPA-454-/R-99-037, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, September 1999.

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## Quality Control Procedures

You should follow prescribed QC procedures while inputting and manipulating data. You should also conduct some of the technical reviews and accuracy checks listed in Table M-1. These procedures are briefly described below. Carefully review the QA/QC portion of your inventory preparation plan to identify the QC activities you are responsible for.

Quality control is best implemented through the use of standardized checklists that assess the adequacy of the data and procedures at various intervals in the inventory development process. The EIIP series of documents addresses QC procedures and provides detailed checklists to assist you.

Specifically, you should use QC checklists to monitor the following procedures and tasks:

- Data collection;
- Data calculations;
- Evaluation of data reasonableness;
- Evaluation of data completeness;
- Data coding and recording; and
- Data tracking.

Checklists can assist you in finalizing the inventory prior to submitting it to a reviewing agency (e.g., EPA). The checklist includes questions concerning completeness, use of approved procedures, and reasonableness. **An example QC checklist is included in Appendix L.**

Since most, if not all, of the emission calculations activities are performed electronically, rather than manually, it is critical that the spreadsheets used to generate the emission estimates be checked for accuracy. **Appendix N provides procedures for developing, documenting, and evaluating the data in spreadsheets.**

### **Reality Check**

The reality check is the most commonly used QA/QC method and is used to catch large errors early in the estimation process. This check is in the form of the questions “Is this number reasonable?” or “Does this number make sense?” **You should never use the reality check as the sole criterion of quality.** Each reviewer should carefully document the results of the reality check, using standardized forms or report formats, when applicable.

Table M-1.

Primary QA/QC Functions Of General Types Of Methods

Method	Ensure Reasonableness of Emissions, Data	Ensure Validity of Assumptions, Methods	Ensure Mathematical Correctness	Ensure Valid Data Were Used	Optimize QA/QC Efforts	Ensure Proper Implementation of QA/QC Program	Assess Accuracy of Estimates
Reality checks	T						
Peer review	T	T	T	T			T
Sample calculations			T	T			T
Computerized checks	T		T	T			T
Sensitivity analysis		T			T		
Statistical checks	T		T				
Independent audits	T	T	T	T	T	T	
Emissions estimation validation	T	T					T

When using the reality check as a QC check of the data, you must keep in mind:

- In order to answer the reality check questions with confidence, the reviewer must have a sound understanding of what is reasonable for the value being estimated;
- An estimate can appear to be reasonable, and be incorrect;
- An estimate can appear to be not reasonable, and be correct; and
- This method does not yield any information about the source of the error.

Table M-2 summarizes the EIIP preferred and alternative methods for performing reality checks.

### ***Peer Review***

Peer review is an independent review of calculations, assumptions, and/or documentation by a person with a moderate to high level of technical experience. Peer review generally involves reading or reviewing documentation. Peer review is conducted to ensure that assumptions and procedures are reasonable, but might not include rigorous certification of data or references.

When using peer review as a QC check of the data, you must keep in mind:

- Peer review is a form of reality check, and therefore has the same limitations;
- For large or complex inventories, it is easy for a peer reviewer to overlook errors.

No specific tools are required to conduct a peer review, but the use of checklists or review forms is recommended. A checklist ensures that reviewers have a clear understanding of what they are expected to do. Also, checklists provide an efficient means to document the QC procedure. Each reviewer should carefully document the results of the peer review, using standardized forms or report formats, when applicable. Table M-3 summarizes the EIIP preferred and alternative methods for performing peer reviews.

### ***Replication of Calculations***

Replication of calculations is the most reliable way to detect computational errors and can be done by any team member involved in the inventory. Replication of calculations should be conducted throughout the inventory process by the author of the original calculations as a self-check, by the team member conducting QC checks, and as part of the QA audit.

When using replication of calculations as a QC check of the data, you must keep in mind:

- Replication of calculations does not check to ensure that the approach and assumptions are correct;

**Table M-2.****Reality Checks: Preferred and Alternative Methods**

<b>Method</b>	<b>Procedure</b>
Preferred	Compare data or estimate to a standard reference value.
Alternative 1	Compare data or estimate to a value from a previous or alternative inventory (or database) for the same region.
Alternative 2	Compare data to values used for other regions.
Alternative 3	Use expert or engineering judgment to assess the reasonableness of the values.
Alternative 4	Compare estimates for similar categories within the same inventory.

**Table M-3.****Peer Review: Preferred and Alternative Methods**

<b>Method</b>	<b>Procedure</b>
Preferred	Use of a checklist showing elements to be covered by the review. Provides a guide for the peer reviewer and can be tailored to fit a specific situation.
Alternative 1	Written comments by reviewer identifying issues noted.
Alternative 2	Written notes summarizing reviewer's comments identifying issues noted by reviewer as told to author of notes.

- Replication of calculations does not involve a check of the accuracy or quality of the original data; and
- This is a labor-intensive process.

No specific tools are required to conduct replication of calculations, but the use of checklists or review forms is recommended. A checklist ensures that reviewers have a clear understanding of what they are expected to do. Also, checklists provide an efficient means to document the QC

procedure. Each reviewer should carefully document the results of the replication of calculations, using standardized forms or report formats when applicable.

Because replication of calculations is a labor-intensive process, you must follow procedures presented in the QA/QC portion of the inventory plan to determine the percentage of calculations to be checked. As a general rule, a minimum of ten percent of calculations is checked, but this percentage will vary depending on:

- The complexity of the calculations;
- The inventory DQOs; and
- The rate of errors encountered in the data that are checked.

Table M-4 summarizes the EIIP preferred and alternative methods for replication of calculations.

**Table M-4.**

**Calculation Checks: Preferred and Alternative Methods**

<b>Method</b>	<b>Procedure</b>
Preferred	Hand replication of one complete set of calculations.
Alternative 1	Hand replication of most complex calculations.
Alternative 2	Hand calculation using a different method, attempting to approximate the result.

***Computerized***

Automated data checks can be built-in functions of databases, models, or spreadsheets or can be designed as stand-alone programs. You can use automated QA/QC functions to facilitate peer review or, in some cases, replace manual reality checks. Computer-based QC checks can process large volumes of data quickly, significantly reducing the amount of time needed to compile and QA an inventory. You can use automated data checks to:

- Check for data format errors. For example, a program can be used to ensure that characters cannot be entered in a field that requires a numerical value;
- Conduct range checks to ensure that data falls within a specified minimum and maximum range; or

- Provide look-up tables to define permissible entries.

When using automated data checks as a QC check of the data, you must keep in mind:

- Human reasoning and judgment are necessary to evaluate the data for errors. Automated data checks are not a substitute for evaluation of the data by an auditor; they serve as a tool to allow an auditor to evaluate the data efficiently;
- These checks provide only the information requested. Data not subject to computerized checks must be evaluated by another means;
- Automated data checks do not check to ensure that the approach and assumptions are correct;
- Automated data checks do not involve a check of the accuracy or quality of the original data; and
- Each reviewer should carefully document the results of the review, using standardized forms or report formats when applicable.

Table M-5 presents examples of computerized data checks.

### **Statistical Checks**

Commonly used statistical methods for QC of an emissions inventory are:

- Descriptive statistics - mean, standard deviation, frequency distributions. These are used to summarize the data set and facilitate peer review;
- Statistical procedures to identify outliers; and
- Statistical tests, such as the t-test, can be used for comparability checks, for data validation, or to evaluate the relationships between parameters used in an inventory.

Statistical procedures can be used as tools to facilitate reality checks, peer reviews, and independent audits. They can be used to compare results or to identify unusual or unlikely values. Statistical data checks can process large amounts of data and reduce the subjectivity of informal reality checks. Refer to EIIP Volume VI for additional information.

Table M-5.

## Summary of Common Automated Checks

Type of Automated Check	Description	Examples	Strengths/Limitations
Variable type check	Alerts user if wrong data type or inappropriate value is entered.	Numeric value is expected, character string entered: a warning is issued immediately or field is flagged in subsequent report.	Reduces errors early in process, especially if warning issued interactively and/or if incorrect data entry prohibited. Report in which error is flagged is easily ignored.
Range (value) checks	Checks value entered to determine if it is within an expected or acceptable range.	Range of stack heights is used to flag a stack height that is too high or low.	Flags suspicious data for further review. Does not eliminate possibility that wrong value entered is within range, or that value outside range could still be correct.
Look-up table	Uses a parameter (such as user-supplied input variable) to select other appropriate parameters from a table.	User enters a source category code (SCC) and program supplies appropriate emission factor.	Eliminates some types of data entry errors; assures data consistency. If wrong value added (i.e., incorrect SCC), all dependent values will also be wrong.
Pull-down menu, pop-up window	Presents selection of possible values for a particular field.	List of possible fuel types is presented to user when entering data to calculate boiler emissions.	Eliminates transcription errors, reduces chance of using wrong value due to user not understanding what is wanted. Does not eliminate possibility that wrong choice will be made by user.
Completeness/Consistency checks	These two terms are often used to describe similar operations; include a wide array of checks and/or comparisons.	Checks verify that some specified amount of data for certain fields has been entered; or, if a certain field has data, verifies that other required fields also have data. Assure that units, equipment types, IDs, and other parameters are consistent.	Completeness is often difficult to quantify; in practice, a minimum expected value is used to determine completeness. Does not assure that data are correct. Impossible to completely automate these types of checks, some expert judgment usually required. If too much consistency automated into process, inflexibility may result.

When using statistical methods for QC checks of the data, you must keep in mind:

- Human reasoning and judgment are necessary to evaluate the data for errors. Statistical analyses are not a substitute for evaluation of the data by an auditor; they serve as a tool to allow an auditor to evaluate the data efficiently;
- Common statistical methods are based on the assumptions of normality. Emissions data are often not normally distributed;
- Statistical data checks do not check to ensure that the approach and assumptions are correct;
- Statistical data checks do not involve a check of the accuracy or quality of the original data; and
- Each reviewer should carefully document the results of the review, using standardized forms or report formats when applicable.

### **Quality Assurance Audits**

Independent audits (QA audits) involve a systematic evaluation of the emission inventory preparation process. They are a managerial tool to evaluate how effectively the emissions inventory team complies with predetermined specifications for developing an accurate and complete inventory. QA audits are conducted to determine whether QC procedures in place are effective, are being followed, and if additional QC is necessary to the inventory development process.

Because QA audits are conducted by personnel outside of the emissions inventory team, you will not be involved in this process. You should be prepared to fully cooperate with any auditor who requests information or documentation.

Specifically, QA audits are managerial tools used to:

- Identify staffing issues such as understaffing, or inadequate training of staff;
- Evaluate the effectiveness of the technical and quality procedures used to develop the emissions data;
- Provide confidence in the accuracy and completeness of the emissions data;
- Determine if DQOs are being met;
- Identify the need for additional QC measures; and
- Streamline the costs associated with the inventory development.



# APPENDIX N

## PROCEDURES FOR DEVELOPING, DOCUMENTING, AND EVALUATING THE ACCURACY OF SPREADSHEET DATA

Source: *Handbook for Criteria Pollutant Inventory Development: A Beginner's Guide for Point and Area Sources, Appendix O*. EPA-454-/R-99-037, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, September 1999.

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## **Procedures for Developing, Documenting, and Evaluating the Accuracy of Spreadsheet Data**

### **Procedure**

To maintain acceptable data quality, it is important to practice adequate QC measures during the development and review of spreadsheets. The information presented in a spreadsheet should be evaluated to determine if input data are transcribed correctly, calculated results are technically sound, and the final results are reported in a manner that will allow the data to be evaluated.

The procedures to follow when developing, documenting, and evaluating the accuracy of spreadsheets are described in this appendix. These procedures describe the minimum standards to be maintained to help ensure data quality and reproducibility. An example spreadsheet (with facility identification removed) is presented at the end of this appendix.

### **Definitions**

**Spreadsheet** - An electronic table that is used to process or present data. A spreadsheet can be used to store and manipulate data, as well as present data in report-quality, tabular format.

**Spreadsheet Developer (Developer)** - The person responsible for the overall accuracy and quality of a spreadsheet. The Developer ensures that data are entered correctly and that mathematical functions are accurately executed.

**Technical Reviewer** - The person not associated with the development of the spreadsheet that is technically qualified and responsible for verifying the accuracy, completeness, and reasonableness of the data in the spreadsheet.

**Quality Assurance Coordinator(QAC)** - The person that ensures that QC checks and technical review are performed on the spreadsheet.

### **Summary of Responsibilities**

#### *The Spreadsheet Developer:*

- Describes the development of the spreadsheet in the project notebook or in a memorandum to the project file.
- Ensures that all original data are transcribed (entered) to the spreadsheet correctly.

- Ensures that all equations used to generate results are entered correctly; ensures that all equations are used appropriately.
- Ensures that all conversion factors and constants used in equations are described.
- Ensures that all sources of original data are referenced in the spreadsheet.
- Ensures that all variables within equations are defined.
- Ensures that all supporting documentation for the information provided in the spreadsheet is obtained and submitted to the project file; ensures that memoranda summarizing procedures, activities, etc., are also maintained in the project file.
- Keeps a log of spreadsheet revisions. If different versions of a spreadsheet are created, the Developer maintains a log that describes the changes made to the different versions and maintains a historical file of the spreadsheet(s).
- Locks and protects the spreadsheet when giving the electronic file to reviewers. If the spreadsheet is being given to someone who will make revisions or enter data, data cells that should not be changed should be locked. Locking data cells in this manner will help prevent inadvertent changes to the spreadsheet.

*The Team Manager or Leader:*

- Determines when the use of spreadsheets (rather than database technology) are appropriate.
- Determines if a specific format must be used and specifies what information should be included in each spreadsheet.
- Reviews and approves the procedure for spreadsheet development.
- Ensures that these procedures are followed.
- Ensures that methods and technical approaches used to produce a desired result are technically sound.
- Assigns adequately trained staff to develop and review the spreadsheet.
- Specifies the level of detail to follow in reviewing the spreadsheet.
- Determines the level of QC necessary. For example, the Team Manager or Leader must decide if all data points and all calculations should be checked, or if only a

percentage should be checked. It may be appropriate to initially check a percentage and, based on the number of discrepancies identified, decide if additional QC is required.

- Considers the data quality objectives of the work (how will the data be used?), the complexity of the calculations, and experience level of the data generator.
- Specifies the level of detail to be included in the spreadsheet documentation.
- Ensures that spreadsheet documentation is included in the project file.
- Assigns a project assistant to organize and maintain a project file.
- Provides guidance on how to present data in the spreadsheet.

*The Technical Reviewer:*

- Verifies that the Developer's technical approach is reasonable and logical.
- Verifies that documentation is complete and clear.
- Ensures that assumptions and procedures used are reasonable.
- Provides timely, constructive, and direct comments to the Developer.
- Verifies (manually recalculates) at least one result at both low and high extremes as well as a result around the mid-point of the two.
- Verifies at least one calculation for each equation or combination of equations used.
- Verifies the accuracy of total values, means, and statistical evaluations of the data.
- With the Team Manager or Leader, determines the amount of data to check; the number of errors found will dictate the amount of data evaluated for accuracy. The higher the error rate, the more data points to be checked. If numerous errors are found, the spreadsheet should be returned to the data generator with a note that includes a description of the review procedure and percentage of errors found. The error rate is a good indicator of the accuracy of all of the information in the spreadsheet. If needed, the QA Coordinator should be consulted for guidance in determining the most effective way to determine which and how many values to recalculate.

- Verifies that original data were input correctly.
- Evaluates the technical soundness of methods and approaches used.
- Ensures that equations in the spreadsheet produce the correct result and that equations were entered into the spreadsheet accurately.
- Ensures that adequate documentation is included in the spreadsheet and that the documentation supports the data in the spreadsheet.
- Verifies that the source of all original data is referenced and all equations are explained.
- Notes all discrepancies identified during their QC review.
- Discusses all discrepancies with the Developer and Team Manager or Leader, as appropriate. Actual spreadsheet errors identified by the Reviewer should be corrected by the Developer.
- Summarizes the review (provides a written summary of the data checked, the errors or problems found, and the recommendations for revisions). The summary should also include the reviewer's name, date of QC review (month/day/year), name of file, type of data reviewed, and the percentage of each type reviewed.
- Keeps a copy of the written summary along with an electronic copy of the spreadsheet that was reviewed.

*The Quality Assurance Coordinator:*

- Ensures that an appropriate Technical Reviewer has been assigned to review the spreadsheet.
- Reviews the Developer's quality control (QC) plan.
- Ensures that the procedures described here are followed.

Spreadsheet Identification

- Include a title in the spreadsheet, at the beginning. Make the title descriptive enough to clearly identify the data presented and the project.

- Identify the Developer and the actual date (month/day/year) the spreadsheet was developed. (Distinguish between the “print” date and the “actual” date the spreadsheet was finalized.)
- Identify the reviewer and the date (month/day/year) the spreadsheet was reviewed.
- Include headers or footers that identify the name of the electronic spreadsheet file, the page number, and total number of pages (e.g., Page 1 of 2), and the date the spreadsheet was last revised. The name of the disk or drive on which the file is stored may also be included with the file name. An exception to this procedure is a report-quality table for inclusion in a report.
- Assign a unique name and number to the revised version of the spreadsheet. Add comments as a footnote to explain what was revised, the date the revision was made, and by whom.

### Spreadsheet Development

- Keep the spreadsheet as simple as possible. Clarity is important. Avoid numerous calculations in one equation.
- Identify any constants or conversion factors used.
- Identify the source of all information and data. Include as much detail as possible (e.g., table and page number along with the title of the document, where appropriate).
- Describe all equations, using footnotes or a comments field, where appropriate. (e.g., if gram/kilogram are being converted to pound/ton, the equation performing the calculation should be explained as: “Convert g/kg to lb/ton:  $1 \text{ g/kg} \times 1 \text{ lb}/453.59 \text{ g} \times 1 \text{ kg}/1,000 \text{ g} \times 453.59 \text{ g/lb} \times 2,000 \text{ lb/ton}$ , which is equivalent to multiplying by 2”). If detailed descriptions exist in project notebooks, then a reference to that notebook (e.g., notebook and page number) should be made in the comments field.
- Describe spreadsheet functions (e.g., average, conditional operators [IF statements]).
- Avoid using specific values in equations, except for easily recognizable conversion factors or constants.
- Enter values within a cell. Equations that use the value should reference the cell.

- When a single equation is used numerous times, it may be desirable to enter the equation in a cell and reference the cell when the equation is used. (e.g., If 20 data elements are being converted from g/kg to lb/ton, enter the conversion equation in one cell and reference the cell 20 times, rather than entering the conversion equation 20 times.)
- Hand (manually) verify equation cells.
- Protect verified equation cell regions of spreadsheets to avoid accidentally over writing.

### Supporting Data Requirements

The original raw data used in the spreadsheet should be retained in the project file and in the project archive. Reference all information and published documents used for spreadsheet development. Where applicable, photocopy the cover/title page and specific pages of the reference document.

Describe the development of the spreadsheets in the project notebook or in a memorandum or calculation sheet addressed to the project file. Include the following information:

- Project name/reference number;
- Purpose/task;
- Data references;
- Problems that may have occurred during the development of the spreadsheet and how they were eliminated;
- Justification for the technical approach; and
- A description of the data review process and the written comments from the technical reviewer (signed/dated).

### Project Data File Requirements

Include all of the data required to reconstruct the development of the spreadsheet and determine the accuracy of the information reported. Include the electronic version of the spreadsheet in the project data file. Maintain an electronic backup copy at an identified location and in hard copy in the project file.



**Project: Identification of Emission Factors for CO<sub>2</sub>/Coal-Fired Boilers**

Developed by: JLJ 06/21/98

Reviewed by: RFD 07/02/98

File name:

TEST REPORT TITLE: RESULTS OF THE NOVEMBER 7, 1991 AIR TOXIC EMISSION  
STUDY ON THE NOS. 3, 4, 5 & 6 BOILERS AT THE @@@@ PLANT

FACILITY: @@@@  
UNIT NO.: 3, 4, 5 & 6  
LOCATION: @@@@  
COAL EF DATABASE REFERENCE NO 5

## PROCESS DATA

	Run 1	Run 2	Run 3
Oxygen (% v/v) a	7.70	7.60	7.80
Vol. Flow Rate (dscf/m) b	804,786	788,668	815,076
Vol. Flow Rate (dscf/hr)	48,287,160	47,320,080	48,904,560
F-factor (dscf/MMBtu) c	9,780	9,780	9,780
Heat input (MMBtu/hr)	3,118	3,079	3,134
HHV Bituminous Coal (Btu/lb)	8,498	8,498	8,498
HHV Bituminous Coal (Btu/ton)	16,996,000	16,996,000	16,996,000
Coal Feed Rate (ton/hr)	183	181	184
Coal type e	Subbituminous		
Boiler configuration e	Pulverized, dry bottom		
Coal source e	Rochelle		
SCC	10100222		
Control device 1 e	ESPC		
Control device 2 e	None		
Data Quality	B		
Process Parameters e	Watertube boilers with economizers and air preheaters		
Test methods f	MM 5 metals, PM, PM10, Method 3 for CO2, Method 18 for		
Number of test runs g	3		

a Page 29.

b Page 37.

c 40 CFR Pt 60, App A, Meth.

d Page 42

e Page 1.

f Page 1.

g Various pages.

## CO2 EMISSION FACTORS

	Run 1	Run 2	Run 3	Avg
CO2 concentration (%v/v) a	11.9	11.9	11.60	
CO2 concentration (ppm) b	0.00119	0.00119	0.00116	
CO2 molecular weight	44	44	44	
CO2 concentration (lb/dscf)	1.36E-10	1.36E-10	1.32E-10	
CO2 emission rate (lb/hr) d	0.007	0.006	0.006	
CO2 emission factor (lb/ton)	3.57E-05	3.55E-05	3.51E-05	#N/A

a Page 29  
b convert 1/100 to  
c (concentration, ppm \* molecular weight)/385,500,000  
d concentration, lb/dscf \* Volumetric flow rate \* 60 min/hr  
e emission rate/coal feed rate

Date developed: 06/21/98

Date revised: Not applicable

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**VOLUME II: CHAPTER 2**

# **PREFERRED AND ALTERNATIVE METHODS FOR ESTIMATING AIR EMISSIONS FROM BOILERS**

**January 2001**



Prepared by:  
Eastern Research Group, Inc.

Prepared for:  
Point Sources Committee  
Emission Inventory Improvement Program

## **DISCLAIMER**

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

## ACKNOWLEDGEMENT

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# 1

## INTRODUCTION

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The purposes of the preferred methods guidelines are to describe emission estimation techniques for stationary point sources in a clear and unambiguous manner and to provide concise example calculations to aid in the preparation of emission inventories. This chapter describes the procedures and recommended approaches for estimating emissions from external combustion sources (i.e., boilers).

Section 2 of this chapter contains a general description of the boiler source category, a listing of emission sources commonly associated with boilers, and an overview of the available control technologies for various boiler types. Section 3 of this chapter provides an overview of available emission estimation methods. It should be noted that the use of site-specific emission data is often preferred over the use of industry-averaged data such as *AP-42* emission factors. However, depending upon available resources, site-specific data may not be cost effective to obtain. Section 4 presents the preferred emission estimation methods for boilers by pollutant, and Section 5 presents the alternative emission estimation techniques. Quality assurance (QA) and quality control (QC) procedures are described in Section 6, and data coding procedures are discussed in Section 7. Section 8 lists references. Appendix A provides an example data collection form for boilers to assist in information gathering prior to emissions calculations. Refer to Chapter 1 of this volume, *Introduction to Stationary Point Source Emission Inventory Development*, for general concepts and technical approaches.

This chapter does not specifically discuss State Implementation Plans (SIPs) or base year, periodic, and planning inventories. However, the reader should be aware that the U.S. Environmental Protection Agency (EPA) procedures manuals pertaining to the preparation of emission inventories for carbon monoxide and precursors of ozone are available (EPA, May 1991).

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# 2

## GENERAL SOURCE CATEGORY DESCRIPTION

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### 2.1 SOURCE CATEGORY DESCRIPTION

This section provides a brief overview discussion of boilers. The reader is referred to the *Air Pollution Engineering Manual* (sometimes referred to as *AP-40*) (Buonicore and Davis, 1992) and *AP-42* (EPA, January 1995) for a more detailed discussion on boilers, boiler designs, boiler operations and their influences on emissions.

The boiler source category comprises sources that combust fuels to produce hot water and/or steam. Utility boilers utilize steam to generate electricity. Industrial boilers often generate steam for electrical power as well as process steam. Space heaters use the hot water for heating commercial and residential building space. Fuels typically used in boilers include coal, oil, and natural gas. In addition, liquified petroleum gas (LPG), process and waste gases, and wood wastes may be used. In general, boilers are categorized as follows:

Types of Boilers	Size
Utility	>100 MMBtu/hr
Industrial	10 - 250 MMBtu/hr
Commercial/Institutional	<10 MMBtu/hr
Residential	<<10 MMBtu/hr

These categorizations are general to the types of boilers listed above. It should be noted that regulations developed under the Clean Air Act (such as New Source Performance Standards for Steam Generating Units) may have different size cut-offs for applicability than are listed here.

#### 2.1.1 COAL-FIRED BOILERS

Coal is broadly classified into one of four types (anthracite, bituminous, subbituminous, or lignite) based on differences in heating values and amounts of fixed carbon, volatile matter, ash,

sulfur, and moisture. The following sections discuss the four main types of coal boilers (pulverized coal, cyclone, spreader stoker, and fluidized bed) and the processes that occur at all four types of coal-fired boilers. Pulverized coal and cyclone boilers employ a technique known as suspension firing; they are sometimes categorized by this technique.

### ***Pulverized Coal Furnaces***

Pulverized coal furnaces are used primarily in utility and large industrial boilers (Buonicore and Davis, 1992; EPA, January 1995). In a pulverized coal system, the coal is pulverized in a mill to the consistency of talcum powder. The pulverized coal is then entrained in primary air before being fed through the burners to the combustion chamber, where it burns in suspension.

Pulverized coal furnaces are classified as either dry or wet bottom, depending on the ash removal technique. Dry-bottom furnaces may either be tangential- or nontangential-fired units. Some examples of nontangential-fired pulverized coal furnaces are wall-fired, turbo, cell-fired, vertical, and arch. Dry-bottom furnaces fire coal with high ash fusion temperatures, whereas wet-bottom furnaces fire coal with low ash fusion temperatures. Wet-bottom furnace designs have higher nitrogen oxides (NO<sub>x</sub>) emission rates and are no longer being built, though many remain in service.

### ***Cyclone Furnaces***

Cyclone furnaces are used mostly in utility and large industrial applications (Buonicore and Davis, 1992). Cyclone furnaces burn coal that has a low ash fusion temperature and has been crushed to a four-mesh size (larger than pulverized coal). Coal in a cyclone furnace is fed tangentially with primary air to a horizontal cylindrical combustion chamber. In this chamber, small coal particles are burned in suspension, while the larger particles are forced against the outer wall. Because of the high temperatures developed in the relatively small combustion chamber and because of the low fusion temperature of the coal ash, much of the ash forms a liquid slag that is drained from the bottom of the furnace through a slag tap opening (EPA, January 1995).

### ***Spreader Stokers***

In spreader stokers, a rotating flipping mechanism throws the coal into the furnace and onto a moving fuel bed. Combustion occurs partly in suspension and partly on the grate. Because of significant amounts of carbon in the particulate, fly ash reinjection from mechanical collectors is commonly employed to improve boiler efficiency. Ash residue in the fuel bed is deposited in a receiving pit at the end of the grate (EPA, January 1995). Anthracite coal is not used in spreader stokers because of its low volatile matter content and relatively high ignition temperature.

### **Fluidized Bed Combustors**

In a fluidized bed combustor (FBC), coal is introduced to a bed of either sorbent (limestone or dolomite) or inert material (usually sand) that is fluidized by an upward flow of air. Combustion takes place in the bed at lower temperatures than other boiler types. Key benefits to this relatively new process are fuel flexibility and reduced emissions. FBCs are typically used for industrial-sized boilers and may be emerging as a competitive design for electric power generation (Stultz and Kitto, 1992).

#### **2.1.2 OIL-FIRED BOILERS**

There is little variation between the design of oil-fired units and the design of coal-fired units; almost all are either tangential-fired or wall-fired. Fuel oils are broadly classified into two major types: distillate and residual. Distillate oils (fuel oil grade Nos. 1 and 2) are used mainly in domestic and small commercial applications in which easy fuel burning is required. Distillates are more volatile and less viscous than residual oils. Being more refined, they have negligible ash content, and usually contain less than 0.3 weight percent sulfur. Residual oils (grade Nos. 4, 5, and 6) are used mainly in utility, industrial, and large commercial applications with sophisticated combustion equipment. Residual No. 4 oil is sometimes classified as a distillate, and No. 6 is sometimes referred to as Bunker C. The heavier residual oils (grade Nos. 5 and 6) are more viscous and less volatile than distillate oils and, therefore, must be heated to facilitate handling and proper atomization. Because residual oils are produced from the crude oil residue after lighter fractions (gasoline, kerosene, and distillate oils) have been removed, these oils contain significant quantities of ash, nitrogen, and sulfur (EPA, January 1995). However, low-sulfur residual oil is becoming more commonplace.

#### **2.1.3 NATURAL GAS-FIRED BOILERS**

Natural gas is used for power generation, industrial process steam and production activities, and domestic and commercial space heating. The primary component of natural gas is methane, although small amounts of ethane, nitrogen, helium, and carbon dioxide (CO<sub>2</sub>) can also be present (EPA, January 1995).

Natural gas boilers are considered clean relative to coal- or oil-fired boilers, but improper operating conditions (such as poor air-fuel mixing) may still result in smoke (unburned carbon) in the exhaust, as well as carbon monoxide (CO) and perhaps small amounts of unburned hydrocarbons. NO<sub>x</sub> emissions are usually the major pollutants of concern in a well-operated natural gas boiler. NO<sub>x</sub> emissions are primarily a function of the combustion chamber temperature.

Several modifications can be made to natural gas boilers to reduce NO<sub>x</sub> emissions. Staged combustion can reduce NO<sub>x</sub> emissions by 5 to 20 percent (EPA, January 1995); low excess air levels and flue gas recirculation also often lower NO<sub>x</sub> emissions.

#### **2.1.4 BOILERS USING OTHER TYPES OF FUEL**

Other fuels such as LPG, process gas, wood and/or bark, bagasse and solid/liquid waste may be used in boilers.

LPG is either butane, propane, or a mixture of the two. This gas is often called bottled gas. Grade A LPG is mostly butane and Grade F is mostly propane, with Grades B through E consisting of varying mixtures of butane and propane. Although LPG is considered a clean fuel, gaseous pollutants such as CO, organic compounds (including volatile organic compounds or VOCs), and NO<sub>x</sub> are emitted as are small amounts of sulfur dioxide (SO<sub>2</sub>).

Process gases that are used for fuel include petroleum refinery gas, blast furnace gas, coke oven gas, landfill gas, and any other process gases with sufficient and economically recoverable heating values.

The burning of wood and/or bark in boilers is mostly confined to situations where steady supplies of wood or bark are available as a byproduct or in close proximity to the boiler. In most cases, the wood is waste that would otherwise present a solid waste disposal problem. The common types of boilers used to burn wood/bark are Dutch ovens, fuel cell ovens, spreader stokers, vibrating grate stokers, and cyclone (tangential-fired) boilers (EPA, January 1995).

Bagasse is the matted cellulose fiber residue from sugar cane that has been processed in a sugar mill. Fuel cells, horseshoe boilers, and spreader stoker boilers are used to burn bagasse.

Solid or liquid waste may consist of general waste solids or liquids, refuse-derived fuel, or waste oil. Waste oil, or used oil, refers to spent lubrication and other industrial oils that would otherwise present a liquid waste disposal problem. The most common type of waste oil is used vehicle crankcase oil. Other oils include metalworking lubricants, animal and vegetable oils and fats, and transformer and other heat transfer fluids. Waste oils may have higher emissions of SO<sub>2</sub> and particulates than refined fuel oils, but will have similar levels of emissions for NO<sub>x</sub>, CO, and organic compounds (EPA, January 1995). Heavy metal emissions may be greater from crankcase oil combustion.

#### **2.1.5 COGENERATION UNITS**

Cogeneration is the production of more than one useful form of energy (such as process heat and electric power) from the same energy source. Cogeneration plants produce electric power and



also meet the process heat requirements of industrial processes (Cengel and Boles, 1989). A steam turbine, gas-cycle turbine, or combined-cycle turbine can be used to produce power in a cogeneration plant.

In a typical cogeneration plant, energy is transferred to water by burning coal, oil, natural gas, or other (nonfossil) fuels in a boiler. The high-pressure, high-temperature steam leaving the boiler is expanded in a turbine that drives a generator to produce electric power. The low-pressure, low-temperature steam leaving the turbine is used as process heat. Industries likely to use cogenerated process heat are the chemical, pulp and paper, oil production and refining, steel making, food processing, and textile industries. Besides the steam-turbine cycle described above, a gas-cycle or a combined-cycle turbine can be used to produce power in a cogeneration plant (Cengel and Boles, 1989). Combustion turbines are also commonly used for cogeneration.

### **2.1.6 AUXILIARY SOURCES**

Auxiliary sources associated with boilers include fuel storage piles, fuel storage tanks, materials handling, and other sources of fugitive emissions. These sources are often overlooked and not reported as a part of the emission inventory. However, it is essential that these sources be considered in the emission inventory to develop a complete record of the emissions coming from the facility.

Coal storage piles are used to store coal at the boiler site. Material handling involves the receipt of coal, movement of coal to the preparation (crushing) facility, and movement of coal to the boilers, which may result in the release of particulate matter (PM) emissions. A coal-fired boiler may also use fuel oil or gas for the initial light-off of the boilers. In this case, as well as for oil-fired boilers, VOC losses from fuel oil storage tanks should be considered (EPA, January 1995).

Because coal crushing operations can generate a significant amount of fine PM, they should be included in the inventory. Because of the potential for explosion from this fine particulate, crushing operations are typically well controlled (EPA, January 1995).

## **2.2 EMISSION SOURCES**

Air pollutant emissions associated with boilers can occur at the following points/processes. Section 7 lists the source classification codes (SCCs) for these emission points.

### **2.2.1 MATERIAL HANDLING (FUGITIVE EMISSIONS)**

Material handling includes the receipt, movement, and processing of fuel and materials to be used at the boiler facility. Coal, limestone, wood, bark, and solid waste may all be included, and their handling may result in particulate emissions. Organic compound emissions can also result from the transfer of liquid and gaseous fuels. This source category includes storage bins and

open stockpiles, as well as the processes used to transfer these materials (e.g., unloading, loading, and conveying).

### 2.2.2 STORAGE TANKS

Storage tanks are used to store fuel oils at boiler facilities, and should be inventoried as a source of organic compound emissions. Storage tanks at boiler facilities are usually one of two types: fixed roof or floating roof. Emissions at fixed-roof tanks are typically divided into two categories: working losses and breathing losses. Working losses refer to the combined loss from filling and emptying the tank. Filling losses occur when the organic compounds and VOCs contained in the saturated air are displaced from a fixed-roof vessel during loading. Emptying losses occur when air drawn into the tank becomes saturated and expands, exceeding the capacity of the vapor space. Breathing losses are the expulsion of vapor from a tank through vapor expansion caused by changes in temperature and pressure.

Emissions at floating roof tanks are reported in two categories: standing losses and withdrawal losses. Withdrawal loss is the vaporization of liquid that clings to the tank wall and that is exposed to the atmosphere when a floating roof is lowered by withdrawal of liquid. Standing losses result from wind-induced mechanisms and occur at rim seals, deck fittings, and deck seams (EPA, January 1995).

The TANKS program is commonly used to quantify emissions from oil-fired boilers. Its use at boiler installations should be carefully evaluated because it is a complicated program with a great number of input parameters. It is commonly used at large oil-burning facilities where VOC emissions may be significant. Check with your local or state authority as to whether TANKS is required for your facility. The use of the TANKS program for calculating emissions from storage tanks is discussed in Chapter 1 of Volume II, *Introduction to Stationary Point Source Emissions Inventory Development*. TANKS can be downloaded from the EPA's CHIEF website at [www.epa.gov/ttn/chief](http://www.epa.gov/ttn/chief).

### 2.2.3 PROCESS EMISSIONS

For boilers, emissions resulting from the process (combustion of fuel to generate hot water and steam) are typically vented to the atmosphere via a stack or vent. The major pollutants of concern from boiler stacks are PM, sulfur oxides ( $\text{SO}_2$  and sulfur trioxide [ $\text{SO}_3$ ]), VOC, and  $\text{NO}_x$ . CO and unburned combustibles, including numerous organic compounds (e.g., benzene) can also be emitted under certain boiler operating conditions. Most of the carbon in fossil fuels is emitted as  $\text{CO}_2$  during combustion, and may be inventoried due to its role as a greenhouse gas. Trace metals, such as arsenic and cadmium, may also be emitted as a result of combustion of coal and oil. Additionally, organic pollutants such as formaldehyde, and polycyclic organic matter (POM) may be formed during combustion and emitted (EPA, April 1989). Typical pollutants associated

with boiler emissions are listed in Table 2.2-1 by fuel type. Not all listed pollutants will be emitted in every case, so site-specific pollutant data (from fuel analysis or stack tests) should always be used if available.

## 2.3 FACTORS AND DESIGN CONSIDERATIONS INFLUENCING EMISSIONS

### 2.3.1 PROCESS OPERATING FACTORS

The combustion process is defined as the rapid oxidation of substances (fuels) with the evolution of heat. Boilers utilize the heat generated by combustion to produce hot water, steam, or both. The fuel types discussed in this chapter include coal, oil, natural gas, and other fuels such as wood, LPG, and process gases. When these burn, they are converted into  $\text{CO}_2$  and water, referred to as the combustion products. The noncombustible portion of a fuel remains as a solid residue or ash. The coarser, heavier portion remains within the combustion chamber and is called “bottom ash.” The finer portion, referred to as “fly ash,” exits the furnace with the flue gas.

Combustion products from boiler operation can also include partially oxidized hydrocarbons,  $\text{CO}$ ,  $\text{SO}_2$ ,  $\text{SO}_3$ ,  $\text{NO}_x$ , acids such as hydrochloric acid, and organohalides such as dioxins and furans. The generation of undesirable combustion products is strongly influenced by fuel type, furnace type, firing configuration, and boiler operating conditions. Although a detailed discussion of boiler operations cannot be presented here, some general observations are included to assist in understanding the relative impact of various boilers and fuel types on air emissions.

The discussion on coal-fired boilers introduced the four primary classifications of coal: lignite, anthracite, bituminous, and subbituminous. Fuel is ranked based on American Society for Testing and Materials (ASTM) standard methods referred to as “proximate” and “ultimate” analyses. Proximate analyses report fuel composition in broad categories such as moisture content and ash content. Ultimate analyses provide an estimate of the carbon, hydrogen, sulfur, oxygen, nitrogen, and water content of the fuel. An ultimate analysis is used to compute combustion air requirements and can also be used to calculate fuel factors ( $F_d$ ) for determining exhaust gas flow rates (see Equation 2.4-4). Sections 3 and 4 discuss how fuel analysis can be used to estimate emissions of sulfur oxides and metals from fuel combustion. Generally, boiler size, firing configuration, and operation have little effect on the percent conversion of fuel sulfur to sulfur oxides, so fuel analysis is typically a valid means of predicting emissions of sulfur oxides.

By contrast,  $\text{NO}_x$  formation is highly dependent on boiler conditions, especially temperature and air/fuel ratios near the burner.  $\text{NO}_x$  is produced by three mechanisms: conversion of fuel-

TABLE 2.2-1

## POLLUTANTS ASSOCIATED WITH BOILER EMISSIONS

Criteria Pollutants	Hazardous Air Pollutants
<b>Coal</b>	
<ul style="list-style-type: none"> <li>• Carbon Monoxide</li> <li>• Lead</li> <li>• Nitrogen Oxides</li> <li>• PM-Primary</li> <li>• PM-Filterable</li> <li>• PM-Condensable</li> <li>• PM10-Primary*</li> <li>• PM10-Filterable*</li> <li>• PM2.5- Primary*</li> <li>• PM2.5-Filterable*</li> <li>• Sulfur Oxides</li> </ul>	<ul style="list-style-type: none"> <li>• Antimony &amp; Compounds</li> <li>• Benzene</li> <li>• Beryllium &amp; Compounds</li> <li>• Cadmium &amp; Compounds</li> <li>• Chromium &amp; Compounds</li> <li>• Cobalt Compounds</li> <li>• Dioxin/Furans as 2,3,7,8-TCDD TEQ</li> <li>• Ethylbenzene</li> <li>• Formaldehyde</li> <li>• Hydrogen Chloride</li> <li>• Hydrogen Fluoride</li> <li>• Lead &amp; Compounds</li> <li>• Manganese &amp; Compounds</li> <li>• Mercury &amp; Compounds</li> <li>• Methyl Chloroform (1,1,1-Trichloroethane)</li> <li>• Methyl Ethyl Ketone (2-Butanone)</li> <li>• Nickel &amp; Compounds</li> <li>• Toluene</li> <li>• Xylenes (includes o, m, and p)</li> </ul>
<b>Natural Gas</b>	
<ul style="list-style-type: none"> <li>• Carbon Monoxide</li> <li>• Lead</li> <li>• Nitrogen Oxides</li> <li>• PM-Primary</li> <li>• PM-Filterable</li> <li>• PM-Condensable</li> </ul>	<ul style="list-style-type: none"> <li>• Benzene</li> <li>• Cadmium &amp; Compounds</li> <li>• Chromium &amp; Compounds</li> <li>• Cobalt Compounds</li> <li>• Formaldehyde</li> <li>• Lead &amp; Compounds</li> </ul>

**TABLE 2.2-1**  
**(CONTINUED)**

<b>Criteria Pollutants</b>	<b>Hazardous Air Pollutants</b>
<b>Natural Gas (Continued)</b>	
<ul style="list-style-type: none"> <li>• PM10-Primary*</li> <li>• PM10-Filterable*</li> <li>• PM2.5- Primary*</li> <li>• PM2.5-Filterable*</li> <li>• Sulfur Oxides</li> </ul>	<ul style="list-style-type: none"> <li>• Manganese &amp; Compounds</li> <li>• Mercury &amp; Compounds</li> <li>• Nickel &amp; Compounds</li> <li>• Toluene</li> </ul>
<b>Oil</b>	
<ul style="list-style-type: none"> <li>• Carbon Monoxide</li> <li>• Lead</li> <li>• Nitrogen Oxides</li> <li>• PM-Primary</li> <li>• PM-Filterable</li> <li>• PM-Condensable</li> <li>• PM10-Primary*</li> <li>• PM10-Filterable*</li> <li>• PM2.5- Primary*</li> <li>• PM2.5-Filterable*</li> <li>• Sulfur Oxides</li> </ul>	<ul style="list-style-type: none"> <li>• Benzene</li> <li>• Beryllium &amp; Compounds</li> <li>• Cadmium &amp; Compounds</li> <li>• Chromium &amp; Compounds</li> <li>• Cobalt Compounds</li> <li>• Dioxins/Furans as 2,3,7,8-TCDD TEQ</li> <li>• Ethylbenzene</li> <li>• Formaldehyde</li> <li>• Lead &amp; Compounds</li> <li>• Manganese &amp; Compounds</li> <li>• Mercury &amp; Compounds</li> <li>• Methyl Chloroform (1,1,1-Trichloromethane)</li> <li>• Nickel &amp; Compounds</li> <li>• Toluene</li> <li>• Xylenes (includes o, m, and p)</li> <li>• Dioxins/Furans as 2,3,7,8-TCDD TEQ</li> <li>• Ethylbenzene</li> <li>• Formaldehyde</li> <li>• Lead &amp; Compounds</li> <li>• Manganese &amp; Compounds</li> <li>• Mercury &amp; Compounds</li> </ul>

\* PM10 and PM2.5 refer to PM less than or equal to an aerodynamic diameter of 10 $\mu$ m and 2.5 $\mu$ m, respectively.

bound nitrogen in fuel, oxidation of molecular nitrogen from combustion air (referred to as thermal NO<sub>x</sub> formation) and reaction of hydrocarbon fragments and atmospheric nitrogen (prompt NO<sub>x</sub>). Thermal NO<sub>x</sub> formation is highly temperature dependent and becomes rapid as temperatures exceed 3,000°F (Buonicore and Davis, 1992). Lower operating temperatures result in decreased thermal NO<sub>x</sub> production. Shorter residence time also lowers thermal NO<sub>x</sub> generation. Prompt NO<sub>x</sub> is formed very early in the combustion process and is significant only in very fuel-rich flames.

Fuel NO<sub>x</sub> will generally account for over 50 percent of the total NO<sub>x</sub> generated by oil- and coal-fired boilers. NO<sub>x</sub> emissions from tangential-fired oil boilers are typically lower than those from horizontally opposed units. Many boilers employ combustion modifications to reduce NO<sub>x</sub> emissions. These include staged combustion, off-stoichiometric firing, flue gas recirculation, and low-NO<sub>x</sub> burners with overfire air (OFA). These control strategies can reduce NO<sub>x</sub> emissions by 5 to 50 percent (Buonicore and Davis, 1992). For a more detailed discussion of NO<sub>x</sub> control strategies, see Chapter 12 of EIIP Volume II, *How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates*.

The utility sector is dominated by pulverized dry-bottom, coal-fired units. Stoker boilers, currently accounting for a small percentage of total national capacity, are less common. Coal-fired pulverized wet-bottom and cyclone boilers are no longer manufactured due to their inability to meet NO<sub>x</sub> standards, although many are still in use.

In the industrial sector, more natural gas is used relative to coal and oil. The commercial/institutional sector consumes a greater proportion of oil and natural gas relative to coal consumption than the other two sectors.

### 2.3.2 CONTROL TECHNIQUES

Table 2.2-2, "Boiler Controls," lists the control technologies associated with boiler operations, along with their typical efficiencies. Control efficiency for a specific piece of equipment will vary depending on the age of the equipment and quality of the maintenance/repair program at a particular facility.

#### **Particulate Control**

In addition to PM and PM with an aerodynamic diameter of less than 10 μm (PM<sub>10</sub>) emissions, particulate control also serves to remove trace metals, as well as metals (such as lead) that are vaporized in the combustion chamber and condensed onto fly ash in the exhaust. However, the PM control efficiencies listed in Table 2.2-2 may not correspond to actual removal efficiencies of specific hazardous air pollutants (HAPs) or metals, due to the phenomena of fine particle

**TABLE 2.2-2**  
**BOILER CONTROLS**

Fuel	Pollutant	Control Device Type	Average Control Efficiency <sup>a</sup> (%)	Control Efficiency Range <sup>a</sup> (%)	
				Minimum Value	Maximum Value
Bagasse	PM	Mechanical Collector		20	60
		Wet PM Scrubber		90	
Coal	NO <sub>x</sub>	Flue Gas Recirculation		5	45
		Low Excess Air		5	30
		Low NO <sub>x</sub> Burners		35	55
		Natural Gas Burners/Reburn		50	70
		Overfire Air		5	30
		Selective Catalytic Reduction		63	94
		Selective Non-catalytic Reduction		30	60
		Low NO <sub>x</sub> Burner w/ Selective Non-catalytic Reduction		50	80
		Low NO <sub>x</sub> Burner w/ Overfire Air and Selective Catalytic Reduction		85	95
		Low NO <sub>x</sub> Burner w/ Overfire Air		40	60
	SO <sub>2</sub> <sup>b</sup>	Wet Acid Gas Scrubber		80	99
		Spray Dryer Absorber		70	90

TABLE 2.2-2

(CONTINUED)

Fuel	Pollutant	Control Device Type	Average Control Efficiency <sup>a</sup> (%)	Control Efficiency Range <sup>a</sup> (%)	
				Minimum Value	Maximum Value
Coal (Continued)	PM	Electrostatic Precipitator	99	90	99.9
		Fabric Filter	99	99	
		Mechanical Collector	65	90	95
		Wet PM Scrubber		50	99
Coal (Anthracite)	PM	Electrostatic Precipitator	98.4		
		Fabric Filter		98.4	99.4
Coal (Bituminous)	PM	Electrostatic Precipitator		96	99.4
		Fabric Filter		98.3	99.9
	PM-10	Fuel Switching to Sub-bituminous Coal (Industrial Sources) <sup>c</sup>	21.4		
		Fuel Switching to Residual Oil (Industrial Sources) <sup>c</sup>	62.9		
		Fuel Switching to Natural Gas (Industrial Sources) <sup>c</sup>	98.2		



TABLE 2.2-2

(CONTINUED)

Fuel	Pollutant	Control Device Type	Average Control Efficiency <sup>a</sup> (%)	Control Efficiency Range <sup>a</sup> (%)	
				Minimum Value	Maximum Value
Coal (Bituminous) (Continued)	PM -10 (Continued)	Fuel Switching to Sub-bituminous Coal (Utility Sources) <sup>c</sup>	21.4		
		Fuel Switching to Residual Oil (Utility Sources) <sup>c</sup>	69.5		
		Fuel Switching to Natural Gas (Utility Sources) <sup>c</sup>	99.3		
	PM - 2.5	Fuel Switching to Sub-bituminous Coal (Industrial Sources) <sup>c</sup>	21.4		
		Fuel Switching to Residual Oil (Industrial Sources) <sup>c</sup>	7.4		
		Fuel Switching to Natural Gas (Industrial Sources) <sup>c</sup>	93.1		
		Fuel Switching to Sub-bituminous Coal (Utility Sources) <sup>c</sup>	21.4		

TABLE 2.2-2

(CONTINUED)

Fuel	Pollutant	Control Device Type	Average Control Efficiency <sup>a</sup> (%)	Control Efficiency Range <sup>a</sup> (%)	
				Minimum Value	Maximum Value
Coal (Bituminous) (Continued)	PM - 2.5 (continued)	Fuel Switching to Natural Gas (Utility Sources) <sup>c</sup>	97.5		
Coal (Sub-bituminous)	PM - 10	Fuel Switching to Residual Oil (Industrial Sources) <sup>c</sup>	52.8		
		Fuel Switching to Natural Gas (Industrial Sources) <sup>c</sup>	97.7		
		Fuel Switching to Residual Oil (Utility Sources) <sup>c</sup>	61.2		
		Fuel Switching to Natural Gas (Utility Sources) <sup>c</sup>	99.2		
	PM - 2.5	Fuel Switching to Natural Gas (Industrial Sources) <sup>c</sup>	91.2		
		Fuel Switching to Natural Gas (Utility Sources) <sup>c</sup>	96.8		

TABLE 2.2-2

(CONTINUED)

Fuel	Pollutant	Control Device Type	Average Control Efficiency <sup>a</sup> (%)	Control Efficiency Range <sup>a</sup> (%)	
				Minimum Value	Maximum Value
Lignite	SO <sub>2</sub> <sup>b</sup>	Wet Acid Gas Scrubber		90	
	PM	Electrostatic Precipitator		95	99.5
		Mechanical Collector		60	80
Oil, Distillate, No. 2	NO <sub>x</sub>	Flue Gas Recirculation		45	55
		Low Excess Air		2	19
		Overfire Air		20	45
		Selective Catalytic Reduction			90
Oil, Residual, Nos. 4, 5, and 6	NO <sub>x</sub>	Flue Gas Recirculation	21	2	31
		Low Excess Air		5	31
		Overfire Air		24	47
		Selective Catalytic Reduction		70	80
		Selective Non-catalytic Reduction		35	70

TABLE 2.2-2

(CONTINUED)

Fuel	Pollutant	Control Device Type	Average Control Efficiency <sup>a</sup> (%)	Control Efficiency Range <sup>a</sup> (%)	
				Minimum Value	Maximum Value
Oil, Residual, Nos. 4, 5, and 6	PM - 10	Fuel Switching to Natural Gas (Industrial Sources) <sup>c</sup>	95.1		
		Fuel Switching to Natural Gas (Utility Sources) <sup>c</sup>	97.9		
	PM - 2.5	Fuel Switching to Natural Gas (Industrial Sources) <sup>c</sup>	92.5		
		Fuel Switching to Natural Gas (Utility Sources) <sup>c</sup>	97.0		
Utility Oil or Natural Gas	NO <sub>x</sub>	Flue Gas Recirculation		40	65
Municipal Waste	NO <sub>x</sub>	Selective Catalytic Reduction	69		80
Natural Gas	NO <sub>x</sub>	Flue Gas Recirculation		49	68
		Low Excess Air		0	31
		Low NO <sub>x</sub> Burners		40	85
		Overfire Air	60	13	73
		Selective Catalytic Reduction		80	90

TABLE 2.2-2

(CONTINUED)

Fuel	Pollutant	Control Device Type	Average Control Efficiency <sup>a</sup> (%)	Control Efficiency Range <sup>a</sup> (%)	
				Minimum Value	Maximum Value
Natural Gas (Continued)	NO <sub>x</sub> (Continued)	Selective Non-catalytic Reduction		35	80
Natural Boiler Gas	NO <sub>x</sub>	Low NOX Burner w/ Overfire Air		40	50
Sewage Sludge	PM	Wet PM Scrubber		60	99
Wood	NO <sub>x</sub>	Selective Non-catalytic Reduction		50	70
	PM	Electrostatic Precipitator		93	99.8
		Fabric Filter	98	95.9	99.9
		Mechanical Collector		65	95
		Wet PM Scrubber	90	95	99
		Wet PM Scrubber <sup>d</sup>		92.1	93.3
Wood Bark	PM	Wet PM Scrubber <sup>d</sup>		83.8	85.1

TABLE 2.2-2

(CONTINUED)

Fuel	Pollutant	Control Device Type	Average Control Efficiency <sup>a</sup> (%)	Control Efficiency Range <sup>a</sup> (%)	
				Minimum Value	Maximum Value
Not Identified	SO <sub>2</sub> <sup>b</sup>	Wet Acid Gas Scrubber (Chemical Manufacturing) (b)		90	99

Source: EIIP Volume II, Chapter 12, *How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates*.

a) A blank field indicates that no data was available for this pollutant, fuel type, and control device.

b) Control device controls SO<sub>x</sub>.

c) These are the potential emission reductions from fuel switching. Source: EPA. 1998. *Stationary Source Control Techniques Document for Fine Particulate Matter*. U.S. Environmental Protection Agency. EPA 452/R-97-001.

d) Control efficiency is applicable to general fuel combustion operations.

enrichment. This phenomena may be especially important for metals that volatilize at peak combustion temperatures and condense on particulate at flue gas temperatures downstream.

**Electrostatic Precipitators (ESPs).** ESPs are widely used to control emissions from coal-fired boilers and account for 95 percent of all utility particulate controls in the United States (Buonicore and Davis, 1992). ESPs are PM control devices that employ electrical forces to remove particles from the flue gas onto collecting plates (EPA, June 1991). The accumulated particles are then knocked or washed off the plates and into collecting hoppers.

**Fabric Filters.** Fabric filter systems (also called baghouses) filter particles through fabric filtering elements (bags). Particles are caught on the surface of the bags, while the cleaned flue gas passes through. To minimize pressure drop, the bags must be cleaned periodically as the dust layer builds up. Fabric filters can achieve the highest particulate collection efficiency of all particulate control devices. A trend toward using more fabric filters in the electric utility industry is expected because of increasing restrictions on emissions of PM<sub>10</sub> and the growing use of dry SO<sub>2</sub> control technologies, such as dry injection and spray drying (Buonicore and Davis, 1992).

**Multiple Cyclones.** The cyclone (also known as a “mechanical collector”) is a particulate control device that uses gravity, inertia, and impaction to remove particles from the flue gas. A multiple cyclone consists of numerous small-diameter cyclones operating in parallel. Multiple cyclones are less expensive to install and operate than ESPs and fabric filters, but are not as effective at removing particulates. They are often used as precleaners to remove the bulk of heavier particles from the flue gas before it enters the main control device. They are often used on wood-fired boilers in series with scrubbers, ESPs, or fabric filters (Buonicore and Davis, 1992).

**Venturi Scrubbers.** Venturi scrubbers (sometimes referred to as high-energy wet scrubbers) are used to remove coarse and fine PM. Flue gas passes through a venturi tube while low-pressure water is added at the throat. The turbulence in the venturi tube promotes intimate contact between the particles and the water. The wetted particles and droplets are collected in a cyclone spray separator (sometimes called a cyclonic demister). Venturi scrubbers are often used on wood-fired boilers. Venturi scrubbers have a relatively high pressure drop, often ranging from 25 to 50 inches of water.

### ***Sulfur Dioxide Control***

**Dry Scrubbers.** Dry scrubbing is sometimes referred to as spray drying or spray absorption. It involves spraying a highly atomized slurry (which may contain water) of an alkaline reagent (slaked lime) into the hot flue gas to absorb the SO<sub>2</sub>. The high temperatures of the flue gas evaporates the water (if a wet reagent was used) and a dust collector removes the “dry” reagent which has absorbed the SO<sub>2</sub>. Unlike wet scrubbers, the dry scrubber is positioned before the dust

collector. Dry scrubbers are often applied on smaller industrial boilers, waste-to-energy plants, and units burning low-sulfur fuels (Stultz and Kitto, 1992).

**Wet Scrubbers.** In wet scrubbers, an alkaline liquid slurry is introduced into the flue gas. Wet scrubbing results in the generation of wet waste, which typically must be treated and disposed of in accordance with landfill and wastewater regulations. Limestone scrubbing is widely used on coal-fired utility boilers. Less common are regenerable systems that treat the absorber product to recover reagents, sometimes producing salable gypsum, elemental sulfur, or sulfuric acid.

**Low-Sulfur Fuel.** This approach to reducing  $\text{SO}_2$  emissions reduces the sulfur fed to the combustor by burning low-sulfur coals or oils. Fuel blending is the process of mixing high-sulfur-content fuels with low-sulfur-content fuels. The goal of effective fuel blending is to meet the blend specification, including sulfur content, heating value, moisture content, and (for coal) grindability. This practice is highly effective since most studies estimate that over 95 percent of the fuel sulfur is converted to  $\text{SO}_2$  during combustion. The minor amount of sulfur not converted is typically bound in the ash. High-alkali coal tends to bind more  $\text{SO}_2$  in the ash.

### ***Nitrogen Oxides Control***

**Selective Catalytic Reduction.** SCR is an add-on control technology that catalytically promotes the reaction between ammonia (which is injected into the flue gas) and  $\text{NO}_x$  to form nitrogen ( $\text{N}_2$ ) and water. SCR is currently used primarily with natural gas- and oil-fired boilers. In addition, several SCR systems have recently been installed on coal-fired boilers. If sulfur is present in the fuel, ammonium sulfate and bisulfate can form at around  $500^\circ\text{F}$  and can deposit on and foul the catalyst. If chlorine is present, ammonium chloride can form at around  $250^\circ\text{F}$  and result in a visible plume.

**Selective Noncatalytic Reduction.** SNCR technologies inject a reducing agent into  $\text{NO}_x$ -laden flue gas to reduce the  $\text{NO}_x$  to  $\text{N}_2$  and water ( $\text{H}_2\text{O}$ ). Two basic processes are currently available, one based on ammonia injection (Thermal De $\text{NO}_x$ ®), and one based on urea injection (sponsored by the Electric Power Research Institute [EPRI]). Both systems require careful attention to the problem of unreacted ammonia, which can form corrosive ammonia salts that damage downstream equipment.

**Low  $\text{NO}_x$  Burners and Overfire Air.** LNB and OFA have been demonstrated to be effective means of lowering  $\text{NO}_x$  production at utility boilers. These are combustion control methods that reduce peak temperatures in the combustion zone, reduce the gas residence time in the high-temperature zone, and provide a rich fuel/air ratio in the primary flame zone. This is considered a design change although it results in a reduction of emissions.



**Low Excess Air.** LEA is another combustion modification designed to lower  $\text{NO}_x$  emissions by inhibiting the creation of thermal  $\text{NO}_x$ . This is accomplished by limiting the amount of free nitrogen in the combustion zone. Excess air must be present to ensure good fuel use and to prevent smoke formation.

**Natural Gas Burner/Reburn.** In a reburn configured boiler, reburn fuel (natural gas, oil, or pulverized coal) is injected into the upper furnace region to convert the  $\text{NO}_x$  formed in the primary fuel's combustion zone to molecular nitrogen and water.

**Flue Gas Recirculation (FGR).** A portion of flue gas is recycled back to the primary combustion zone. This system reduces  $\text{NO}_x$  formation by two mechanisms:

- Heating in the primary combustion zone of the inert combustion products contained in the recycled flue gas lowers the peak flame temperature, thereby reducing thermal  $\text{NO}_x$  formation.
- To a lesser extent, FGR reduces thermal  $\text{NO}_x$  formation by lowering the oxygen concentration in the primary flame zone.

The recycled flue gas may be pre-mixed with the combustion air or injected directly into the flame zone. Direct injection allows more precise control of the amount and location of FGR.

**Staged Overfire Air.** Staged combustion, or off-stoichiometric combustion, combusts the fuel in two or more steps. A percentage of the total combustion air is diverted from the burners and injected through ports above the top burner level. The total amount of combustion air fed to the furnace remains unchanged. Initially, fuel is combusted in a primary, fuel-rich, combustion zone. Combustion is completed at lower temperatures in a secondary, fuel-lean, combustion zone. The sub-stoichiometric oxygen introduced with the primary combustion air into the high temperature, fuel-rich zone reduces fuel and thermal  $\text{NO}_x$  formation. Combustion in the secondary zone is conducted at a lower temperature, reducing thermal  $\text{NO}_x$  formation.

### **VOC Control**

Boilers do not have controls for organics or VOCs since the combustion process destroys most organic pollutants. Boilers do have residual amounts of organics and HAPs in their exhaust streams, which may be reduced by some add-on controls such as scrubbers used to control other pollutants.

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# 3

## OVERVIEW OF AVAILABLE METHODS FOR ESTIMATING EMISSIONS

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### 3.1 EMISSION ESTIMATION METHODOLOGIES

Several methodologies are available for calculating emissions from boilers. The method used is dependent upon available data, available resources, and the degree of accuracy required in the estimate. In general, site-specific data that are representative of normal operation at that site are preferred over industry-averaged data such as *AP-42* emission factors. For purposes of calculating peak season daily emissions for SIP inventories, refer to the EPA *Procedures* manual (EPA, May 1991).

This section discusses the methods available for calculating emissions from boilers and identifies the preferred method of calculation on a pollutant basis. This discussion focuses on estimating emissions from fuel combustion. Emission estimation approaches for auxiliary processes, such as using EPA's TANKS program to calculate storage tank emissions, are briefly discussed in Chapter 1 of this volume.

#### 3.1.1 CONTINUOUS EMISSION MONITORING SYSTEM (CEMS)

A CEMS provides a continuous record of emissions over an extended and uninterrupted period of time. Various principles are employed to measure the concentration of pollutants in the gas stream; they are usually based on photometric measurements. Once the pollutant concentration is known, emission rates are obtained by multiplying the pollutant concentration by the volumetric stack gas flow rate. The accuracy of this method may be problematic at low pollutant concentrations.

#### 3.1.2 PREDICTIVE EMISSION MONITORING (PEM)

PEM is based on developing a correlation between pollutant emission rates and process parameters and could be considered a hybrid of continuous monitoring, emission factors, and stack tests. A correlation test must first be performed to develop this relationship. Emissions at a later time can then be estimated or predicted using process parameters to predict emission rates based on the results of the initial source test. For example, emissions from a boiler controlled by

an SO<sub>2</sub> scrubber could be predicted, based on the correlation of the scrubbing solution to the pH and flow rate.

### 3.1.3 STACK SAMPLING

Stack sampling provides a “snapshot” of emissions during the period of the test. Samples are collected using probes inserted into the stack, and pollutants are collected in or on various media and sent to a laboratory for analysis. Some stack test methods provide real time data where the gas sample is analyzed on-site by continuous analysis (e.g., EPA Method 6C and 7E). Pollutant concentrations are obtained by dividing the amount of pollutant collected during the test by the volume of the sample. Emission rates are then determined by multiplying the pollutant concentration by the volumetric stack flow rate. Only experienced stack testers should perform the stack tests. The accuracy of this method may be problematic at low pollutant concentrations.

### 3.1.4 FUEL ANALYSIS

Fuel analysis data can be used to predict emissions by applying mass conservation laws. For example, if the concentration of a pollutant, or pollutant precursor, in a fuel is known, emissions of that pollutant can be calculated by assuming that all of the pollutant is emitted. This approach is appropriate for pollutants such as metals, SO<sub>2</sub>, and CO<sub>2</sub>. It should be noted, however, that some of the pollutant may end up in physical or chemical states (ash, unburned hydrocarbons, etc.) not emitted to the atmosphere.

### 3.1.5 EMISSION FACTORS

Emission factors are available for many source categories and are based on the results of source tests performed at one or more facilities within an industry. Basically, an emission factor is the pollutant emission rate relative to the level of source activity. Chapter 1 of this volume contains a detailed discussion of the reliability, or quality, of available emission factors. EPA provides compiled emission factors for criteria and HAPs in *AP-42*, the locating and estimating (L&E) series of documents, and the Factor Information Retrieval (FIRE) System. These may be found online at: [www.epa.gov/ttn/chief/](http://www.epa.gov/ttn/chief/)

## 3.2 COMPARISON OF AVAILABLE EMISSION ESTIMATION METHODOLOGIES

Table 2.3-1 identifies the preferred and alternative emission estimation approach for selected pollutants. For many of the pollutants emitted from boilers, several of the previously defined emission estimation methodologies can be used.

TABLE 2.3-1

**SUMMARY OF PREFERRED AND ALTERNATIVE EMISSION  
ESTIMATION METHODS FOR BOILERS**

<b>Parameter</b>	<b>Preferred Emission Estimation Approach</b>	<b>Alternative Emission Estimation Approach<sup>a</sup></b>
SO <sub>2</sub>	CEMS/PEM data	1. Fuel Analysis <sup>b</sup> 2. Stack sampling data 3. EPA/state published emission factors
NO <sub>x</sub>	CEMS/PEM data	1. Stack sampling data 2. EPA/state published emission factors
CO	CEMS/PEM data	1. Stack sampling data 2. EPA/state published emission factors
CO <sub>2</sub>	CEMS/PEM data	1. Stack sampling data 2. Fuel analysis 3. EPA/state published emission factors
VOC <sup>c</sup>	Stack sampling data	EPA/state published emission factors
THC <sup>d</sup>	CEMS/PEM data	1. Stack sampling data 2. EPA/state published emission factors
PM/PM <sub>10</sub> /PM <sub>2.5</sub> /PM <sub>condensable</sub>	Stack sampling data	EPA/state published emission factors

TABLE 2.3-1

(CONTINUED)

Parameter	Preferred Emission Estimation Approach	Alternative Emission Estimation Approach <sup>a</sup>
Heavy metals	Fuel analysis <sup>c</sup>	1. Stack sampling data 2. EPA/state published emission factors
Speciated organics	Stack sampling data	EPA/state published emission factors
Sulfuric acid mist	Stack sampling data	EPA/state published emission factors
Flow rate	CFRM <sup>f</sup> data/stack sampling data	1. Stack sampling data 2. EPA/state published emission factors

<sup>a</sup> In most cases, there are several alternative emission estimation approaches.

<sup>b</sup> May be used when no SO<sub>2</sub> control device is present.

<sup>c</sup> There is no direct measurement method for VOC. VOC is defined by EPA as those volatile organic compounds that are photo reactive and contribute to ozone formation. There are 2 common ways for determining VOC. The first is to measure as many of the individual organic compounds as possible and add those that are considered VOC. The second is to measure total hydrocarbons, subtract methane and ethane, and add formaldehyde. The second procedure is more of an estimate of VOC, but is considered acceptable. When using emission factors for VOC and speciated organics it should be noted that the sum of individual organic compounds may exceed the VOC emission factor due to the differences in test methods and the availability of test data for each pollutant.

<sup>d</sup> THC = Total hydrocarbons.

<sup>e</sup> Preferred for oil combustion only when no particulate control device is present; otherwise use stack sampling data.

<sup>f</sup> CFRM = Continuous flow rate monitor.

The preferred method for estimating boiler emissions is to use some form of direct or indirect measurement. This includes stack samples using a standard EPA reference method or other method of known quality, CEMS, or PEM. The preferred method is determined by the time specificity of the emission estimate (i.e., is an average acceptable or is the value on a given day needed?) and the data quality; the quality of the data will depend on a variety of factors including the number of data points generated, the representativeness of those data points, and the proper operation and maintenance of the equipment being used to record the measurements.

For annual emission inventories, CEMS data should always be used if available, and CEM is the preferred method for SO<sub>2</sub>, NO<sub>x</sub>, CO, CO<sub>2</sub>, and THC. PEM also provides an accurate estimate of emissions, but since emissions are not directly measured on a continuous basis, PEM should not be used if CEMS data is available.

In general, short-term stack samples obtained using an EPA reference method will give the highest quality (most accurate) data for any given point in time. However, for long-term estimates (such as annual emissions), CEMS data is expected to provide the most accurate emission estimate as emissions are being measured directly over the entire period of interest.

The performance of CEMS and PEM is measured with respect to the EPA reference method using an index known as relative accuracy (RA). The RA for CEMS or PEM is generally expressed as a percentage, and should have been quantified for any CEMS/PEM installed for regulatory compliance purposes. Also, the stack sampling data used to establish RA should be available; if the standard error of the sample data is greater than the RA, and if the CEMS is known to be adequately maintained, the CEMS data should be used to calculate emissions for any averaging period. The same discussion applies to PEM. For more discussion of statistical measures of uncertainty and data quality, refer to the *Quality Assurance Procedures* in Volume VI of the EIIP Document Series (refer to Section 7 of Chapter 3 and refer to Chapter 4).

### 3.2.1 CEMS

The use of site-specific CEMS data is preferred for estimating NO<sub>x</sub>, CO, CO<sub>2</sub>, SO<sub>2</sub>, and total hydrocarbon (THC) emissions because it provides a detailed record of emissions over time. Other alternative methods available to estimate emissions of these pollutants provide only short-term emissions data (in the case of stack sampling) or industry averages (in the case of emission factors) that may not be accurate or representative for a specific source.

Instrument calibration drift can be problematic for CEMS and uncaptured data can create long-term incomplete data sets. However, it is misleading to assert that a snapshot (stack sampling) can better predict long-term emission characteristics. It is the responsibility of the source owner to properly operate, calibrate, and validate the monitoring equipment and the corresponding emission data.

The preferred approach for obtaining stack gas flow rate is through the use of continuous monitoring. While flow rate can be measured using short-term stack sampling measurements, continuous monitoring provides more accurate long-term data.

### 3.2.2 PEM

PEM is a predictive emission estimation methodology whereby emissions are correlated to process parameters based on demonstrated correlations between emissions and process parameters. For example, testing may be performed on a boiler stack while the boiler is operated at various loads. Parameters such as fuel usage, steam production, and furnace temperature are monitored during the tests. These data are then used to produce emission curves. Periodic stack sampling may be required to verify that the emission curves are still accurate or to develop new curves based on the test results.

### 3.2.3 STACK SAMPLING

Stack sampling is the preferred emission estimation methodology for PM, PM<sub>10</sub>, speciated organics, and sulfuric acid mist. There are currently no CEMS methods for measuring these pollutants so the use of short-term, site-specific information is preferred over using emission factors that provide averaged emission data for a particular industry.

Fourier Transform Infrared (FTIR) Spectroscopy is a stack sampling method that may be used for multiple pollutants simultaneously. The sampling procedure is described in EPA Test Method 320. It is extractive, meaning flue gas is extracted from the exhaust of the affected source and transported to the FTIR gas cell through a heated handling system. This method applies to the analysis of vapor phase organic or inorganic compounds which absorb energy in the mid-infrared spectral region. This method is used to determine compound-specific concentrations in a multi-component vapor phase sample. Typically, the sampling apparatus is similar to that used for single-component CEM measurements.

Spectra of samples are collected using double beam infrared absorption spectroscopy and a computer program is used to analyze spectra and report compound concentrations. Analytes includes HAPs for which EPA reference spectra have been developed. Other compounds can also be measured with this method if reference spectra are prepared according to the protocol. NO<sub>x</sub>, CO, CO<sub>2</sub>, SO<sub>2</sub>, NH<sub>3</sub>, formaldehyde, and HCl are commonly sampled and analyzed by FTIR.

### 3.2.4 FUEL ANALYSIS

Site-specific fuel analysis is the preferred emission estimation methodology for metals when air pollution control equipment (e.g., scrubber, ESP) are not installed. In cases where control



equipment is installed, fuel analysis may be preferred if accurate data are available on pollutant-specific collection efficiencies and the amount of pollutant present in bottom ash and fly ash are known. Once the pollutant concentrations are known, their emissions can be calculated based on mass conservation laws. Fuel analysis is also useful in determining SO<sub>2</sub> and CO<sub>2</sub> emissions. While emission factors are available for most metals, the use of site-specific fuel analysis data provides a more accurate emission estimate. For SO<sub>2</sub>, fuel analysis, (specifically, the percentage of sulfur in the fuel) may be used with the appropriate emission factors in AP-42 to estimate SO<sub>2</sub> emissions. Fuel analysis may also be used to calculate CO<sub>2</sub> emissions by assuming complete conversion of the carbon in the fuel to CO<sub>2</sub>.

### **3.2.5 EMISSION FACTORS**

Due to their availability and acceptance in the industry, emission factors are commonly used to prepare emission inventories. However, the emission estimate obtained from using emission factors is based upon emission testing performed at similar facilities and may not accurately reflect emissions at a single source. Thus, the user should recognize that, in most cases, emission factors are averages of available industry-wide data with varying degrees of quality and may not be representative for an individual facility within that industry.

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# 4

## PREFERRED METHODS FOR ESTIMATING EMISSIONS

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The preferred method for estimating emissions of most pollutants emitted from boilers is usually the use of site-specific information (either CEMS data, PEM data, or recent stack tests). This section provides an outline for calculating emissions from boilers based on raw data collected by the CEMS and stack tests. The CEMS is usually used to measure SO<sub>2</sub>, NO<sub>x</sub>, THC, CO, flow rate, and a diluent, which can be either oxygen (O<sub>2</sub>) or CO<sub>2</sub>.

For oil combustion, fuel analysis is the preferred method for estimating emissions of metals.

For PM, sulfuric acid mist, speciated organic emissions, metals from coal combustion, and metals from fuel oil combustion where a particulate control device is used, the preferred emission estimation method is the use of stack sampling test data. Table 2.4-1 lists the variables and symbols used in the following discussion.

### 4.1 EMISSION CALCULATIONS USING CEMS DATA

To monitor SO<sub>2</sub>, NO<sub>x</sub>, THC, and CO emissions using a CEMS, a facility uses a pollutant concentration monitor, which measures concentration in parts per million by volume dry air (ppmvd). Flow rates are measured using a volumetric flow rate monitor, a type “S” pitot tube (as in EPA Method 2) or they can be estimated based on heat input using fuel factors, or “F-Factors”.

Table 2.4-2 presents an example output from a boiler using a CEMS consisting of SO<sub>2</sub>, NO<sub>x</sub>, CO, O<sub>2</sub>, and flow rate monitors. The output usually includes pollutant concentration in parts per million (ppm) and emission rates in pounds per hour (lb/hr).

The measurements presented in Table 2.4-2 represent a “snapshot” of a boiler’s operation; in this case, over a time period of 1 hour and 45 minutes. From these data, it is possible to determine that between 11:00 a.m. and noon, emissions of SO<sub>2</sub> averaged 1,631 (lb/hr). Assuming the CEMS operates properly all year long, an accurate emission estimate can be made by summing the hourly emission estimates.

TABLE 2.4-1

## LIST OF VARIABLES AND SYMBOLS

Variable	Symbol	Units
Concentration	C	parts per million by volume dry air (ppmvd)
Molecular weight	MW	lb/lb-mole
Molar volume	V	cubic feet (ft <sup>3</sup> )/lb-mole
Flow rate	Q	dry standard cubic feet per minute (dscfm) or actual cubic feet per minute (acfm)
Hourly emissions	E <sub>x</sub>	typically lb/hr of pollutant x
Heat input rate	H <sub>in</sub>	million British thermal units (Btu) per hour (MMBtu/hr) <sup>a</sup>
Annual heat input rate	H <sub>in,ann</sub>	MMBtu/yr
Annual emissions	E <sub>tpv,x</sub>	tons per year (tpy) of pollutant x
Higher heating value	HHV	Btu/lb
Fuel factor (dry)	F <sub>d</sub>	dscf/MMBtu at 0% O <sub>2</sub>
Filter catch	C <sub>f</sub>	g
Metered volume	V <sub>m</sub>	ft <sup>3</sup>
Fuel flow	Q <sub>f</sub>	typically, lb/hr
Annual fuel use	Q <sub>f,ann</sub>	lb/yr
Emission factor	EF <sub>x</sub>	typically lb/MMBtu, lb/ft <sup>3</sup> , or lb/gal of pollutant x
Annual Op hours	OpHrs	annual operating hours (hr/yr)

<sup>a</sup> MMBtu = 10<sup>6</sup> Btu.

TABLE 2.4-2

## EXAMPLE CEMS OUTPUT FOR A BOILER BURNING NO. 6 FUEL OIL

Period	O <sub>2</sub> (%V)	SO <sub>2</sub> (C) (ppmvd)	NO <sub>x</sub> (C) (ppmvd)	CO (C) (ppmvd)	Fuel Rate (Q) (10 <sup>3</sup> lb/hr)	Stack Gas Flow Rate (Q) (dscfm)	Emissions			
							SO <sub>2</sub> <sup>a</sup> (lb/MMBtu)	NO <sub>x</sub> <sup>a</sup> (lb/MMBtu)	SO <sub>2</sub> (lb/hr)	NO <sub>x</sub> (lb/hr)
11:00	2.1	1,004.0	216.2	31.5	46.0	155,087	1.9	0.4	1,551	240
11:15	2.0	1,100.0	200.6	25.5	46.5	155,943	2.0	0.4	1,709	224
11:30	2.1	1,050.0	216.7	25.1	46.0	155,087	2.0	0.4	1,622	241
11:45	1.9	1,070.0	220.5	20.8	46.2	154,122	2.0	0.4	1,643	243
12:00	1.9	1,070.0	213.8	19.4	46.8	156,123	2.0	0.4	1,664	239
12:15	1.8	1,050.0	214.0	19.4	46.3	153,647	1.9	0.4	1,607	235
12:30	2.0	1,100.0	209.1	21.5	46.3	155,273	2.0	0.4	1,701	232
12:45	2.0	1,078.0	210.8	50.3	46.5	155,943	2.0	0.4	1,675	235

<sup>a</sup> Based on a fuel heating value of 18,000 Btu/lb.

### 4.1.1 CALCULATING HOURLY EMISSIONS FROM CONCENTRATION MEASUREMENTS

Although CEMS can report real-time hourly emissions automatically, it may be necessary to manually estimate predicted annual emissions from hourly concentration data. This section describes how to calculate emissions from raw CEMS concentration data.

Hourly emissions can be based on concentration measurements as shown in Equation 2.4-1.

$$E_x = \frac{(C * MW * Q * 60)}{(V * 10^6)} \quad (2.4-1)$$

where:

- 60 = 60 min/hr
- $E_x$  = Hourly emissions in lb/hr of pollutant x
- C = Pollutant concentration in ppmvd
- MW = Molecular weight of the pollutant (lb/lb-mole)
- Q = Stack gas volumetric flow rate in dscfm
- V = Volume occupied by 1 mole of ideal gas at standard temperature and pressure (385.5 ft<sup>3</sup>/lb-mole @ 68°F and 1 atm)

### 4.1.2 CALCULATING STACK GAS FLOW RATE

When direct measurements of stack gas flow rates are not available, Q can be calculated using fuel factors (F factors) according to EPA Method 19 as shown below.

$$Q = F_d * \frac{20.9}{(20.9 - \%O_2)} * \frac{H_{in}}{60} \quad (2.4-2)$$

where:

- $F_d$  = Fuel factor, dry basis (from EPA Method 19) in dscf/MMBtu
- $\%O_2$  = Measured oxygen concentration, dry basis expressed as a percentage
- $H_{in}$  = Heat input rate in MMBtu/hr

The F factor is the ratio of the gas volume of the products of combustion to the heat content of the fuel.  $F_d$  includes all components of combustion less water.  $F_d$  can be calculated from fuel analysis results using the following equation:

$$F_d = \frac{10^6 [3.64(\%H) + 1.53(\%C) + 0.57(\%S) + 0.14(\%N) - 0.46(\%O)]}{HHV} \quad (2.4-3)$$

where:

H, C, S, N, and O = Concentrations of hydrogen, carbon, sulfur, nitrogen, and oxygen in the fuel expressed as a percentage as determined by a fuel analysis

HHV = Higher heating value of the fuel in Btu/lb

Fuel heating values are available in publications such as *Steam, Its Generation and Use* (Stultz and Kitto, 1992). The average  $F_d$  factors are provided in EPA Reference Method 19 for different fuels and are shown in Table 2.4-3.

#### 4.1.3 CALCULATING EMISSION FACTORS FROM HEAT INPUT

Sometimes it is desirable to calculate emissions in terms of pounds of pollutant per unit of heat combusted. For regulatory purposes, heat input is calculated based on the HHV of the fuel as measured by analysis. The heat input in terms of MMBtu/hr is calculated using:

$$H_{in} = \frac{(Q_f * HHV)}{10^6} \quad (2.4-4)$$

where:

$H_{in}$  = Heat input rate in MMBtu/hr

$Q_f$  = Mass fuel flow rate in lb/hr

HHV = Higher heating value in Btu/lb

An emission factor relating emissions to the heat input rate for the boiler is expressed as:

$$EF_x = E_x / H_{in} \quad (2.4-5)$$

where:

$EF_x$  = Emission factor in lb/MMBtu of pollutant x

$E_x$  = Emissions of pollutant x in lb/hr

TABLE 2.4-3

**F<sub>d</sub> FACTORS FOR VARIOUS FUELS<sup>a</sup>**

Fuel Type	F <sub>d</sub>	
	dscm/J <sup>b</sup>	dscf/MMBtu
Coal		
Anthracite <sup>c</sup>	2.71 * 10 <sup>-7</sup>	10,100
Bituminous <sup>c</sup>	2.62 * 10 <sup>-7</sup>	9,780
Lignite	2.65 * 10 <sup>-7</sup>	9,860
Oil <sup>d</sup>	2.65 * 10 <sup>-7</sup>	9,190
Gas		
Natural	2.34 * 10 <sup>-7</sup>	8,710
Propane	2.34 * 10 <sup>-7</sup>	8,710
Butane	2.34 * 10 <sup>-7</sup>	8,710
Wood	2.48 * 10 <sup>-7</sup>	9,240
Wood Bark	2.58 * 10 <sup>-7</sup>	9,600

<sup>a</sup> Determined at standard conditions: 20°C (68°F) and 760 mm Hg (29.92 in. Hg).<sup>b</sup> dscm/J = Dry standard cubic meters per joule.<sup>c</sup> As classified according to ASTM Method D 388-77.<sup>d</sup> Crude, residual, or distillate.

#### 4.1.4 CALCULATING EMISSION FACTORS USING EPA METHOD 19

EPA Method 19 may be used to develop site-specific emission factors (EF<sub>x</sub>) for PM, SO<sub>2</sub>, and NO<sub>x</sub> from pollutant concentration data, Oxygen percentage in the gas stream, and F factors (F<sub>d</sub>) using:

$$EF_x = (C_d * F_d) / [20.9 / (20.9 - \%O_2)] \quad (2.4-6)$$



where:

$$\begin{aligned} EF_x &= \text{Emission factor in lb/MMBtu of pollutant } x \\ C_d &= \text{pollutant concentration (lb/dscf)} \\ F_d &= \text{F factor (dscf/MMBtu)} \end{aligned}$$

Example 2.4-1 illustrates the use of Equation 2.4-6.

#### Example 2.4-1

This example shows how a site-specific SO<sub>2</sub> emission factor may be calculated using stack test data and the EPA Method 19 equation 2.4-6:

$$EF_{SO_2} = (C_d * F_d) / [20.9 / (20.9 - \%O_2)]$$

The relevant data for this example is:

$$\begin{aligned} C_{ppm} &= 1,000 \text{ ppm} \\ F_d &= 9,190 \text{ (dscf/MMBtu), from Table 2.4-3} \\ \%O_2 &= 2.1 \text{ (from the testing data presented in Table 2.4-2)} \end{aligned}$$

To convert  $C_{ppm}$  to  $C_d$ , use the appropriate conversion factor ( $1.66 \times 10^{-7}$ ) from EPA Method 19:

$$\begin{aligned} C_d &= C_{ppm} * (1.66 \times 10^{-7}) \\ &= 1,000 * (1.66 \times 10^{-7}) \\ &= 1.66 \times 10^{-4} \end{aligned}$$

The site-specific emission factor is then calculated as follows:

$$\begin{aligned} EF_{SO_2} &= (C_d * F_d) / [20.9 / (20.9 - \%O_2)] \\ EF_{SO_2} &= (1.66 \times 10^{-4} * 9,190) / [20.9 / (20.9 - 2.1)] \\ EF_{SO_2} &= 1.7 \text{ (lb/MMBtu)} \end{aligned}$$

### 4.1.5 CALCULATING ACTUAL ANNUAL EMISSIONS

Emissions in tons per year can be calculated either by multiplying the average hourly emission rate by the number of annual operating hours (Equation 2.4-7) or by multiplying the average

emission factor in lb/MMBtu by the annual heat input (Equation 2.4-9). Equation 2.4-8 shows how to calculate the annual heat input. Example 2.4-2 depicts the use of these equations.

$$E_{\text{tpy},x} = E_x * \text{OpHrs}/2,000 \quad (2.4-7)$$

where:

$E_{\text{tpy},x}$	=	Actual annual emissions in ton/yr of pollutant x
$E_x$	=	Emissions of pollutant x in lb/hr
OpHrs	=	Operating hours per year
2,000	=	lb/ton

Annual heat input may be calculated from annual fuel use using:

$$H_{\text{in,ann}} = \frac{(Q_{\text{f,ann}} * \text{HHV})}{10^6} \quad (2.4-8)$$

where:

$H_{\text{in,ann}}$	=	Annual heat input rate in MMBtu/yr
$Q_{\text{f,ann}}$	=	Annual fuel flow rate in lb/yr
HHV	=	Higher heating value in Btu/lb

$$E_{\text{tpy},x} = EF_x * H_{\text{in,ann}} \quad (2.4-9)$$

where:

$E_{\text{tpy},x}$	=	Actual annual emissions of pollutant x in ton/yr
$EF_x$	=	Emission factor in lb/MMBtu of pollutant x

$E_{\text{fx}}$  may be obtained using either Equation 2.4-5 or 2.4-6, depending on available data.

Example 2.4-2

This example shows how SO<sub>2</sub> emissions can be calculated based on the raw CEMS data for 11:00 shown in Table 2.4-2. Hourly emissions are calculated using Equation 2.4-1:

$$\begin{aligned} E_{\text{SO}_2} &= (C * \text{MW} * Q * 60) / (V * 10^6) \\ &= 1,004 * 64 * 155,087 * 60 / (385.5 * 10^6) \\ &= 1,551 \text{ lb/hr} \end{aligned}$$

Heat input is calculated using Equation 2.4-4:

$$\begin{aligned} H_{\text{in}} &= (Q_f * \text{HHV}) / 10^6 \\ &= 46,000 * 18,000 / 10^6 \\ &= 828 \text{ MMBtu/hr} \end{aligned}$$

An emission factor, in terms of lb/MMBtu, is calculated using Equation 2.4-5:

$$\begin{aligned} \text{EF}_{\text{SO}_2} &= E_{\text{SO}_2} / H_{\text{in}} \\ &= 1,551 / 828 \\ &= 1.9 \text{ lb/MMBtu} \end{aligned}$$

Emissions in tpy (based on a 5,840 hr/yr operating schedule) can then be calculated using Equation 2.4-7:

$$\begin{aligned} E_{\text{tpy}, \text{SO}_2} &= E_{\text{SO}_2} * \text{OpHrs} / 2,000 \\ &= 1,551 * (5,840 / 2,000) \\ &= 4,529 \text{ tpy} \end{aligned}$$

Emissions in tpy (based on  $2.69 * 10^8$  lb annual fuel use) can then be calculated by first using Equation 2.4-8 to calculate annual heat input:

$$\begin{aligned} H_{\text{in,ann}} &= (Q_{\text{f,ann}} * \text{HHV}) / 10^6 \\ &= (2.69 * 10^8 * 18,000) / 10^6 \\ &= 4.84 * 10^6 \text{ MMBtu/yr} \end{aligned}$$

**Example 2.4-2 (Continued)**

Emissions in tpy (based on  $4.84 * 10^6$  MMBtu/yr) can then be calculated using Equation 2.4-9:

$$\begin{aligned} E_{\text{tpy}, \text{SO}_2} &= EF_{\text{SO}_2} * H_{\text{in,ann}} / 2,000 \\ &= 1.9 * 4.84 * 10^6 / 2,000 \\ &= 4,598 \text{ tpy} \end{aligned}$$

Note that the last two calculations in Example 2.4-1 show an actual annual emission estimate based on a 15-minute average and are provided as an example only. Average values of  $E_x$  should be used to obtain a representative annual emissions estimate.

## 4.2 PEM

This section outlines an example of  $\text{SO}_2$  emission monitoring that could be used to develop a PEM protocol for a boiler equipped with a wet scrubber. Boiler and scrubber parameters that affect emissions and that are most likely to be included in the testing algorithm are scrubber water pH and flow rate, and fuel combustion rate.

To develop this algorithm, correlation testing of the stack gas, scrubber, and boiler process variables could be conducted over a range of potential operating conditions using EPA Method 6A or Method 6C to measure  $\text{SO}_2$  emissions. Potential testing conditions are shown in Table 2.4-4. Based on the test data, a mathematical correlation can be developed that predicts  $\text{SO}_2$  emissions using these parameters.

## 4.3 EMISSION CALCULATIONS USING STACK SAMPLING DATA

Stack sampling test reports often provide emissions in terms of lb/hr or lb/MMBtu. Annual emissions may be calculated from these data using Equations 2.4-6 or 2.4-8 as shown in Example 2.4-1. Stack tests performed under a proposed permit condition or a maximum emissions rate may not accurately reflect the emissions that would result under normal operating conditions. Therefore, when using stack sampling test data to estimate emissions, tests should be conducted under “normal” operating conditions.

TABLE 2.4-4

PREDICTIVE EMISSION MONITORING ANALYSIS<sup>a</sup>

Test Number	Scrubber Water Flow Rate	Scrubber Water pH	Fuel Firing Rate
1	B	H	H
2	B	H	M
3	B	H	L
4	B	M	H
5	B	M	M
6	B	M	L
7	B	L	H
8	B	L	M
9	B	L	L

<sup>a</sup> H = High.  
M = Medium.  
L = Low.  
B = Baseline.

Example 2.4-3

This example shows how to calculate SO<sub>2</sub> emissions when the stack gas flow rate, Q, is not available.

The F factor for No. 6 fuel oil, based on Table 2.4-3, is 9,190 dscf/MMBtu. The oxygen content is 2.1 percent. From Example 2.4-1, H<sub>in</sub> is 828 MMBtu/hr. The stack gas flow rate is calculated using Equation 2.4-10:

$$\begin{aligned} Q &= F_d * (20.9)/(20.9 - \%O_2) * (H_{in}/60) \\ Q &= 9,190 * (20.9)/(20.9 - 2.1) * (828/60) \\ Q &= 140,988 \text{ dscfm} \end{aligned} \quad (2.4-10)$$

Using the CEMS data from Table 2.4-2 (for 11:00) and the calculated flow rate, hourly emissions can now be calculated using Equation 2.4-1:

$$\begin{aligned} E_{SO_2} &= (C * MW * Q * 60)/(V * 10^6) \\ E_{SO_2} &= (1,004 * 64 * 140,988 * 60)/(385.5 * 10^6) \\ E_{SO_2} &= 1,410 \text{ lb/hr} \end{aligned} \quad (2.4-1)$$

To express the emissions in terms of pounds per unit of heat combusted, use Equation 2.4-11:

$$\begin{aligned} EF_{SO_2} &= E_{SO_2}/H_{in} \\ EF_{SO_2} &= 1,410/828 \\ EF_{SO_2} &= 1.7 \text{ lb/MMBtu} \end{aligned} \quad (2.4-11)$$

Note that E<sub>SO<sub>2</sub></sub> and EF<sub>SO<sub>2</sub></sub> calculated using F factors is slightly different than the emissions calculated using flow rate measurements. This difference is due to different estimation approaches; depending on the use of the data, either approach may be acceptable.

This section shows how to calculate emissions in lb/hr based on raw stack sampling data. Calculations involved in determining SO<sub>2</sub> and PM<sub>10</sub> emissions from raw EPA Method 201A data are presented in Examples 2.4-3 and 2.4-4, respectively. Because PM<sub>10</sub> emissions cannot be measured continuously, the best method available for measuring PM<sub>10</sub> emissions is Method 201A.

An example summary of a Method 201A test is shown in Table 2.4-5. The table shows the results of three different sampling runs conducted during one test event. The source parameters measured as part of a Method 201A run include gas velocity and moisture content, which are used to determine exhaust gas flow rates in dscfm. The filter weight gain is determined gravimetrically and divided by the volume of gas sampled as shown in Equation 2.4-12 to determine the PM concentration in lb/dscf. Pollutant concentration is then multiplied by the volumetric flow rate to determine the emission rate in pounds per hour, as shown in Equation 2.4-1.

$$E_x = (C_f/V_m) * Q * 60/453.6 \quad (2.4-12)$$

where:

$E_x$	=	Emissions of pollutant x in lb/hr
$C_f$	=	Filter catch (g)
$V_m$	=	Metered volume of sample (ft <sup>3</sup> )
$Q$	=	Stack gas volumetric flow rate (dscfm)
60	=	60 min/hr
453.6	=	453.6 g/lb

#### Example 2.4-4

This example shows how PM<sub>10</sub> emissions may be calculated using Equation 2.4-12 and the stack sampling data for Run 1 (presented in Table 2.4-5).

$$\begin{aligned} E &= (C_f/V_m) * Q * 60/453.6 \\ &= (0.003/120.23) * 206,404 * 60/453.6 \\ &= 0.68 \text{ lb/hr} \end{aligned}$$

## 4.4 EMISSION CALCULATIONS USING FUEL ANALYSIS DATA

Fuel analysis can be used to predict emissions based on application of conservation laws. The presence of certain elements in fuels may be used to predict their presence in emission streams. This includes toxic elements such as metals found in oil as well as other elements such as sulfur that may be converted to other compounds during the combustion process.

TABLE 2.4-5

## SAMPLE TEST RESULTS - METHOD 201A

Parameter	Run 1	Run 2	Run 3
Total sampling time (minutes)	180.00	180.00	180.00
Corrected barometric pressure (in. Hg)	30.56	30.56	30.56
Absolute stack pressure, Ps (in. Hg)	30.49	30.49	30.49
Stack static pressure (in. H <sub>2</sub> O)	-0.89	-0.89	-0.89
Average stack temperature (°F)	328.00	330.00	335.00
Stack area (ft <sup>2</sup> )	113.09	113.09	113.09
Metered volume of sample, V <sub>m</sub> (ft <sup>3</sup> )	116.51	110.20	115.30
Average meter pressure (in. H <sub>2</sub> O)	0.81	0.81	0.81
Average meter temperature (°F)	69.28	71.00	70.20
Moisture collected (g)	258.50	265.00	261.00
Carbon dioxide concentration (%V)	15.50	15.40	15.30
Oxygen concentration (%V)	2.30	2.30	2.30
Nitrogen concentration (%V)	82.20	82.30	82.40
Dry gas meter factor	1.01080	1.01080	1.01080
Pitot constant	0.84	0.84	0.84
PM <sub>10</sub> filter catch (g)	0.003	0.004	0.003
Average sampling rate (dscfm)	0.67	0.67	0.67
Standard metered volume, V <sub>m</sub> (std) (dscf)	120.23	121.30	118.50
Standard volume water vapor, Vw (scf)	12.19	13.00	12.50
Stack moisture (%V)	9.20	9.50	9.60
Mole fraction dry stack gas	0.908	0.908	0.908
Dry molecular weight (g)	29.37	29.37	29.37
Wet molecular weight (g)	28.32	28.32	28.32
Stack gas velocity, V <sub>s</sub> (ft/min)	3000.00	2950.00	2965.00
Volumetric flow rate (acfm)	339270	333616	335312
Volumetric flow rate (dscfm)	206404	201791	201319
Percent isokinetic	96.48	97.00	98.00
Concentration of particulate (g/dscf)	0.00002	0.00003	0.00003
PM <sub>10</sub> emission rate (lb/hr)	0.68	0.90	0.69



The basic equation used in fuel analysis emission calculations is:

$$E = Q_f * \text{Pollutant concentration in fuel} * \left( \frac{MW_p}{MW_f} \right) \quad (2.4-13)$$

where:

$$\begin{aligned} Q_f &= \text{Fuel flow rate (lb/hr)} \\ MW_p &= \text{Molecular weight of pollutant emitted (lb/lb-mole)} \\ MW_f &= \text{Molecular weight of pollutant in fuel (lb/lb-mole)} \end{aligned}$$

For example, SO<sub>2</sub> emissions from oil combustion can be calculated based on the concentration of sulfur in the oil. This approach assumes complete conversion of sulfur to SO<sub>2</sub>. Therefore, for every pound of sulfur (MW = 32 g) burned, 2 lb of SO<sub>2</sub> (MW = 64 g) are emitted. The application of this emission estimation technique is shown in Example 2.4-5.

#### Example 2.4-5

This example shows how SO<sub>2</sub> emissions can be calculated from oil combustion based on fuel analysis results and the fuel flow information provided in Table 2.4-2.

E<sub>SO2</sub> may be calculated using Equation 2.4-13.

$$\begin{aligned} Q_f &= 46,000 \text{ lb/hr} \\ \text{Percent sulfur (\%S) in fuel} &= 1.17 \end{aligned}$$

$$\begin{aligned} E_{SO2} &= Q_f * \text{Pollutant concentration in fuel} * (MW_p/MW_f) \\ &= (46,000) * (1.17/100) * (64/32) \\ &= 1,076 \text{ lb/hr} \end{aligned}$$

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# 5

## ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

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### 5.1 EMISSION FACTOR CALCULATIONS

Emission factors are commonly used to calculate emissions from boilers when site-specific stack monitoring data are unavailable. The EPA maintains a compilation of emission factors in *AP-42* (EPA, January 1995) for criteria pollutants and HAPs. The most comprehensive source for toxic and hazardous air pollutant emission factors is the FIRE data system (EPA, September 2000). FIRE also contains emission factors for criteria pollutants.

Much work has been done recently on developing emission factors for HAPs and recent *AP-42* revisions have included these factors. In addition, many states have developed their own HAP emission factors for certain source categories and may require their use in any inventories including HAPs. Refer to Chapter 1 of Volume II for a complete discussion of available information sources for locating, developing, and using emission factors as an estimation technique.

Emission factors developed from measurements for a specific boiler may sometimes be used to estimate emissions at other sites. For example, a company may have several boilers of a similar model and size; if emissions were measured from one boiler, a factor can be developed and applied to the other boilers. It is advisable to have the factor approved by state/local agencies or by the EPA.

The basic equation used in emission factor emissions calculations is:

$$E_x = EF_x * \text{Activity Rate} \quad (2.5-1)$$

where:

$E_x$	=	Emissions of pollutant x
$EF_x$	=	Emission factor

In cases where more than one fuel type is used, annual emissions should be calculated using appropriate emission factors and proportioned based on the amount of each type of fuel used. Examples 2.5-1 and 2.5-2 show the use of Equations 2.5-1.

#### Example 2.5-1

This example shows how CO emissions may be calculated for No. 6 oil combustion based on the boiler fuel rate information provided in Table 2.4-2 and a CO emission factor from AP-42, Table 1.3-2, for No. 6 fuel oil.

$$\begin{aligned}
 E_x &= EF_x * \text{Activity Rate } (Q_f) \\
 EF_{CO} &= 5 \text{ lb}/10^3 \text{ gal} \\
 Q_f &= (46.0 * 10^3 \text{ lb/hr}) * 1 \text{ gal}/8 \text{ lb} \\
 &= 5,750 \text{ gal/hr} \\
 E_{CO} &= EF_{CO} * Q_f \\
 &= 5/10^3 * 5,750 \\
 &= 28.75 \text{ lb/hr}
 \end{aligned}$$

#### Example 2.5-2

This example shows how chromium emissions may be calculated for No. 6 oil combustion based on a heat input rate of 828 MMBtu/hr and a chromium emission factor from FIRE for SCC 1-01-004-01.

$$\begin{aligned}
 EF(\text{chromium}) &= 6.31 * 10^{-6} \text{ lb/MMBtu} \\
 \text{Chromium emissions} &= EF(\text{chromium}) * H_{in} \\
 &= (6.31 * 10^{-6}) * 828 \\
 &= 5.22 * 10^{-3} \text{ lb/hr}
 \end{aligned}$$

# 6

## QUALITY ASSURANCE/QUALITY CONTROL

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The consistent use of standardized methods and procedures is essential in the compilation of reliable emission inventories. QA and QC of an inventory is accomplished through a set of procedures that ensure the quality and reliability of data collection and analysis. These procedures include the use of appropriate emission estimation techniques, applicable and reasonable assumptions, accuracy/logic checks of computer models, checks of calculations, and data reliability checks. Chapter 3 of Volume VI of this series describes additional QA/QC methods and tools for performing these procedures.

Chapter 1, *Introduction to Stationary Point Source Emission Inventory Development*, of this volume presents recommended standard procedures to follow that ensure the reported inventory of this volume data are complete and accurate. Chapter 1, Section 9, should be consulted for current EIIP guidance for QA/QC checks for general procedures, recommended components of a QA plan, and recommended components for point source inventories. The QA plan discussion includes recommendations for data collection, analysis, handling, and reporting. The recommended QC procedures include checks for completeness, consistency, accuracy, and the use of approved standardized methods for emission calculations, where applicable. Chapter 1, Section 9, also describes guidelines to follow in order to assure the quality and validity of the data from manual and continuous emission monitoring methodologies used to estimate emissions.

### 6.1 GENERAL FACTORS INVOLVED IN EMISSION ESTIMATION TECHNIQUES

#### 6.1.1 STACK TESTS AND CEMS

Data collected via CEMS, PEM, or stack tests must meet quality objectives. Stack test data must be reviewed to ensure that the test was conducted under normal operating conditions and that data were generated according to an acceptable method for each pollutant of interest. Calculation and interpretation of accuracy for stack testing methods and CEMS are described in detail in *Quality Assurance Handbook for Air Pollution Measurements Systems: Volume III. Stationary Source Specific Methods (Interim Edition)* (EPA, April 1994).

The acceptance criteria, limits, and values for each control parameter associated with manual sampling methods, such as dry gas meter calibration and leak rates, are summarized in of Chapter 1 of this volume. Continuous monitoring for NO<sub>x</sub>, CO, CO<sub>2</sub>, and THC's using various instruments is discussed in Section 3 of this chapter. QC procedures for all instruments used to continuously collect emissions data are similar. The primary control check for precision of the continuous monitors is daily analysis of control standards. The CEMS acceptance criteria and control limits are also listed in Chapter 1.

### 6.1.2 EMISSION FACTORS

The use of emission factors is straightforward when the relationship between process data and emissions is direct and relatively uncomplicated. When using emission factors, the user should be aware of the quality indicator associated with the value. Emission factors published within EPA documents and electronic tools have a quality rating applied to them. The lower the quality indicator, the more likely that a given emission factor may not be representative of the source type. It is always better to rely on actual stack test or CEMS data, where available. The reliability and uncertainty of using emission factors as an emission estimation technique are discussed in detail in Chapter 1 of this volume.

## 6.2 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

One measure of emission inventory data quality is the DARS score (Beck et al. 1994). Four examples are given here to illustrate DARS scoring using the preferred and alternative methods. The DARS provides a numerical ranking on a scale of 1 to 10 for individual attributes of the emission factor and the activity data. Each score is based on what is known about the factor and the activity data, such as the specificity to the source category and the measurement technique employed. The composite attribute score for the emissions estimate can be viewed as a statement about the confidence that can be placed in the data. For a complete discussion of DARS and other rating systems, see the *QA Source Document* (Volume VI, Chapter 4) and Volume II, Chapter 1, *Introduction to Stationary Point Source Emission Inventory Development*. These are available on the EIIP web page at [www.epa.gov/ttn/chief/eiip/](http://www.epa.gov/ttn/chief/eiip/).

Each of the examples below is hypothetical. A range is given where appropriate to cover different situations. The scores are assumed to apply to annual emissions from a boiler. Table 2.6-1 gives a set of scores for an estimate based on CEMS/PEM data. A perfect score of 1.0 is achievable using this method if data quality is very good. Note that maximum scores of 1.0 are automatic for the source definition and spatial congruity attributes. Likewise, the temporal congruity attribute receives a 1.0 if data capture is greater than 90 percent; this assumes that data are sampled adequately throughout the year. The measurement attribute score of 1.0 assumes that the pollutants of interest were measured directly. A lower score is given if the

emissions are speciated using a profile, or if the emissions are used as a surrogate for another pollutant. Also, the measurement/method score can be less than 1.0 if the relative accuracy is poor (e.g., >10 percent), if the data are biased, or if data capture is closer to 90 percent than to 100 percent.

TABLE 2.6-1

**DARS SCORES: CEMS/PEM DATA<sup>a</sup>**

Attribute	Emission Factor Score	Activity Data Score	Composite Scores		Comment
			Range	Midpoint	
Measurement/method	0.9 - 1	0.9 - 1	0.81 - 1	0.905	Lower scores given if relative accuracy poor (e.g., >10 percent) or data capture closer to 90 percent.
Source definition	1.0	1.0	1.0	1.0	
Spatial congruity	1.0	1.0	1.0	1.0	
Temporal congruity	1.0	1.0	1.0	1.0	
Weighted Score	0.98 - 1	0.98 - 1	0.95 - 1	0.98	

<sup>a</sup> Assumes data capture is 90 percent or better, and representative of entire year; monitors, sensors, and other equipment properly maintained.

The use of stack sample data can give DARS scores as high as those for CEMS/PEM data. However, the sample size is usually too low to be considered completely representative of the range of possible emissions making a score of 1.0 for measurement/method unlikely. A typical DARS score is generally closer to the low end of the range shown in Table 2.6-2.

Two examples are given for emissions calculated using emission factors. For both of these examples, the activity data are assumed to be measured directly or indirectly. Table 2.6-3 applies to an emission factor developed from CEMS/PEM data from one boiler and then applied to a different boiler of similar design and age. Table 2.6-4 gives an example for an estimate made with an *AP-42* emission factor. *AP-42* factors are defined for classes of boilers (based on size and fuel type); for some pollutants, the variability in emissions among this population may be high. The *AP-42* factor is a mean and could overestimate or underestimate emissions for any single boiler in the population. Also, the data on which some of these factors are based are often

TABLE 2.6-2

**DARS SCORES: STACK SAMPLE DATA<sup>a</sup>**

Attribute	Emission Factor Score	Activity Data Score	Composite Scores		Comment
			Range	Midpoint	
Measurement/method	0.7 - 1	0.7 - 1	0.49 - 1	0.745	
Source definition	1 - 1	1 - 1	1 - 1	1	
Spatial congruity	1 - 1	1 - 1	1 - 1	1	
Temporal congruity	0.7 - 1	0.7 - 1	0.49 - 1	0.745	Lower scores given if emissions vary temporally and sample does not cover range.
Weighted Score	0.85 - 1	0.85 - 1	0.75 - 1	0.87	

<sup>a</sup> Assumes use of an EPA reference method, high quality data.

limited in numbers and may be 10-20 years old. Thus, the confidence that can be placed in emissions estimated for a specific boiler with a general *AP-42* factor is lower than emissions based on source-specific data.

The example in Table 2.6-3 shows that emission factors based on high-quality data from a similar unit will typically give better results than a general factor. The main criterion affecting the score is how similar the boiler used to generate the factor is to the target boiler.

If sufficient data are available, the uncertainty in the estimate should be quantified. QA methods are described in the (Volume VI, Chapter 4).



TABLE 2.6-3

**DARS SCORES: SOURCE-SPECIFIC EMISSION FACTOR<sup>a</sup>**

Attribute	Emission Factor Score	Activity Data Score	Composite Scores		Comment
			Range	Midpoint	
Measurement/method	0.9 - 1	0.8 - 1	0.72 - 1	0.86	Factor score for this attribute depends entirely on data quality.
Source definition	0.5 - 0.9	0.8 - 0.9	0.4 - 0.81	0.61	Factor score lowest if unit differs much from original source of data.
Spatial congruity	1 - 1	1 - 1	1 - 1	1	
Temporal congruity	1 - 1	0.5 - 0.9	0.5 - 0.9	0.7	
Weighted Score	0.85 - 0.98	0.78 - 0.95	0.66 - 0.93	0.79	

<sup>a</sup> Assumes factor developed from PEM or CEMS data from an identical emission unit (same manufacturer, model).

TABLE 2.6-4

DARS SCORES: AP-42 EMISSION FACTOR<sup>a</sup>

Attribute	Emission Factor Score	Activity Data Score	Composite Scores		Comment
			Range	Midpoint	
Measurement/method	0.6 - 0.8	0.8 - 1	0.48 - 0.7	0.59	Score depends on quality and quantity of data points used to develop factor.
Source definition	0.5 - 0.9	0.8 - 0.9	0.4 - 0.81	0.605	Emission factor score will be low if variability in source population is high.
Spatial congruity	0.6 - 0.8	1 - 1	0.6 - 0.8	0.7	Factor score lower if geographic location has significant effect on emissions.
Temporal congruity	0.5 - 0.9	0.5 - 0.9	0.25 - 0.81	0.53	Lower scores given if emissions vary temporally and sample does not cover range.
Weighted Score	0.55 - 0.85	0.78 - 0.95	0.43 - 0.78	0.61	

<sup>a</sup> Assumes activity data (e.g., fuel use) or surrogate is measured directly in some manner.

# 7

## DATA CODING PROCEDURES

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This section describes the methods and codes available for characterizing emission sources at boiler facilities using SCC and Aerometric Information Retrieval System (AIRS) control device codes. Consistent categorization and coding will result in greater uniformity among inventories. The SCCs are the building blocks on which point source emissions data are structured. Each SCC represents a unique process or function within a source category that is logically associated with an emission point. Without an appropriate SCC, a process cannot be accurately identified for retrieval purposes. In addition, the procedures described here will assist the reader preparing data for input to a database management system. For example, the use of the SCCs provided in Table 2.7-1 are recommended for describing boiler operations. Refer to the Clearinghouse for Inventories and Emission Factors (CHIEF) for a complete listing of SCCs for boilers. While the codes presented here are currently in use, they may change based on further refinement by the emission inventory user community. As part of the Emission Inventory Improvement Program (EIIP), a common emissions data exchange format is being developed to facilitate data transfer between industry, states, and EPA.

### 7.1 PROCESS EMISSIONS

Use of the codes in Table 2.7-1 are recommended for describing boilers that burn anthracite, bituminous, subbituminous, or lignite coal; oil- or natural gas-fired electric utility boilers; peaking plants; cogeneration units; and electric utility boilers that burn other types of fuel. More than one code may be necessary for each boiler if auxiliary fuel is used. Auxiliary fuels such as oil are used during start-up of utility boilers, or to sustain combustion (such as coal, oil, or natural gas used at utility boilers that predominantly burn wood/bark or waste).

### 7.2 STORAGE TANKS

The codes in Table 2.7-1 are recommended to describe emissions related to fuel storage.

### 7.3 FUGITIVE EMISSIONS

Fugitive emissions at boiler facilities may result from coal, wood/bark, and solid/liquid waste handling and storage. Limestone handling and storage emissions may also occur if the facility uses limestone in control devices such as scrubbers. There are undoubtedly sources of fugitive emissions within the facility or sources that have not been specifically discussed thus far; these

should be included. Conditions vary from plant to plant, so each specific case cannot be discussed within the context of this document.

Codes that may be used to describe fugitive emissions at boiler facilities are also presented in Table 2.7-1. It may be necessary to use a miscellaneous fugitive emission code for sources without a unique code. Many database systems used for inventory management contain a comment field that may be used to describe the fugitive emissions.

## 7.4 CONTROL DEVICES

The codes found in Table 2.7-2<sup>1</sup> are recommended for describing control devices used at electric utilities and may also be applicable to control devices used at commercial and institutional boilers. The “099” control code may be used to handle miscellaneous control devices that do not have a unique control equipment identification code. For a complete listing, the reader may consult the *AIRS User’s Guide Volume XI: AFS Data Dictionary* (AFS is AIRS Facility Subsystem) (EPA, January 1992).

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<sup>1</sup> Note: At the time of publication, these control device codes were under review by the EPA. The reader should consult the EPA for the most current list of codes.

TABLE 2.7-1

## SOURCE CLASSIFICATION CODES FOR BOILERS

Source Description	Process Description	SCC	Units
<b>External Combustion Boilers</b>			
External Combustion Boilers: Electric Generation	Pulverized Coal (Anthracite)	1-01-001-01	Tons Anthracite Coal Burned
	Traveling Grate (Overfeed) Stoker (Anthracite Coal)	1-01-001-02	Tons Anthracite Coal Burned
	Pulverized Coal: Wet Bottom (Bituminous Coal)	1-01-002-01	Tons Bituminous Coal Burned
	Pulverized Coal: Dry Bottom (Bituminous Coal)	1-01-002-02	Tons Bituminous Coal Burned
	Cyclone Furnace (Bituminous Coal)	1-01-002-03	Tons Bituminous Coal Burned
	Spreader Stoker (Bituminous Coal)	1-01-002-04	Tons Bituminous Coal Burned
	Traveling Grate (Overfeed) Stoker (Bituminous Coal)	1-01-002-05	Tons Bituminous Coal Burned
	Wet Bottom (Tangential) (Bituminous Coal)	1-01-002-11	Tons Bituminous Coal Burned
	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	1-01-002-12	Tons Bituminous Coal Burned
	Cell Burner (Bituminous Coal)	1-01-002-15	Tons Bituminous Coal Burned
	Atmospheric Fluidized Bed Combustion: Bubbling Bed (Bituminous Coal)	1-01-002-17	Tons Bituminous Coal Burned
	Atmospheric Fluidized Bed Combustion: Circulating Bed (Bitum. Coal)	1-01-002-18	Tons Bituminous Coal Burned
	Pulverized Coal: Wet Bottom (Subbituminous Coal)	1-01-002-21	Tons Subbituminous Coal Burned
	Pulverized Coal: Dry Bottom (Subbituminous Coal)	1-01-002-22	Tons Subbituminous Coal Burned
	Cyclone Furnace (Subbituminous Coal)	1-01-002-23	Tons Subbituminous Coal Burned
	Spreader Stoker (Subbituminous Coal)	1-01-002-24	Tons Subbituminous Coal Burned
	Traveling Grate (Overfeed) Stoker (Subbituminous Coal)	1-01-002-25	Tons Subbituminous Coal Burned

TABLE 2.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
<b>External Combustion Boilers (Continued)</b>			
External Combustion Boilers: Electric Generation (Continued)	Pulverized Coal: Dry Bottom Tangential (Subbituminous Coal)	1-01-002-26	Tons Subbituminous Coal Burned
	Cell Burner (Subbituminous Coal)	1-01-002-35	Tons Subbituminous Coal Burned
	Atmospheric Fluidized Bed Combustion - Circulating Bed (subbitum coal)	1-01-002-38	Tons Subbituminous Coal Burned
	Pulverized Coal: Wet Bottom (Lignite)	1-01-003-00	Tons Lignite Burned
	Pulverized Coal: Dry Bottom, Wall Fired (Lignite)	1-01-003-01	Tons Lignite Burned
	Pulverized Coal: Dry Bottom, Tangential Fired (Lignite)	1-01-003-02	Tons Lignite Burned
	Cyclone Furnace (Lignite)	1-01-003-03	Tons Lignite Burned
	Traveling Grate (Overfeed) Stoker (Lignite)	1-01-003-04	Tons Lignite Burned
	Spreader Stoker (Lignite)	1-01-003-06	Tons Lignite Burned
	Atmospheric Fluidized Bed (Lignite)** (See 101003-17 & -18)	1-01-003-16	Tons Lignite Burned
	Atmospheric Fluidized Bed Combustion - Bubbling Bed (Lignite)	1-01-003-17	Tons Lignite Burned
	Atmospheric Fluidized Bed Combustion - Circulating Bed (Lignite)	1-01-003-18	Tons Lignite Burned
	Normal Firing, Grade 6 Oil (Residual)	1-01-004-01	1000 Gallons Residual Oil Burned
	Tangential Firing, Grade 6 Oil (Residual)	1-01-004-04	1000 Gallons Residual Oil Burned
	Normal Firing, Grade 5 Oil (Residual)	1-01-004-05	1000 Gallons Residual Oil Burned
	Tangential Firing, Grade 5 Oil (Residual)	1-01-004-06	1000 Gallons Residual Oil Burned
	Grades 1 and 2 Oil (Distillate)	1-01-005-01	1000 Gallons Distillate Oil Burned

TABLE 2.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
<b>External Combustion Boilers (Continued)</b>			
External Combustion Boilers: Electric Generation (Continued)	Normal Firing, Grade 4 Oil (Distillate)	1-01-005-04	1000 Gallons Distillate Oil Burned
	Tangential Firing, Grade 4 Oil (Distillate)	1-01-005-05	1000 Gallons Distillate Oil Burned
	Natural Gas Boilers > 100 Million Btu/hr except Tangential	1-01-006-01	Million Cubic Feet Natural Gas Burned
	Natural Gas Boilers < 100 Million Btu/hr except Tangential	1-01-006-02	Million Cubic Feet Natural Gas Burned
	Natural Gas Boilers: Tangentially Fired Units	1-01-006-04	Million Cubic Feet Natural Gas Burned
	Process Gas Boilers > 100 Million Btu/hr	1-01-007-01	Million Cubic Feet Process Gas Burned
	Process Gas Boilers < 100 Million Btu/hr	1-01-007-02	Million Cubic Feet Process Gas Burned
	Coke, All Boiler Sizes	1-01-008-01	Tons Coke Burned
	Bark-fired Boiler (Wood/Bark Waste)	1-01-009-01	Tons Bark Burned
	Wood/Bark Fired Boiler (Wood/Bark Waste)	1-01-009-02	Tons Wood/Bark Burned
	Wood-fired Boiler (Wood/Bark Waste)	1-01-009-03	Tons Wood Burned
	Fuel cell/Dutch oven boilers (Wood/Bark Waste)	1-01-009-10	Ton Wood/Bark Burned
	Stoker boilers (Wood/Bark Waste)	1-01-009-11	Ton Wood/Bark Burned
	Fluidized bed combustion boilers (Wood/Bark Waste)	1-01-009-12	Ton Wood/Bark Burned
	Liquified Petroleum Gas (LPG), Butane	1-01-010-01	1000 Gallons Butane Burned
	Liquified Petroleum Gas (LPG), Propane	1-01-010-02	1000 Gallons Propane Burned
	Liquified Petroleum Gas (LPG), Butane/Propane Mixture: Specify Percent Butane in Comments	1-01-010-03	1000 Gallons Propane/Butane Burned
	Bagasse, All Boiler Sizes	1-01-011-01	Tons Bagasse Burned
	Solid Waste, Specify Material in Comments	1-01-012-01	Tons Solid Waste Burned

TABLE 2.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
<b>External Combustion Boilers (Continued)</b>			
External Combustion Boilers: Electric Generation (Continued)	Solid Waste, Refuse Derived Fuel	1-01-012-02	Tons Refuse Derived Fuel Burned
	Liquid Waste, Specify Waste in Comments	1-01-013-01	1000 Gallons Liquid Waste Burned
	Liquid Waste, Waste Oil	1-01-013-02	1000 Gallons Waste Oil Burned
	Geothermal Power Plants: Off-Gas Ejectors	1-01-015-01	Megawatt-Hour Electricity Produced
	Geothermal Power Plants: Cooling Tower Exhaust	1-01-015-02	Megawatt-Hour Electricity Produced
External Combustion Boilers: Industrial Boilers	Pulverized Coal (Anthracite)	1-02-001-01	Tons Anthracite Coal Burned
	Traveling Grate (Overfeed) Stoker (Anthracite)	1-02-001-04	Tons Anthracite Coal Burned
	Hand-fired (Anthracite)	1-02-001-07	Tons Anthracite Coal Burned
	Fluidized Bed Boiler Burning Anthracite-Culm Fuel	1-02-001-17	Tons Anthracite Coal Burned
	Pulverized Coal: Wet Bottom (Bituminous Coal)	1-02-002-01	Tons Bituminous Coal Burned
	Pulverized Coal: Dry Bottom (Bituminous Coal)	1-02-002-02	Tons Bituminous Coal Burned
	Cyclone Furnace (Bituminous Coal)	1-02-002-03	Tons Bituminous Coal Burned
	Spreader Stoker (Bituminous Coal)	1-02-002-04	Tons Bituminous Coal Burned
	Overfeed Stoker (Bituminous Coal)	1-02-002-05	Tons Bituminous Coal Burned
	Underfeed Stoker (Bituminous Coal)	1-02-002-06	Tons Bituminous Coal Burned
	Overfeed Stoker (Bituminous Coal)	1-02-002-10	Tons Bituminous Coal Burned
	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	1-02-002-12	Tons Bituminous Coal Burned
	Wet Slurry (Bituminous Coal)	1-02-002-13	Tons Bituminous Coal Burned



TABLE 2.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
<b>External Combustion Boilers (Continued)</b>			
External Combustion Boilers: Industrial Boilers (Continued)	Atmospheric Fluidized Bed Combustion: Bubbling Bed (Bituminous Coal)	1-02-002-17	Tons Bituminous Coal Burned
	Atmospheric Fluidized Bed Combustion: Circulating Bed (Bitum. Coal)	1-02-002-18	Tons Bituminous Coal Burned
	Cogeneration (Bituminous Coal)	1-02-002-19	Tons Bituminous Coal Burned
	Pulverized Coal: Wet Bottom (Subbituminous Coal)	1-02-002-21	Tons Subbituminous Coal Burned
	Pulverized Coal: Dry Bottom (Subbituminous Coal)	1-02-002-22	Tons Subbituminous Coal Burned
	Cyclone Furnace (Subbituminous Coal)	1-02-002-23	Tons Subbituminous Coal Burned
	Spreader Stoker (Subbituminous Coal)	1-02-002-24	Tons Subbituminous Coal Burned
	Traveling Grate (Overfeed) Stoker (Subbituminous Coal)	1-02-002-25	Tons Subbituminous Coal Burned
	Pulverized Coal: Dry Bottom Tangential (Subbituminous Coal)	1-02-002-26	Tons Subbituminous Coal Burned
	Cogeneration (Subbituminous Coal)	1-02-002-29	Tons Subbituminous Coal Burned
	Pulverized Coal: Wet Bottom (Lignite)	1-02-003-00	Tons Lignite Burned
	Pulverized Coal: Dry Bottom, Wall Fired (Lignite)	1-02-003-01	Tons Lignite Burned
	Pulverized Coal: Dry Bottom, Tangential Fired (Lignite)	1-02-003-02	Tons Lignite Burned
	Cyclone Furnace (Lignite)	1-02-003-03	Tons Lignite Burned
	Traveling Grate (Overfeed) Stoker (Lignite)	1-02-003-04	Tons Lignite Burned
	Spreader Stoker (Lignite)	1-02-003-06	Tons Lignite Burned
	Cogeneration (Lignite)	1-02-003-07	Tons Lignite Burned
	Grade 6 Oil (Residual)	1-02-004-01	1000 Gallons Residual Oil Burned
	10-100 Million Btu/hr, (Residual Oil)	1-02-004-02	1000 Gallons Residual Oil Burned
	< 10 Million Btu/hr, (Residual Oil)	1-02-004-03	1000 Gallons Residual Oil Burned
	Grade 5 Oil (Residual)	1-02-004-04	1000 Gallons Residual Oil Burned
	Cogeneration (Residual Oil)	1-02-004-05	1000 Gallons Residual Oil Burned

TABLE 2.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
<b>External Combustion Boilers (Continued)</b>			
External Combustion Boilers: Industrial Boilers (Continued)	Grades 1 and 2 Oil (Distillate)	1-02-005-01	1000 Gallons Distillate Oil Burned
	10-100 Million Btu/hr, (Distillate Oil)	1-02-005-02	1000 Gallons Distillate Oil Burned
	< 10 Million Btu/hr, (Distillate Oil)	1-02-005-03	1000 Gallons Distillate Oil Burned
	Grade 4 Oil (Distillate)	1-02-005-04	1000 Gallons Distillate Oil Burned
	Cogeneration (Distillate Oil)	1-02-005-05	1000 Gallons Distillate Oil Burned
	> 100 Million Btu/hr, (Natural Gas)	1-02-006-01	Million Cubic Feet Natural Gas Burned
	10-100 Million Btu/hr, (Natural Gas)	1-02-006-02	Million Cubic Feet Natural Gas Burned
	< 10 Million Btu/hr, (Natural Gas)	1-02-006-03	Million Cubic Feet Natural Gas Burned
	Cogeneration (Natural Gas)	1-02-006-04	Million Cubic Feet Natural Gas Burned
	Petroleum Refinery, (Process Gas)	1-02-007-01	Million Cubic Feet Process Gas Burned
	Blast Furnace, (Process Gas)	1-02-007-04	Million Cubic Feet Process Gas Burned
	Coke Oven, (Process Gas)	1-02-007-07	Million Cubic Feet Process Gas Burned
	Cogeneration (Process Gas)	1-02-007-10	Million Cubic Feet Process Gas Burned
	Other: Specify in Comments (Process Gas)	1-02-007-99	Million Cubic Feet Process Gas Burned
	All Boiler Sizes, (Coke)	1-02-008-02	Tons Coke Burned
	Cogeneration (Coke)	1-02-008-04	Tons Coke Burned
	Bark-fired Boiler (> 50,000 Lb Steam)	1-02-009-01	Tons Bark Burned
	Wood/Bark-fired Boiler (> 50,000 Lb Steam)	1-02-009-02	Tons Wood/Bark Burned
	Wood-fired Boiler (> 50,000 Lb Steam)	1-02-009-03	Tons Wood Burned
	Bark-fired Boiler (< 50,000 Lb Steam)	1-02-009-04	Tons Bark Burned
	Wood/Bark-fired Boiler (< 50,000 Lb Steam)	1-02-009-05	Tons Wood/Bark Burned
	Wood-fired Boiler (< 50,000 Lb Steam)	1-02-009-06	Tons Wood Burned
	Cogeneration (Wood)	1-02-009-07	Tons Wood Burned

TABLE 2.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
<b>External Combustion Boilers (Continued)</b>			
External Combustion Boilers: Industrial Boilers (Continued)	Fuel cell/Dutch oven boilers	1-02-009-10	Tons Wood/Bark Burned
	Stoker boilers	1-02-009-11	Tons Wood/Bark Burned
	Fluidized bed combustion boiler	1-02-009-12	Tons Wood/Bark Burned
	Liquified Petroleum Gas (LPG), Butane	1-02-010-01	1000 Gallons Butane Burned
	Liquified Petroleum Gas (LPG), Propane	1-02-010-02	1000 Gallons Propane Burned
	Liquified Petroleum Gas (LPG), Butane/Propane Mixture: Specify Percent Butane in Comments	1-02-010-03	1000 Gallons Propane/Butane Burned
	Bagasse, All Boiler Sizes	1-02-011-01	Tons Bagasse Burned
	Solid Waste, Specify Material in Comments	1-02-012-01	Tons Solid Waste Burned
	Solid Waste, Refuse Derived Fuel	1-02-012-02	Tons Refuse Derived Fuel Burned
	Liquid Waste, Specify Waste in Comments	1-02-013-01	1000 Gallons Liquid Waste Burned
	Liquid Waste, Waste Oil	1-02-013-02	1000 Gallons Waste Oil Burned
	CO Boiler (Natural Gas)	1-02-014-01	Million Cubic Feet Natural Gas Burned
	CO Boiler (Process Gas)	1-02-014-02	Million Cubic Feet Process Gas Burned
	CO Boiler (Distillate Oil)	1-02-014-03	1000 Gallons Distillate Oil Burned
	CO Boiler (Residual Oil)	1-02-014-04	1000 Gallons Residual Oil Burned
	Methanol, Industrial Boiler	1-02-016-01	1000 Gallons Methanol Burned
	Gasoline, Industrial Boiler	1-02-017-01	1000 Gallons Gasoline Burned
External Combustion Boilers: Industrial Space Heating	Space Heaters (Coal)	1-05-001-02	Tons Coal Burned
	Space Heaters (Distillate Oil)	1-05-001-05	1000 Gallons Distillate Oil Burned

TABLE 2.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
<b>External Combustion Boilers (Continued)</b>			
External Combustion Boilers: Industrial Space Heating (Continued)	Space Heaters (Natural Gas)	1-05-001-06	Million Cubic Feet Natural Gas Burned
	Space Heaters (Liquified Petroleum Gas)	1-05-001-10	1000 Gallons LPG Burned
	Space Heaters, Air Atomized Burner (Waste Oil)	1-05-001-13	1000 Gallons Waste Oil Burned
	Space Heaters, Vaporizing Burner (Waste Oil)	1-05-001-14	1000 Gallons Waste Oil Burned
External Combustion Boilers: Commercial/ Institutional Boilers	Pulverized Coal (Anthracite)	1-03-001-01	Tons Anthracite Coal Burned
	Traveling Grate (Overfeed) Stoker (Anthracite Coal)	1-03-001-02	Tons Anthracite Coal Burned
	Hand-fired (Anthracite)	1-03-001-03	Tons Anthracite Coal Burned
	Cyclone Furnace (Bituminous Coal)	1-03-002-03	Tons Bituminous Coal Burned
	Pulverized Coal: Wet Bottom (Bituminous Coal)	1-03-002-05	Tons Bituminous Coal Burned
	Pulverized Coal: Dry Bottom (Bituminous Coal)	1-03-002-06	Tons Bituminous Coal Burned
	Overfeed Stoker (Bituminous Coal)	1-03-002-07	Tons Bituminous Coal Burned
	Underfeed Stoker (Bituminous Coal)	1-03-002-08	Tons Bituminous Coal Burned
	Spreader Stoker (Bituminous Coal)	1-03-002-09	Tons Bituminous Coal Burned
	Overfeed Stoker (Bituminous Coal)	1-03-002-11	Tons Bituminous Coal Burned
	Hand-fired (Bituminous Coal)	1-03-002-14	Tons Bituminous Coal Burned
	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	1-03-002-16	Tons Bituminous Coal Burned
	Atmospheric Fluidized Bed Combustion: Bubbling Bed (Bituminous Coal)	1-03-002-17	Tons Bituminous Coal Burned
	Atmospheric Fluidized Bed Combustion: Circulating Bed (Bitum. Coal)	1-03-002-18	Tons Bituminous Coal Burned
	Pulverized Coal: Wet Bottom (Subbituminous Coal)	1-03-002-21	Tons Subbituminous Coal Burned

TABLE 2.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
<b>External Combustion Boilers (Continued)</b>			
External Combustion Boilers: Commercial/ Institutional Boilers (Continued)	Pulverized Coal: Dry Bottom (Subbituminous Coal)	1-03-002-22	Tons Subbituminous Coal Burned
	Cyclone Furnace (Subbituminous Coal)	1-03-002-23	Tons Subbituminous Coal Burned
	Spreader Stoker (Subbituminous Coal)	1-03-002-24	Tons Subbituminous Coal Burned
	Traveling Grate (Overfeed) Stoker (Subbituminous Coal)	1-03-002-25	Tons Subbituminous Coal Burned
	Pulverized Coal: Dry Bottom Tangential (Subbituminous Coal)	1-03-002-26	Tons Subbituminous Coal Burned
	Pulverized Coal: Wet Bottom (Lignite)	1-03-003-00	Tons Lignite Burned
	Pulverized Coal: Dry Bottom, Wall Fired (Lignite)	1-03-003-05	Tons Lignite Burned
	Pulverized Coal: Dry Bottom, Tangential Fired (Lignite)	1-03-003-06	Tons Lignite Burned
	Traveling Grate (Overfeed) Stoker (Lignite)	1-03-003-07	Tons Lignite Burned
	Spreader Stoker (Lignite)	1-03-003-09	Tons Lignite Burned
	Grade 6 Oil (Residual)	1-03-004-01	1000 Gallons Residual Oil Burned
	10-100 Million Btu/hr, (Residual Oil)	1-03-004-02	1000 Gallons Residual Oil Burned
	< 10 Million Btu/hr, (Residual Oil)	1-03-004-03	1000 Gallons Residual Oil Burned
	Grade 5 Oil (Residual)	1-03-004-04	1000 Gallons Residual Oil Burned
	Grades 1 and 2 Oil (Distillate)	1-03-005-01	1000 Gallons Distillate Oil Burned
	10-100 Million Btu/hr, (Distillate Oil)	1-03-005-02	1000 Gallons Distillate Oil Burned
	< 10 Million Btu/hr, (Distillate Oil)	1-03-005-03	1000 Gallons Distillate Oil Burned
	Grade 4 Oil (Distillate)	1-03-005-04	1000 Gallons Distillate Oil Burned
	> 100 Million Btu/hr, (Natural Gas)	1-03-006-01	Million Cubic Feet Natural Gas Burned
	10-100 Million Btu/hr, (Natural Gas)	1-03-006-02	Million Cubic Feet Natural Gas Burned
	< 10 Million Btu/hr, (Natural Gas)	1-03-006-03	Million Cubic Feet Natural Gas Burned

TABLE 2.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
<b>External Combustion Boilers (Continued)</b>			
External Combustion Boilers: Commercial/ Institutional Boilers (Continued)	POTW Digester Gas-fired Boiler (Process Gas)	1-03-007-01	Million Cubic Feet Process Gas Burned
	Other Not Classified (Process Gas)	1-03-007-99	Million Cubic Feet Process Gas Burned
	Landfill Gas	1-03-008-11	Million Cubic Feet Landfill Gas Burned
	Bark-fired Boiler (Wood/Bark Waste)	1-03-009-01	Tons Bark Burned
	Wood/Bark-fired Boiler (Wood/Bark Waste)	1-03-009-02	Tons Wood/Bark Burned
	Wood-fired Boiler (Wood/Bark Waste)	1-03-009-03	Tons Wood Burned
	Fuel cell/Dutch oven boilers (Wood/Bark Waste)	1-03-009-10	Tons Wood/Bark Burned
	Stoker boilers (Wood/Bark Waste)	1-03-009-11	Tons Wood/Bark Burned
	Fluidized bed combustion boilers (Wood/Bark Waste)	1-03-009-12	Tons Wood/Bark Burned
	Liquified Petroleum Gas (LPG), Butane	1-03-010-01	1000 Gallons Butane Burned
	Liquified Petroleum Gas (LPG), Propane	1-03-010-02	1000 Gallons Propane Burned
	Liquified Petroleum Gas (LPG), Butane/Propane Mixture: Specify Percent Butane in Comments	1-03-010-03	1000 Gallons Propane/Butane Burned
	Solid Waste, Specify Material in Comments	1-03-012-01	Tons Solid Waste Burned
	Solid Waste, Refuse Derived Fuel	1-03-012-02	Tons Refuse Derived Fuel Burned
	Liquid Waste, Specify Waste in Comments	1-03-013-01	1000 Gallons Liquid Waste Burned
	Liquid Waste, Waste Oil	1-03-013-02	1000 Gallons Waste Oil Burned
	Liquid Waste, Sewage Grease Skimmings	1-03-013-03	1000 Gallons Sewage Grease Skimmings Burned

TABLE 2.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
<b>External Combustion Boilers (Continued)</b>			
External Combustion Boilers: Commercial/Institutional Space Heating	Space Heaters (Coal)	1-05-002-02	Tons Coal Burned
	Space Heaters (Distillate Oil)	1-05-002-05	1000 Gallons Distillate Oil Burned
	Space Heaters (Natural Gas)	1-05-002-06	Million Cubic Feet Natural Gas Burned
	Space Heaters (Wood)	1-05-002-09	Tons Wood Burned
	Space Heaters (Liquified Petroleum Gas)	1-05-002-10	1000 Gallons LPG Burned
	Space Heaters, Air Atomized Burner (Waste Oil)	1-05-002-13	1000 Gallons Waste Oil Burned
	Space Heaters, Vaporizing Burner (Waste Oil)	1-05-002-14	1000 Gallons Waste Oil Burned
<b>Waste Disposal</b>			
Waste Disposal: Solid Waste Landfill	Waste Gas Recovery: Boiler	5-01-004-23	Million Cubic Feet Waste Gas Burned
Waste Disposal: Site Remediation	Thermal Destruction Combustion Unit: Boiler	5-04-105-37	Tons Feed Material Processed
<b>Miscellaneous Industrial Processes with Applicable Codes</b>			
Carbon Black Production	Main Process Vent with CO Boiler and Incinerator	3-01-005-10	Tons Carbon Black Produced
Integrated Iron and Steel Manufacturing	Miscellaneous Combustion Sources: Boilers	3-03-015-82	Tons Material Produced
Sulfate (Kraft) Pulping	Boiler Ash Handling	3-07-001-19	Tons Ash Handled
<b>Fuel Storage and Transfer</b>			
Petroleum Liquids Storage (non-Refinery)	Underground Tanks, Breathing Loss (No. 2 Distillate Oil)	4-04-004-13	1000 Gallons No. 2 Distillate Oil Storage Capacity
	Underground Tanks, Working Loss (No. 2 Distillate Oil)	4-04-004-14	1000 Gallons No. 2 Distillate Oil Throughput
	Underground Tanks, Breathing Loss (Specify Liquid)	4-04-004-97	1000 Gallons Liquid Storage Capacity
	Underground Tanks, Working Loss (Specify Liquid)	4-04-004-98	1000 Gallons Liquid Throughput

TABLE 2.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
<b>Fuel Storage and Transfer (Continued)</b>			
Industrial Processes, In-Process Fuel Use	Fixed Roof Tanks, Breathing Loss (Residual Oil)	3-90-900-01	1000 Gallons Residual Oil Storage Capacity
	Fixed Roof Tanks, Working Loss (Residual Oil)	3-90-900-02	1000 Gallons Residual Oil Throughput
	Fixed Roof Tanks, Breathing Loss (No. 2 Distillate Oil)	3-90-900-03	1000 Gallons No. 2 Distillate Oil Storage Capacity
	Fixed Roof Tanks, Working Loss (No. 2 Distillate Oil)	3-90-900-04	1000 Gallons No. 2 Distillate Oil Throughput
	Fixed Roof Tanks, Breathing Loss (No. 6 Oil)	3-90-900-05	1000 Gallons No. 6 Residual Oil Storage Capacity
	Fixed Roof Tanks, Working Loss (No. 6 Oil)	3-90-900-06	1000 Gallons No. 6 Residual Oil Throughput
	Floating Roof Tanks, Standing Loss (Residual Oil)	3-90-910-01	1000 Gallons Residual Oil Storage Capacity
	Floating Roof Tanks, Withdrawal Loss (Residual Oil)	3-90-910-02	1000 Gallons Residual Oil Throughput
	Floating Roof Tanks, Standing Loss (No. 2 Distillate Oil)	3-90-910-03	1000 Gallons No. 2 Distillate Oil Storage Capacity
	Floating Roof Tanks, Withdrawal Loss (No. 2 Distillate Oil)	3-90-910-04	1000 Gallons No. 2 Distillate Oil Throughput
	Floating Roof Tanks, Standing Loss (No. 6 Oil)	3-90-910-05	1000 Gallons No. 6 Residual Oil Storage Capacity
	Floating Roof Tanks, Withdrawal Loss (No. 6 Oil)	3-90-910-06	1000 Gallons No. 6 Residual Oil Throughput
	Pressure Tanks, Withdrawal Loss (Natural Gas)	3-90-920-50	1000 Gallons Natural Gas Throughput



TABLE 2.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
<b>Fuel Storage and Transfer: (Continued)</b>			
Industrial Processes, In-Process Fuel Use (Continued)	Pressure Tanks, Withdrawal Loss (Liquified Petroleum Gas)	3-90-920-51	1000 Gallons LPG Throughput
	Pressure Tanks, Withdrawal Loss (Landfill Gas)	3-90-920-52	1000 Gallons Landfill Gas Throughput
	Pressure Tanks, Withdrawal Loss (Digester Gas)	3-90-920-54	1000 Gallons Digester Gas Throughput
	Pressure Tanks, Withdrawal Loss (Process Gas)	3-909-20-55	1000 Gallons Process Gas Throughput

**TABLE 2.7-2**  
**AIRS CONTROL DEVICE CODES**

<b>Control Device</b>	<b>Code</b>
Wet Scrubber - High-Efficiency	001
Wet Scrubber - Medium-Efficiency	002
Wet Scrubber - Low-Efficiency	003
Gravity Collector - High-Efficiency	004
Gravity Collector - Medium-Efficiency	005
Gravity Collector - Low-Efficiency	006
Centrifugal Collector - High-Efficiency	007
Centrifugal Collector - Medium-Efficiency	008
Centrifugal Collector - Low-Efficiency	009
Electrostatic Precipitator - High-Efficiency	010
Electrostatic Precipitator - Medium-Efficiency	011
Electrostatic Precipitator - Low-Efficiency	012
Fabric Filter - High-Efficiency	016
Fabric Filter - Medium-Efficiency	017
Fabric Filter - Low-Efficiency	018
Mist Eliminator - High-Velocity	014
Mist Eliminator - Low-Velocity	015
Modified Furnace or Burner Design	024
Staged Combustion	025
Flue Gas Recirculation	026
Reduced Combustion-Air Preheating	027
Steam or Water Injection	028

TABLE 2.7-2

(CONTINUED)

Control Device	Code
Low-Excess Air Firing	029
Use of Fuel with Low Nitrogen Content	030
Catalytic Reduction	065
Selective Noncatalytic Reduction for NO <sub>x</sub>	107
Catalytic Oxidation - Flue Gas Desulfurization	039
Dry Limestone Injection	041
Wet Limestone Injection	042
Venturi Scrubber	053
Wet Lime Slurry Scrubbing	067
Alkaline Fly Ash Scrubbing	068
Sodium Carbonate Scrubbing	069
Miscellaneous Control Device	099

Note: At the time of publication, these control device codes were under review by the EPA. The reader should consult the EPA for the most current list of codes.

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## **APPENDIX A**

# **EXAMPLE DATA COLLECTION FORM AND INSTRUCTIONS - BOILERS**

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**EXAMPLE DATA COLLECTION FORM INSTRUCTIONS - BOILER**

1. This form may be used as a work sheet to aid the plant engineer in collecting the information necessary to calculate emissions from boilers. The information requested on the form relates to the methods (described in Sections 3 and 4) for quantifying emissions. This form may also be used by the regulatory agency to assist in area-wide inventory preparation.
2. The completed forms should be maintained in a reference file by the plant engineer with other supporting documentation.
3. The information identified on these forms is needed to generate a complete emissions inventory. If the information requested does not apply to a particular boiler, write "NA" in the blank.
4. If you want to modify the form to better serve your needs, an electronic copy of the form may be obtained through the EIIP on the CHIEF system.
5. If rated capacity is not documented in MMBtu/hr, please enter the capacity in lb/hr steam produced, or other appropriate units of measure.
6. If hourly or monthly fuel use information is not available, enter the information in another unit (quarterly or yearly). Be sure to indicate on the form what the unit of measure is.
7. Use the comments field on the form to record all useful information that will allow your work to be reviewed and reconstructed.

**EXAMPLE DATA COLLECTION FORM - BOILER****GENERAL INFORMATION**

Facility/Plant Name: \_\_\_\_\_

SIC Code: \_\_\_\_\_

SCC: \_\_\_\_\_

SCC Description:

Utility \_\_\_\_\_

Commercial \_\_\_\_\_

Industrial \_\_\_\_\_

Location: \_\_\_\_\_

County: \_\_\_\_\_

City: \_\_\_\_\_

State: \_\_\_\_\_

Plant Geographical Coordinates:

Latitude: \_\_\_\_\_

Longitude: \_\_\_\_\_

UTM Zone: \_\_\_\_\_

UTM Easting: \_\_\_\_\_

UTM Northing: \_\_\_\_\_

Contact Name: \_\_\_\_\_

Title: \_\_\_\_\_

Telephone Number: \_\_\_\_\_

Unit ID Number: \_\_\_\_\_

Permit Number: \_\_\_\_\_

SOURCE INFORMATION	COMMENTS
Unit ID:	
Manufacturer:	
Date Installed:	
Rated Capacity (units):	
Maximum Heat Input (units):	
Fuel Type:	
Operating Schedule:	
Hours/Day:	
Days/Week:	
Weeks/Year:	
<b>FUEL USE<sup>a</sup>:</b>	
Year:	
Maximum Hourly Fuel Use (units):	
Monthly Fuel Use (units):	
January:	
February:	
March:	
April:	
May:	
June:	
July:	
August:	
September:	
October:	
November:	
December:	
Total Annual Fuel Use (units):	

<sup>a</sup> This form should be completed for each fuel type used.

---

---

**FIRING CONFIGURATION (Check the appropriate type)**

---

Tangential Fired ☐   Horizontally Fired ☐   Vertically Fired ☐   Pulverized Coal Fired ☐

---

Dry Bottom ☐   Wet Bottom ☐

---

Cyclone Furnace ☐

---

Spreader Stoker ☐   Uncontrolled ☐   Controlled ☐

---

Overfeed Stoker ☐   Uncontrolled ☐   Controlled ☐

---

Underfeed Stoker ☐   Uncontrolled ☐   Controlled ☐

---

Hand-fired Units ☐

---

**POLLUTION CONTROL EQUIPMENT (Enter control efficiency and source of information)**

---

ESP:

---

Baghouse:

---

Wet Scrubber:

---

Dry Scrubber:

---

Spray Dryer:

---

Cyclone:

---

Other:

---

---

FUEL ANALYSIS	COMMENTS
Sulfur Content (S):	
Ash Content:	
Nitrogen Content (N):	
Lead Content (Pb):	
Mercury (Hg):	
Others:	
Higher Heating Value (HHV in Btu/lb):	
Reference (Attach Analysis if Available):	
<b>STACK INFORMATION:</b>	
Stack ID:	
Unit ID:	
Stack (Release) Height (feet):	
Stack Diameter (inch):	
Stack Gas Temperature (°F):	
Stack Gas Velocity (ft/sec):	
Stack Gas Flow Rate (acsf/min):	
Do Other Sources Share This Stack (Y/N)?: (If yes, include Unit IDs for each).	
Site-specific Stack Sampling Report Available (Y/N)?:	
Reference (Include Full Citation of Test Reports Used):	

## EMISSION ESTIMATION RESULTS

 Unit ID: \_\_\_\_\_  
 Fuel Type: \_\_\_\_\_

Pollutant	Emission Estimation Method <sup>a</sup>	Emissions	Emissions Units	Emission Factor <sup>b</sup>	Emission Factor Units	Comments
VOC						
NO <sub>x</sub>						
CO						
SO <sub>2</sub>						
PM <sub>10</sub>						
Total Particulate						
Hazardous Air Pollutants (list individually)						

<sup>a</sup> Use the following codes to indicate which emission estimation method is used for each pollutant:

CEMS/PEM = CEMS/PEM

Emission Factor = EF

Stack Test Data = ST

Other (indicate) = O

Fuel Analysis = FA

<sup>b</sup> Where applicable, enter the emission factor and provide the full citation of the reference or source of information from where the emission factor came. Include edition, version, table, and page numbers if AP-42 is used.

# **PREFERRED AND ALTERNATIVE METHODS FOR ESTIMATING AIR EMISSIONS FROM HOT-MIX ASPHALT PLANTS**

**Final Report**

**July 1996**



Prepared by:  
Eastern Research Group, Inc.  
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Prepared for:  
Point Sources Committee  
Emission Inventory Improvement Program

## **DISCLAIMER**

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.



## ACKNOWLEDGEMENT

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# 1

## INTRODUCTION

---

The purposes of the preferred methods guidelines are to describe emission estimation techniques for stationary point sources in a clear and unambiguous manner and to provide concise example calculations to aid in the preparation of emission inventories. While emissions estimates are not provided, this information may be used to select an emission estimation technique best suited to a particular application. This chapter describes the procedures and recommends approaches for estimating emissions from hot-mix asphalt (HMA) plants.

Section 2 of this chapter contains a general description of the HMA plant source category, common emission sources, and an overview of the available control technologies used at HMA plants. Section 3 of this chapter provides an overview of available emission estimation methods.

Section 4 presents the preferred methods for estimating emissions from HMA plants, while Section 5 presents the alternative emission estimation techniques. It should be noted that the use of site-specific emission data is preferred over the use of industry-averaged data such as *AP-42* emission factors (EPA, 1995a). Depending upon available resources, site-specific data may not be cost effective to obtain. However, this site-specific data may be a requirement of the state implementation plan (SIP) and may preclude the use of other data. Quality assurance and control procedures are described in Section 6. Coding procedures used for data input and storage are discussed in Section 7. Some states use their own unique identification codes, so individual state agencies should be contacted to determine the appropriate coding scheme to use. References are cited in Section 8. Appendix A provides an example data collection form to assist in information gathering prior to emissions calculations.

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# 2

## GENERAL SOURCE CATEGORY DESCRIPTION

---

This section provides a brief overview of HMA plants. The reader is referred to the *Air Pollution Engineering Manual* (referred to as AP-40) and AP-42, 5th Edition, January 1995, for a more detailed discussion on these facilities (AWMA, 1992; EPA, 1995a).

### 2.1 PROCESS DESCRIPTION

HMA paving materials are a mixture of well graded, high quality aggregate (which can include reclaimed or recycled asphalt pavement [RAP]) and liquid asphalt cement, which is heated and mixed in measured quantities to produce HMA. Aggregate and RAP (if used) constitute over 92 percent by weight of the total HMA mixture. Aside from the relative amounts and types of aggregate and RAP used, mix characteristics are determined by the amount and grade of asphalt cement used. Additionally, the asphalt cement may be blended with petroleum distillates or emulsifiers to produce "cold mix" asphalt, sometimes referred to as cutback or emulsified asphalt, respectively (EPA, 1995a; Gunkel, 1992; TNRCC, 1994).

The process of producing HMA involves drying and heating the aggregate to prepare them for the asphalt cement coating. In the drying process, the aggregate are dried in a rotating, slightly inclined, direct-fired drum dryer. The aggregate is introduced into the higher end of the dryer. The interior of the dryer is equipped with flights that veil the aggregate through the hot exhaust as the dryer rotates. After drying, the aggregate is typically heated to temperatures ranging from 275 to 325°F and then coated with asphalt cement in one of two ways. In most drum mix plants, the asphalt is introduced directly into the dryer chamber to coat the aggregate. In batch mix plants, the mixing of aggregate and asphalt takes place in a separate mixing chamber called a pug mill.

The variations in the HMA manufacturing process are primarily defined by the following types of plants:

- Batch mix plants;
- Parallel flow drum mix plants; and
- Counterflow drum mix plants.

(Continuous mix plants, which represent a very small fraction of the plants presently operating, are not discussed here [EPA, 1995a]. The estimation techniques described for the batch mixing process should be followed when estimating emissions from continuous mix plant operations.).

### **2.1.1 BATCH MIXING PROCESS**

In the batch mixing process, the aggregate is transported from storage piles and is placed in the appropriate hoppers of a cold feed unit. The material is metered from the hoppers onto a conveyor belt and is transported into a rotary dryer (typically gas- or oil-fired) (Gunkel, 1992; NAPA, 1995).

As hot aggregate leave the dryer, it drops into a bucket elevator and is transferred to a set of vibrating screens, that drop the aggregate into individual "hot" bins according to size. To control aggregate size distribution in the final batch mix, the operator opens various hot bins over a weigh hopper until the desired mix and weight for individual components are obtained. RAP may also be added at this point. Concurrent with the aggregate being weighed, liquid asphalt cement is pumped from a heated storage tank to an asphalt bucket, where it is weighed to achieve the desired mix.

Aggregate from the weigh hopper is dropped into the mixer (pug mill) and dry-mixed for 6 to 10 seconds. The liquid asphalt is then dropped into the pug mill where it is wet-mixed until homogeneous. The hot-mix is conveyed to a hot storage silo or dropped directly into a truck and hauled to a job site.

### **2.1.2 PARALLEL FLOW DRUM MIXING PROCESS**

The parallel flow drum mixing process is a continuous mixing type process that uses proportioning cold feed controls for the process materials. The major difference between this process and the batch process is that the dryer is used not only to dry aggregate but also to mix the heated and dried aggregate with the liquid asphalt cement. Aggregate, which has been proportioned by size gradations, is introduced to the drum at the burner end. As the drum rotates, the aggregate, as well as the combustion products, move toward the other end of the drum in parallel (EPA, 1995). The asphalt cement is introduced into approximately the lower third of the drum. The aggregate are is coated with asphalt cement as it veils to the end of the drum. The RAP is introduced at some point along the length of the drum, as far away from the combustion zone as possible (about the midpoint of the drum), but with enough drum length remaining to dry and heat the material adequately before it reaches the coating zone (Gunkel, 1992). The flow of liquid asphalt cement is controlled by a variable flow pump electronically linked to the aggregate and RAP weigh scales (EPA, 1995a).

### **2.1.3 COUNTERFLOW DRUM MIXING PROCESS**

In the counterflow drum mixing process, the aggregate is proportioned through a cold feed system prior to introduction to the drying process. As opposed to the parallel flow drum mixing process though, the aggregate moves opposite to the flow of the exhaust gases. After drying and heating take place, the aggregate is transferred to a part of the drum that is not exposed to the exhaust gas and coated with asphalt cement. This process prevents stripping of the asphalt cement by the hot exhaust gas. If RAP is used, it is usually introduced into the coating chamber.

## **2.2 EMISSION SOURCES**

Emissions from HMA plants derive from both controlled (i.e., ducted) and uncontrolled sources. Section 7 lists the source classification codes (SCCs) for these emission points.

### **2.2.1 MATERIAL HANDLING (FUGITIVE EMISSIONS)**

Material handling includes the receipt, movement, and processing of fuel and materials used at the HMA facility. Fugitive particulate matter (PM) emissions from aggregate storage piles are typically caused by front-end loader operations that transport the aggregate to the cold feed unit hoppers. The amount of fugitive PM emissions from aggregate piles will be greater in strong winds (Gunkel, 1992). Piles of RAP, because RAP is coated with asphalt cement, are not likely to cause significant fugitive dust problems. Other pre-dryer fugitive emission sources include the transfer of aggregate from the cold feed unit hoppers to the dryer feed conveyor and, subsequently, to the dryer entrance. Aggregate moisture content prior to entry into the dryer is typically 3 percent to 7 percent. This moisture content, along with aggregate size classification, tend to minimize emissions from these sources, which contribute little to total facility PM emissions. PM less than or equal to 10  $\mu\text{m}$  in diameter ( $\text{PM}_{10}$ ) emissions from these sources are reported to account for about 19 percent of their total PM emissions (NAPA, 1995).

If crushing, breaking, or grinding operations occur at the plant, these may result in fugitive PM emissions (TNRCC, 1994). Also, fine particulate collected from the baghouses can be a source of fugitive emissions as the overflow PM is transported by truck (enclosed or tarped) for on-site disposal. At all HMA plants there may be PM and slight process fugitive volatile organic compound (VOC) emissions from the transport and handling of the hot-mix from the mixer to the storage silo and also from the load-out operations to the delivery trucks (EPA, 1994a). Small amounts of VOC emissions can also result from the transfer of liquid and gaseous fuels, although natural gas is normally transported in a pipeline (Gunkel, 1992, Wiese, 1995).

## 2.2.2 GENERATORS

Diesel generators may be used at portable HMA plants to provide electricity. Maximum electricity generation during process operations is typically less than 500 kilowatts per hour (kW/hr) with rates of 20-50 kW/hr at other times (Fore, 1995). (Note that 1 kW equals 1.34 horsepower.) Emissions from these generators are likely uncontrolled and are correlated with fuel usage, as determined by engine size, load factor, and hours of operation. Emissions primarily include criteria pollutants—particularly  $\text{NO}_x$  and CO (EPA, 1995b).

## 2.2.3 STORAGE TANKS

Storage tanks are used to store fuel oils, heated liquid asphalts, and asphalt cement at HMA plants, and may be a source of VOC emissions. Storage tanks at HMA plants are usually fixed roof (closed or enclosed) due to the smaller size of the tanks, usually less than 30,000 gallons (Fore, 1995; Patterson, 1995). Emissions from fixed-roof tanks (closed or enclosed) are typically divided into two categories: working losses and breathing losses. Working losses refer to the combined loss from filling and emptying the tank. Filling losses occur when the VOC contained in the saturated air are displaced from a fixed-roof vessel during loading. Emptying losses occur when air drawn into the tank becomes saturated and expands, exceeding the capacity of the vapor space. Breathing losses are the expulsion of vapor from a tank through vapor expansion caused by changes in temperature and pressure. Because of the small tank sizes and fuel usage, total VOC emissions would typically be less than 1 ton per year. Emissions from tanks used for No. 5 or 6 oils or for asphalt cement may be increased when they are heated to control oil viscosity. Emissions from asphalt cement tanks are particularly low, due to its low vapor pressure.

The TANKS computer program, available from the EPA, is commonly used to quantify emissions; however, its use should be carefully evaluated since it is a complicated program with a great number of input parameters. Check with your local or state authority as to whether TANKS is required for your facility. The use of the TANKS program for calculating emissions from storage tanks is discussed in Chapter 1 of this volume, *Introduction to Stationary Point Source Emissions Inventory Development*.

## 2.2.4 PROCESS EMISSIONS

The most significant source of emissions from HMA plants is the dryer (EPA, 1995a; Gunkel, 1992; NAPA, 1995). Dryer burners capacities are usually less than 100 million British thermal units per hour (100 MMBtu/hr), but may be as large as 200 MMBtu/hr (NAPA, 1995; Wiese, 1995). Combustion emissions from the dryer include products of complete combustion and products of incomplete combustion. Products of complete combustion include carbon dioxide ( $\text{CO}_2$ ), water, oxides of nitrogen ( $\text{NO}_x$ ), and, if sulfur is present in the fuel, oxides of sulfur ( $\text{SO}_x$ ), for example sulfur dioxide ( $\text{SO}_2$ ). Products of

incomplete combustion include carbon monoxide (CO), VOC, including smaller quantities of hazardous air pollutants (HAP) (e.g., benzene, toluene, and xylene), and other organic particulate matter. These incomplete combustion emissions result from improper air and fuel mixtures (e.g., poor mixing of fuel and air), inadequate fuel air residence time and temperature, and quenching of the burner flame. Depending on the fuel, small amounts of ash may also be emitted. In addition to combustion emissions, emissions from a dryer include water and PM from the aggregate. Non-combustion emissions from rotary drum dryers may include small amounts of VOC, polynuclear aromatic hydrocarbons (PAH), aldehydes, and HAP from the volatile fraction of the asphalt cement and organic residues that are commonly found in recycled asphalt (i.e., gasoline and engine oils) (EPA, 1995a; Gunkel, 1992; TNRCC, 1994; EPA, 1991a; NAPA, 1995).

For drum mix processes, the dryer contributes most of the facility's total PM emissions (NAPA, 1995). At these plants, PM emissions from post-dryer processes are minimal due to the mixing with asphalt cement.

In batch mix plants, post-dryer PM emission sources include hot aggregate screens, hot bins, weigh hoppers, and pug mill mixers (NAPA, 1995, TNRCC, 1994). Uncontrolled PM emissions from these sources will be greater than emissions from pre-dryer sources primarily due to the lower aggregate moisture content in addition to the greater number of transfer points (NAPA, 1995). Post-dryer emission sources at batch plants are usually controlled by venting to the primary dust collector (along with the dryer gas) or sometimes to a separate dust collection system. Captured emissions are mostly aggregate dust, but they may also contain gaseous VOC and a fine aerosol of condensed liquid particles. This liquid aerosol is created by the condensation of gas into particles during the cooling of organic vapors volatilized from the asphalt cement and RAP in the pug mill. The aerosol emissions are primarily dependent upon the temperatures of the materials entering the mixing process. This problem appears to be more acute when the RAP has not been preheated prior to entering the pug mill or boot of the hot elevator. This results in a sudden, rapid release of steam resulting from evaporation of the moisture in the RAP upon mixing it into the superheated (often above 400°F) aggregate (EPA, 1995a; Gunkel, 1992).

Recycled tires, which are sometimes used in the production of asphalt concrete, may be a source of VOC and PM emissions. When heated, ground up tire pieces (referred to as crumb rubber) have been shown to emit VOC. These emissions are a function of the quantity of crumb rubber used in the liquid asphalt and the temperature of the mix (TNRCC, 1994).

If cutback or emulsions are used to make cold mix asphalt concrete, VOC emissions can be significant. These emissions can occur as stack emissions from mixing of asphalt batches and as fugitives from handling areas. Emission levels depend on the type and quantity of the cold mix produced. VOC emissions associated with cutback asphalt production may include naphtha, kerosene, or diesel vapors.

In some states (e.g., Wisconsin) asphalt drum dryers are used for soil remediation. In this practice, the contaminated soil may be run through the dryer as an aggregate, cut with virgin aggregate at ratios ranging from 1:1 to 1:10 (contaminated soil to virgin aggregate) depending on the clay content of the material. The dried material is coated with asphalt and "RAP" is produced. The manufactured RAP can then be fed into the hot mix asphalt process normally, as any RAP would be, and incorporated into the final mix. This practice can result in HAP emissions, which are a function of the HAP content and quantity of the soil as well as the dryer temperature and residence time. There is significant control of VOC/HAPs in the dryer drum. Based on testing performed by the asphalt industry, a control on the average of 75 percent with numbers ranging from 45 to 98 percent control depending on the plant type (parallel flow versus counterflow drum designs) have been recorded. (Wiese, 1995).

## 2.3 PROCESS DESIGN AND OPERATING FACTORS INFLUENCING EMISSIONS

There are two methods of introducing combustion air to the dryer burners and two types of combustion chambers, with the combination resulting in four types of burner systems that can be found at HMA plants. The type of burner system employed has a direct effect on gaseous combustion emissions, including VOC, HAP, CO, and NO<sub>x</sub>. The two types of burners related to the introduction of combustion air include the induced draft burner and the forced draft burner. Forced draft burners are usually more fuel efficient under proper operating and maintenance conditions and, consequently, have lower emissions (Gunkel, 1992). The two types of burners related to the use of combustion chambers include those with refractory-lined combustion chambers and those without combustion chambers. While most older burners had combustion chambers, today's burners generally do not (Gunkel, 1992).

Incomplete combustion in the dryer burner increases emissions of CO and organics (e.g., VOC). This may be caused by: (1) improper air and fuel mixtures (e.g., poor mixing prior to combustion); (2) inadequate residence time (i.e., too short) and temperature (i.e., too low); and (3) flame quenching. The primary cause of CO and organic emissions in chamberless burners is quenching of the flame caused by improper flighting. This occurs when the flame temperature is reduced by contact with cold surfaces or cold material dropping through the flame (NAPA, 1995). In addition, the moisture content of the aggregate in the dryer may contribute to the formation of CO and unburned fuel emissions by reducing the temperature (Gunkel, 1992). A secondary cause of these gaseous pollutants may be excess air entering the combustion process, particularly in the case of an induced draft burner. The use of a precombustion chamber to promote better fuel air mixing may reduce VOC and CO emissions.

NO<sub>x</sub> is primarily formed from nitrogen in the combustion air, thermal NO<sub>x</sub>, and from nitrogen in the fuel, fuel NO<sub>x</sub>. Thermal NO<sub>x</sub> is negligible below 1300°C and increases with combustion temperature (Nevers, 1995). Fuel NO<sub>x</sub>, which is likely lower than thermal NO<sub>x</sub> from dryer burners, is formed by conversion of some of the nitrogen in the burner fuel. While No. 4, 5 and 6 fuel oils may contain significant amounts of nitrogen, No. 1 and 2 oils and natural gas contain very little (Nevers, 1995).

Dryer burners can be designed to operate on almost any type of fuel; natural gas, liquefied petroleum gas (LPG), light fuel oils, heavy fuel oils, and waste fuel oils (Gunkel, 1992). The type of fuel and its sulfur content will affect SO<sub>x</sub>, VOC, and HAP emissions and, to a lesser extent, NO<sub>x</sub> and CO emissions. Sulfur in the burner fuel will convert to SO<sub>x</sub> during combustion; burner operation will have little effect on the percent of this conversion (TNRCC, 1994; EIIP, 1995). VOC emissions from natural gas combustion are less than emissions from LPG or fuel oil combustion, which are lower than emissions from waste-blended fuel combustion (TNRCC, 1994). Ash levels and concentrations of most of the trace elements in waste oils are normally much higher than those in virgin oils, producing higher emission levels of PM and trace metals. Chlorine in waste oils also typically exceeds the levels in virgin oils. High levels of halogenated solvents are often found in waste oil as a result of the additions of contaminant solvents to the waste oils.

When cold mix asphalt cement is heated, organic fumes (i.e., VOC) may be released as visible emissions if the asphalt is cut with lighter ends or other additives needed for a specification; however, these emissions are not normally seen when heating asphalt cement, as the boiling point of asphalt cement is much higher (Patterson, 1995). In drum mix plants, hydrocarbon (e.g., aldehydes) and PAH emissions may result from the heating and mixing of liquid asphalt inside the drum as hot exhaust gas in the drum strips light ends from the asphalt. The magnitude of these emissions is a function of the process temperatures and constituents of the asphalt being used. The mixing zone temperature in parallel flow drums is largely a function of drum length and flighting. The processing of RAP materials, particularly in parallel flow plants, may also increase VOC emissions, because of an increase in mixing zone temperature during processing. In counterflow drum mix plants, the liquid asphalt cement, aggregate, and sometimes RAP, are mixed in a zone not in contact with the hot exhaust gas stream. Consequently, counterflow drum mix plants will likely have lower VOC emissions than parallel flow drum mix plants. In batch mix plants, the amount of hydrocarbons (i.e., liquid aerosol) produced depends to a large extent on the temperature of the asphalt cement and aggregate entering the pug mill (EPA, 1995a; Gunkel, 1992). Particulate emissions from parallel flow drum mix plants are reduced because the aggregate and asphalt cement mix for a longer time. The amount of PM generated within the dryer in this process is usually lower than that generated within batch dryers, but because the asphalt is heated to higher temperatures for a longer period of time, organic emissions (gaseous and liquid aerosol) are typically greater than in conventional batch plants (EPA, 1991a).

## 2.4 CONTROL TECHNIQUES

Control techniques and devices typically used at HMA facilities are described below and presented in Table 3.2-1. Control efficiency for a specific piece of equipment will vary depending not only on the type of equipment and quality of the maintenance/repair program at a particular facility, but also the velocity of the air through the dryer.

#### **2.4.1 PROCESS AND PROCESS FUGITIVE PARTICULATE CONTROL (INCLUDING METALS)**

Process and process fugitive particulates at HMA plants are typically controlled using primary and secondary collection devices. Primary devices typically include cyclone and settling chambers to remove larger PM. Smaller PM is typically collected by secondary devices, including fabric filters and venturi scrubbers. PM from the dry control devices is usually collected and mixed back into the process near the entry point of the asphalt cement in drum-mix plants. In addition to PM and PM<sub>10</sub> emissions, particulate control also serves to remove trace metals emitted as particulate. These controls are primarily used to reduce PM emissions from the dryer; however at batch mix plants, these controls are also used for post-dryer sources, where fugitive emissions may be scavenged at an efficiency of 98 percent (NAPA, 1995).

##### ***Cyclones***

The cyclone (also known as a "mechanical collector") is a particulate control device that uses gravity, inertia, and impaction to remove particles from a ducted stream. Large diameter cyclones are often used as primary precleaners to remove the bulk of heavier particles from the flue gas before it enters a secondary or final collection system. A secondary collection device, which is more effective at removing particulates than a primary collector, is used to capture remaining PM from the primary collector effluent.

In batch plants, cyclones are often used to return collected material to the hot elevator and to combine it with the drier virgin aggregate (EPA, 1995a; Gunkel, 1992; Khan, 1977; NAPA, 1995).

##### ***Multiple cyclones***

A multiple cyclone consists of numerous small-diameter cyclones operating in parallel. Multiple cyclones are less expensive to install and operate than fabric filters, but are not as effective at removing smaller particulates. They are often used as precleaners to remove the bulk of heavier particles from the flue gas before it enters the main control device (EPA, 1995a; Gunkel, 1992; Khan, 1977).

##### ***Settling Chambers***



**TABLE 3.2-1****TYPICAL HOT-MIX ASPHALT PLANT EMISSION CONTROL TECHNIQUES**

<b>Emission Source</b>	<b>Pollutant</b>	<b>Control Technique</b>	<b>Typical Efficiency (%)</b>
Process	PM and PM <sub>10</sub>	Cyclones	50 - 75 <sup>a,b</sup>
		Multiple cyclones	90 <sup>c</sup>
		Settling chamber	<50 <sup>b</sup>
		Baghouse	99 - 99.97 <sup>a,d</sup>
		Venturi scrubber	90 - 99.5 <sup>d,e</sup>
	VOC	Dryer and combustion process modifications	37 - 86 <sup>f,g</sup>
	SO <sub>x</sub>	Limestone	50 <sup>b,e</sup>
		Low sulfur fuel	80 <sup>c</sup>
Fugitive dust	PM and PM <sub>10</sub>	Paving and maintenance	60 - 99 <sup>g</sup>
		Wetting and crusting agents	70 <sup>b</sup> - 80 <sup>c</sup>
		Crushed RAP material, asphalt shingles	70 <sup>h</sup>

<sup>a</sup> Control efficiency dependent on particle size ratio and size of equipment.

<sup>b</sup> Source: Patterson, 1995c.

<sup>c</sup> Source: EIIP, 1995.

<sup>d</sup> Typical efficiencies at a hot-mix asphalt plant.

<sup>e</sup> Source: TNRCC, 1995.

<sup>f</sup> Source: Gunkel, 1992.

<sup>g</sup> Source: TNRCC, 1994.

<sup>h</sup> Source: Patterson, 1995a.

Settling chambers, also referred to as knock-out boxes, are used at HMA plants as primary dust collection equipment. To capture remaining PM, the primary collector effluent is ducted to a secondary collection device such as a baghouse, which is more effective at removing particulates (EPA, 1995a, Khan, 1977).

### ***Baghouses***

Baghouses, or fabric filter systems, filter particles through fabric filtering elements (bags). Particles are caught on the surface of the bags, while the cleaned flue gas passes through. To minimize pressure drop, the bags must be cleaned periodically as the dust layer builds up. Fabric filters can achieve the highest particulate collection efficiency of all particulate control devices. Most HMA plants with baghouses use them for process and process fugitive emissions control. The captured dust from these devices is usually returned to the production process (EPA, 1995a; Gunkel, 1992).

### ***Venturi Scrubbers***

Venturi scrubbers (sometimes referred to as high energy wet scrubbers) are used to remove coarse and fine particulate matter. Flue gas passes through a venturi tube while low pressure water is added at the throat. The turbulence in the venturi promotes intimate contact between the particles and the water. The wetted particles and droplets are collected in a cyclone spray separator (sometimes called a cyclonic demister). Venturi scrubbers are often used in similar applications to baghouses (EPA, 1995a; Gunkel, 1992).

In addition to controlling particulate emissions, the venturi scrubber is likely to remove some of the process organic emissions from the exhaust gas (Gunkel, 1992). While the high-pressure venturi scrubber is reliable at controlling PM, it requires considerable attention and daily maintenance to maintain a high degree of PM removal efficiency (Gunkel, 1992).

## **2.4.2 FUGITIVE PARTICULATE EMISSIONS CONTROL**

### ***Driving Surfaces***

Unpaved driving surfaces are commonly maintained by utilizing wet-down techniques using water, or other agents. In some areas unpaved roadways may alternatively be covered with crushed recycled material (e.g., tires, asphalt shingles) with equal success. In recent years, there has been a trend toward paving the driving surfaces to eliminate fugitive particulates. Facilities with paved surfaces may additionally employ sweeping or vacuuming as maintenance measures to reduce PM emissions (EPA, 1995a; Gunkel, 1992; TRNCC, 1994).

### ***Aggregate Stockpiles***

Watering of the stockpiles is not typically used because of the burden it puts on the heating and drying process (Gunkel, 1992). Occasionally, crusting agents may be applied to aggregate piles. These crusting agents have served fairly well to mitigate fugitive dust emissions in these instances (TNRCC, 1994). There are many variables that affect the fugitive dust emissions from stockpiles including moisture content of the material, amount of fines (< 200 mesh), and age of pile (i.e., older piles tend to loose their surface fines). Pre-washed aggregate, from which fines have been removed, may be used for additional PM control (Patterson, 1995a).

### **2.4.3 VOC (INCLUDING HAP) CONTROL**

VOCs are the total organic compounds emitted by the process minus the methane constituent. Once the exhaust stream cools after discharge from the process stack, some VOCs condense to form a fine liquid aerosol or "blue smoke" plume. A number of process modifications or restrictions have been introduced to reduce blue smoke, including installation of flame shields, rearrangement of flights inside the drum, adjustments of the asphalt injection point, and other design changes (EPA, 1995a; Gunkel, 1992). Periodic burner tune-ups may reduce VOC emissions by about 38 percent (Patterson, 1995a). Burner combustion air can be optimized to reduce emissions by monitoring the pressure drop across induced draft burners with a photohelic device tied to an automatic damper that adjusts the exhaust fan (Patterson, 1995a).

Organic vapors from heated asphalt cement storage tanks can be reduced by condensing the vapors with air-cooled vent pipes. In some cases, tank emissions may be routed back to combustion units. Organic emissions from heated asphalt storage tanks may also be controlled with carbon canisters on the vents or by other measures such as condensing precipitation or stainless steel shaving condensers (Wiese, 1995). Although not common, organic emissions from truck-loading of asphaltic concrete can be controlled by venting into the dryer (EPA, 1995a). This is usually practiced in non-attainment areas.

### **2.4.4 SULFUR OXIDES CONTROL**

#### ***Low Sulfur Fuel***

This approach to reducing SO<sub>x</sub> emissions reduces the sulfur fed to the combustor by burning low sulfur fuels. Fuel blending is the process of mixing higher sulfur content fuels with lower sulfur fuels (e.g., low sulfur oil). The goal of effective fuel blending is to provide a fuel supply with reasonably uniform properties that meet the blend specification, typically including sulfur content, heating value, and moisture content (EIIP, 1995).

#### ***Aggregate Adsorption***

Alkaline aggregate (i.e., limestone) may adsorb sulfur compounds from the exhaust gas. In exhaust streams controlled by baghouses,  $\text{SO}_x$  may be reduced by limestone dust that coats the baghouse filters (Patterson, 1995). Consequently, limestone aggregate may maximize the removal of sulfur compounds (Gunkel, 1992). Sulfur compounds from the exhaust gas may also be adsorbed by a venturi scrubber with recirculated water containing limestone (Wiese, 1995).

## **2.4.5 NITROGEN OXIDES CONTROL**

### ***Low Nitrogen Fuels***

Fuels lower in nitrogen content may reduce some  $\text{NO}_x$  emissions (NAPA, 1995). At temperatures above  $1300^\circ\text{C}$ , however, conversion from high-nitrogen fuels to low-nitrogen fuels may not substantially reduce  $\text{NO}_x$  emissions, as thermal  $\text{NO}_x$  contributions will be more significant (Nevers, 1995). Consequently,  $\text{NO}_x$  emissions are generally inversely related to CO emissions (NAPA, 1995).

Staged combustion systems such as low  $\text{NO}_x$  burners that are used to reduce  $\text{NO}_x$  emissions in other industries, are not typically employed in the HMA industry due to economic and engineering considerations (NAPA, 1995). Recirculation of the exhaust gas may be precluded by the relatively high moisture content (e.g., 30 percent) of the gas stream. Exhaust recirculation in these instances may cause some flame quenching around the edges and could contribute to higher VOC and CO emissions when sealed burners are not used (Patterson, 1995a).

# OVERVIEW OF AVAILABLE METHODS

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## 3.1 DESCRIPTION OF EMISSION ESTIMATION METHODOLOGIES

There are several methodologies available for calculating emissions from HMA plants. The method used is dependent upon available data, available resources, and the degree of accuracy required in the estimate. In general, site-specific data is preferred over industry averaged data such as *AP-42* emission factors for more accurate emissions estimates (EPA, 1995a). (Each state may have a different preference or requirement and so it is suggested that the reader contact the nearest state or local air pollution agency before deciding on which emission estimation methodology to use.) This document evaluates emission estimation methodologies with respect to accuracy and does not mandate any emission estimation method. For purposes of calculating peak season daily emissions for State Implementation Plan inventories, refer to the EPA *Procedures* manual (EPA, May 1991).

This section discusses the methods available for calculating emissions from HMA plants and identifies the preferred method of calculation on a pollutant basis. These emission estimation methodologies are listed in no particular order and the reader should not infer a preference based on the order they are listed in this section. A discussion of the sampling and analytical methods available for monitoring each pollutant is provided in Chapter 1, *Introduction to Stationary Point Source Emissions Inventory Development*.

Emission estimation techniques for auxiliary processes, such as using EPA's TANKS program to calculate storage tank emissions, are also discussed in Chapter 1.

### 3.1.1 STACK SAMPLING

Stack sampling provides a "snapshot" of emissions during the period of the stack test. Stack tests are typically performed during either representative (i.e., normal) or worst case conditions, depending upon the requirements of the state. Samples are collected from the stack using probes inserted through a port in the stack wall, and pollutants are collected in or on various media and sent to a laboratory for analysis. Pollutant concentrations are obtained by dividing the amount of pollutant collected during the test by the volume of the sample. Emission rates are then determined by multiplying the pollutant concentration by the volumetric stack gas flow rate. Because there are many steps in the stack sampling procedures where errors can occur, only experienced stack testers should perform such tests.

### 3.1.2 EMISSION FACTORS

Emission factors are available for many source categories and are based on the results of source tests performed at an individual plant or at one or more facilities within an industry. Basically, an emission factor is the pollutant emission rate relative to the level of source activity. Chapter 1 of this volume of documents contains a detailed discussion of the reliability, or quality, of available emission factors. EPA-developed emission factors for criteria and hazardous air pollutants are available in *AP-42*, the *Locating and Estimating Series* of documents, and the Factor Information Retrieval (FIRE) System.

### 3.1.3 FUEL ANALYSIS

Fuel analysis data can sometimes be used to predict emissions by applying mass conservation laws. For example, if the concentration of a pollutant, or pollutant precursor, in a fuel is known, emissions of that pollutant can be calculated by assuming that all of the pollutant is emitted or by adjusting the calculated emissions by the control efficiency. This approach is appropriate for SO<sub>2</sub>.

### 3.1.4 CONTINUOUS EMISSION MONITORING SYSTEM (CEMS) AND PREDICTIVE EMISSION MONITORING (PEM)

A CEMS provides a continuous record of emissions over time. Various principles are employed to measure the concentration of pollutants in the gas stream and are usually based on photometric measurements. Once the pollutant concentration is known, emission rates are obtained by multiplying the pollutant concentration by the volumetric gas flow rate. Stack gas flow rate can also be measured by continuous monitoring instruments; but it is more typically determined using manual methods (e.g., pitot tube traverse). At low pollutant concentrations, the accuracy of this method may decrease. Instrument drift can be problematic for CEMS and uncaptured data can create long-term, incomplete data sets.

PEM is based on developing a correlation between pollutant emission rates and process parameters. A PEM may be considered a specialized usage of an emission factor. Correlation tests must first be performed to develop this relationship. At a later time emissions can then be calculated using process parameters to predict emission rates based on the results of the initial source test.

## **3.2 COMPARISON OF AVAILABLE EMISSION ESTIMATION METHODOLOGIES**

Table 3.3-1 identifies the preferred and alternative emission estimation approach(s) for selected pollutants. Table 3.3-1 is ordered according to the accuracy of the emission estimation approach. The reader and the local air pollution agency must decide which emission estimation approach is applicable based on costs and air pollution control requirements in their area. The preferred method chosen should also recognize the time specificity of the emission estimate and the data quality. The quality of the data will depend on a variety of factors including the number of data points generated, the representativeness of those data points, and the proper operation and maintenance of the equipment being used to record the measurements.

### **3.2.1 STACK SAMPLING**

Without considering cost, stack sampling is the preferred emission estimation methodology for process NO<sub>x</sub>, CO, VOC, THC, PM, PM<sub>10</sub>, metals and speciated organics. EPA reference methods and other methods of known quality can be used to obtain accurate estimates of emissions at a given time for a particular facility.

### **3.2.2 EMISSION FACTORS**

Due to their availability and acceptance in the industry, emission factors are commonly used to prepare emission inventories. However, the emission estimate obtained from using emission factors is based upon emissions testing performed at similar facilities and may not accurately reflect emissions at a single source. Thus, the user should recognize that, in most cases, emission factors are averages of available industry-wide data with varying degrees of quality and may not be representative of averages for an individual facility within that industry. Emission factors are the preferred technique for estimating fugitive dust emissions for aggregate stockpiles and driving surfaces, as well as process fugitives.

### **3.2.3 FUEL ANALYSIS**

Fuel analysis can be used as an approximation if no emission factors or site specific stack test data are available. Once the concentration of sulfur in a fuel is known, SO<sub>2</sub> emissions can be calculated based on mass conservation laws, assuming negligible adsorption by alkaline aggregates.

**TABLE 3.3-1**  
**SUMMARY OF PREFERRED EMISSION**  
**ESTIMATION METHODS FOR HOT-MIX ASPHALT PLANTS**

Parameter	Preferred Emission Estimation Approach Ordered by Accuracy <sup>a</sup>
SO <sub>2</sub>	1. Stack sampling data 2. CEMS/PEM 3. Fuel analysis 4. EPA/state published emission factors <sup>b</sup>
NO <sub>x</sub>	1. Stack sampling data 2. CEMS/PEM data 3. EPA/state published emission factors <sup>b</sup>
CO	1. Stack sampling data 2. CEMS/PEM data 3. EPA/state published emission factors <sup>b</sup>
VOC	1. Stack sampling data 2. EPA/state published emission factors
THC <sup>c</sup>	1. Stack sampling data 2. CEMS/PEM data 3. EPA/state published emission factors <sup>b</sup>
PM	1. Stack sampling data <sup>d</sup> 2. EPA/state published emission factors <sup>e</sup>
PM <sub>10</sub>	1. Stack sampling data <sup>d</sup> 2. EPA/state published emission factors <sup>e</sup>
Heavy metals	1. Stack sampling data 2. EPA/state published emission factors <sup>b</sup>



**TABLE 3.3-1****(CONTINUED)**

<b>Parameter</b>	<b>Preferred Emission Estimation Approach Ordered by Accuracy<sup>a</sup></b>
Speciated organics	1. Stack sampling data 2. EPA/state published emission factors <sup>b</sup>

<sup>a</sup> Preferred emission estimation approaches do not include considerations such as cost. The costs, benefits, and relative accuracy should be considered prior to method selection. Readers are advised to check with local air pollution control agency before choosing a preferred emission estimation approach.

<sup>b</sup> Assumes emission factors are not based on site-specific fuel analysis.

<sup>c</sup> THC = total hydrocarbons.

<sup>d</sup> Preferred method for process and process fugitive emissions.

<sup>e</sup> Preferred method for fugitive dust.

### 3.2.4 CEMS AND PEM

HMA plants would not likely estimate emissions using CEMS and PEM. HMA plants have conditions unfavorable to generating accurate CEM data including, high vibrations, high moisture content of the stack gas, and dust. Nightly shutdown of CEMS would also adversely affect their performance. In some instances, however, CEMS may be used to estimate emissions of NO<sub>x</sub>, CO, and THC. This method may be used, for example, when detailed records of emissions are needed over time. Similarly, stack gas flow rate may be monitored using a continuous flow rate monitor, including pitot tubes, ultrasonic, and thermal monitors (Patterson, 1995a).

PEM is a predictive emission estimation methodology whereby emissions are correlated to process parameters based on an initial series of stack tests at a facility. For example, VOC emissions may occur from asphalt mixtures produced at various temperatures with different combustion fuels and varying quantities of asphalt cement, aggregates, RAP, and crumb rubber. Similarly, sulfur dioxide emissions may be controlled by scrubbers that operate at variable pressure drops, alkalinity, and recirculation rates. These parameters may be monitored during the tests and correlated to the pollutant emission rates. Following the correlation development, parameters would be monitored to periodically predict emission rates. Periodic stack sampling may be required to verify that the predictive emission correlations are still accurate; if not, new correlations are developed.

# 4

## PREFERRED METHODS FOR ESTIMATING EMISSIONS

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Without consideration of cost, the preferred method for estimating emissions of most pollutants emitted from HMA plants is the use of site-specific recent stack tests. Each state may have a different preference or requirement and so it is suggested that the reader contact the nearest state or local air pollution agency before deciding on which emission estimation methodology to use. This section provides an outline for calculating emissions from HMA plants based on raw data collected by stack tests.

Table 3.4-1 lists the variables and symbols used in the following discussions.

### 4.1 EMISSION CALCULATIONS USING STACK SAMPLING DATA

Stack sampling test reports often provide emissions data in terms of lb/hr or grain/dscf. Annual emissions may be calculated from these data using Equations 3.4-1 or 3.4-2. Stack tests performed under a proposed permit condition or a maximum emissions rate are likely to be higher than the emissions which would result under normal operating conditions. The emission testing should only be completed after the purpose of the testing is known. For example, emission testing for particulate emissions may be different than emission testing for New Source Performance Standards (NSPS) because the back-half catch portion is not considered.

This section shows how to calculate emissions in lb/hr based on stack sampling data. Calculations involved in determining particulate emissions from Method 5 data are used as an example. Because continuous PM monitors have not been demonstrated for this industry, the only available methods for measuring PM emissions are EPA Methods 5 or 17 and EPA Method 201A for PM<sub>10</sub>. EPA Method 5 is used for NSPS testing. If condensible PM is needed in the emissions estimate, the test method selected must be configured accordingly.

**TABLE 3.4-1****LIST OF VARIABLES AND SYMBOLS**

<b>Variable</b>	<b>Symbol</b>	<b>Units</b>
Concentration	C	parts per million volume dry (ppmvd)
Molecular weight	MW	lb/lb-mole
Molar volume	V	385.5 ft <sup>3</sup> /lb-mole @ 68°F and 1 atmosphere
Flow rate	Q <sub>a</sub>	actual cubic feet per minute (acfm)
Flow rate	Q <sub>d</sub>	dry standard cubic feet per minute (dscfm)
Emissions	E <sub>x</sub>	typically lb/hr of pollutant x
Annual emissions	E <sub>tpy,x</sub>	ton/year of pollutant x
Filter catch	C <sub>f</sub>	grams (g)
Fuel use	Q <sub>f</sub>	typically, lb/hr
PM concentration	C <sub>PM</sub>	grain/dscf
Metered volume at standard temperature and pressure	V <sub>m,STP</sub>	dscf
Moisture	R	percent
Temperature	T	degrees fahrenheit
Asphalt production	A	ton/hr
Annual operating hours	OpHrs	hr/yr

An example summary of a Method 5 test is shown in Table 3.4-2. The table shows the results of three different sampling runs conducted during one test event. The source parameters measured as part of a Method 5 run include gas velocity and moisture content, which are used to determine exhaust gas flow rates in dscfm. The filter weight gain is determined gravimetrically and divided by the volume of gas sampled (as shown in Equation 3.4-1) to determine the PM concentration in grains per dscf. Note that this example does not present the condensible PM emissions.

Pollutant concentration is then multiplied by the volumetric flow rate to determine the emission rate in pounds per hour, as shown in Equation 3.4-2 and Example 3.4-1.

$$C_{PM} = C_f / V_{m,STP} * 15.43 \quad (3.4-1)$$

where:

$C_{PM}$	=	concentration of PM or grain loading (grain/dscf)
$C_f$	=	filter catch (g)
$V_{m,STP}$	=	metered volume of sample at STP (dscf)
15.43	=	15.43 grains per gram

$$E_{PM} = C_{PM} * Q_d * 60/7000 \quad (3.4-2)$$

where:

$E_{PM}$	=	hourly emissions in lb/hr of PM
$Q_d$	=	stack gas volumetric flow rate (dscfm)
60	=	60 min/hr
7000	=	7000 grains per pound

**TABLE 3.4-2**  
**TEST RESULTS - METHOD 5**

Parameter	Symbol	Run 1	Run 2	Run 3
Total sampling time (minutes)	min	120	120	120
Moisture collected (grams)	g	395.6	372.6	341.4
Filter catch (grams)	$C_f$	0.0851	0.0449	0.0625
Average sampling rate (dscfm)	dscfm	0.34	0.34	0.34
Standard metered volume, (dscf)	$V_{m,STP}$	41.83	40.68	40.78
Volumetric flow rate (acfm or dscfm)	$Q_a$ or $Q_d$	17,972	17,867	17,914
Concentration of particulate (grains/dscf)	$C_{PM}$	0.00204	0.00110	0.00153
Particulate emission rate (lb/hr)	$E_{PM}$	4.84	2.61	3.63

Example 3.4-1

PM emissions calculated using Equations 3.4-1 and 3.4-2 and the stack sampling data for Run 1 (presented in Table 3.4-2 are shown below).

$$\begin{aligned}
 C_{PM} &= C_f/V_{m,STP} * 15.43 \\
 &= (0.085/41.83) * 15.43 \\
 &= 0.03 \text{ grain/dscf} \\
 E_{PM} &= C_{PM} * Q_d * 60/7000 \\
 &= 0.03 * 17,972 * (60 \text{ min/hr}) * (1 \text{ lb}/7000 \text{ grains}) \\
 &= 4.84 \text{ lb/hr}
 \end{aligned}$$

The information from some stack tests may be reported in pounds of particulate per pounds of exhaust gas (wet). Use Equation 3.4-3 to calculate the dry particulate emissions in lb/hr.

$$E_{PM} = Q_a/1000 * 60 * 0.075 (1 - R) * (528/460 + T) \quad (3.4-3)$$

where:

$$\begin{aligned}
 E_{PM} &= \text{hourly emissions in lb/hr PM} \\
 Q_a &= \text{actual cubic feet of exhaust gas per minute (acfm)} \\
 1000 &= 1000 \text{ lb exhaust gas per lb of PM} \\
 60 &= 60 \text{ min/hr} \\
 0.075 &= 0.075 \text{ lb/ft}^3 \\
 R &= \text{moisture percent (\%)} \\
 528 &= 528^\circ\text{F} \\
 460 &= 460^\circ\text{F} \\
 T &= \text{stack gas temperature in } ^\circ\text{F}
 \end{aligned}$$

## 4.2 EMISSION FACTOR CALCULATIONS

Emission factors are commonly used to calculate emissions for fugitive dust sources and when site-specific monitoring data are unavailable. EPA maintains a compilation of emission factors in *AP-42* for criteria pollutants and HAPs (EPA, 1995a). A supplementary source for toxic air pollutant emission factors is the Factor Information and Retrieval (FIRE) data system (EPA, 1994). FIRE also contains emission factors for criteria pollutants.

Much work has been done recently on developing emission factors for HAPs and recent AP-42 revisions have included these factors (EPA, 1995a,b). In addition, many states have developed their own HAP emission factors for certain source categories and require their use in any inventories including HAPs. Refer to Chapter 1 of Volume III for a complete discussion of available information sources for locating, developing, and using emission factors as an estimation technique.

Emission factors developed from measurements for a specific mixer or dryer may sometimes be used to estimate emissions at other sites. For example, a company may have several units of similar model and size; if emissions were measured from one dryer or mixer, an emission factor could be developed and applied other similar units. It is advisable to have the emission factor reviewed and approved by state/local agencies or the EPA prior to its use.

The basic equation for using an emission factor to calculate emissions is the following:

$$E_x = EF_x * \text{Activity or Production Rate} \quad (3.4-4)$$

where:

$$\begin{array}{ll} E_x & = \text{emissions of pollutant } x \\ EF_x & = \text{emission factor of pollutant } x \end{array}$$

Calculations using emission factors are presented in Examples 3.4-2 and 3.4-3.

### 4.3 EMISSION CALCULATIONS USING FUEL ANALYSIS DATA

Fuel analysis can be used to predict SO<sub>2</sub> and other emissions based on application of conservation laws, if fuel rate (Q<sub>f</sub>) is measured. The presence of certain elements in fuels may be used to predict their presence in emission streams. This includes elements such as sulfur which may be converted to other compounds during the combustion process.



Example 3.4-2

Example 3.4-2 shows how potential hourly VOC combustion emissions may be calculated for a parallel flow drum mixer using a total organic compound (TOC) emission factor from *AP-42*, Table 11.1-8, for an oil-fired dryer. The asphalt plant is assumed to operate 1,200 hours per year.

$$\begin{aligned}
 EF_{\text{TOC}} &= 0.069 \text{ lb/ton asphalt produced} \\
 \text{Maximum asphalt production rate} &= 350 \text{ ton/hr} \\
 \text{TOC emissions} &= EF_{\text{TOC}} * \text{asphalt production rate} \\
 &= 0.069 * 350 \\
 &= 24.15 \text{ lb/hr} * 1 \text{ ton/2000 lb} * 1200 \text{ hr/yr} \\
 &= 14.5 \text{ ton/yr}
 \end{aligned}$$

Example 3.4-3

Example 3.4-3 shows how potential hourly xylene emissions may be calculated for a batch mix HMA plant with a natural gas-fired dryer based on a xylene emission factor from *AP-42*, Table 11.1-9. The HMA plant is assumed to operate 1,200 hours per year.

$$\begin{aligned}
 EF_{\text{xylene}} &= 0.0043 \text{ lb/ton asphalt produced} \\
 \text{Xylene emissions} &= EF_{\text{xylene}} * \text{maximum asphalt production rate} \\
 &= (0.0043 \text{ lb/ton}) * 350 \text{ ton/hr} \\
 &= 1.5 \text{ lb/hr} * 1 \text{ ton/2000 lb} * 1200 \text{ hr/yr} \\
 &= 0.9 \text{ ton/yr}
 \end{aligned}$$

The basic equation used in fuel analysis emission calculations is the following:

$$E_x = Q_f * \text{Pollutant concentration in fuel} * \left( \frac{MW_p}{MW_f} \right) \quad (3.4-4)$$

where:

E	=	emissions of pollutant x
$Q_f$	=	fuel use (lb/hr)
$MW_p$	=	Molecular weight of pollutant emitted (lb/lb-mole)
$MW_f$	=	Molecular weight of pollutant in fuel (lb/lb-mole)

For instance,  $SO_2$  emissions from oil combustion can be calculated based on the concentration of sulfur in the oil. This approach assumes complete conversion of sulfur to  $SO_2$ . Therefore, for every pound of sulfur ( $MW = 32$  g) burned, two pounds of  $SO_2$  ( $MW = 64$  g) are emitted. The application of this emission estimation technique is shown in Example 3.4-4.

#### Example 3.4-4

This example shows how  $SO_2$  emissions can be calculated from oil combustion based on fuel analysis results and the fuel flow information, if available. The asphalt plant is assumed to operate 1,200 hours per year.

$E_{SO_2}$  may be calculated using Equation 3.4-4.

Assume a given $Q_f$	=	5,000 lb/hr
Given percent weight sulfur (% S) in fuel	=	1.17

$$\begin{aligned}
 E_{SO_2} &= Q_f * \text{pollutant concentration in fuel} * (MW_p/MW_f) \\
 &= (5,000) * (1.17/100) * (64/32) \\
 &= 117 \text{ lb/hr} * \text{ton}/2000 \text{ lb} * 1,200 \text{ hr/yr} \\
 &= 70.2 \text{ ton/yr}
 \end{aligned}$$

# 5

## ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

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### 5.1 EMISSION CALCULATIONS USING CEMS DATA

To monitor SO<sub>2</sub>, NO<sub>x</sub>, THC, and CO emissions using a CEMS, a facility uses a pollutant concentration monitor, which measures concentration in parts per million by volume dry air (ppmvd). Note that a CEMS would not likely be used to monitor emissions for an extended period due to the unfavorable conditions at an HMA plant. Flow rates should be measured using a volumetric flow rate monitor. Flow rates estimated based on heat input using fuel factors may be inaccurate because these systems typically run with high excess air to remove the moisture out of the drum (Patterson, 1995). Emission rates (lb/hr) are then calculated by multiplying the stack gas concentrations by the stack gas flow rates.

Table 3.5-1 presents example CEMS data output averaged for three periods for a parallel flow drum mixer. The output includes pollutant concentrations in parts per million dry basis (ppmvd), diluent (O<sub>2</sub> or CO<sub>2</sub>) concentrations in percent by volume dry basis (%v,d), and emission rates in pounds per hour (lb/hr). These data represent a "snapshot" of a drum mixer operation. While it is possible to determine total emissions of an individual pollutant over a given time period from these data assuming the CEM operates properly all year long, an accurate emission estimate can be made by summing the hourly emission estimates if the CEMS data are representative of typical operating conditions.

Although CEMS can report real-time hourly emissions automatically, it may be necessary to manually estimate annual emissions from hourly concentration data. This section describes how to calculate emissions from CEMS concentration data. The selected CEMS data should be representative of operating conditions. When possible, data collected over longer periods should be used. It is important to note that prior to using CEMS to estimate emissions, a protocol should be developed for collecting and averaging the data.

TABLE 3.5-1

## EXAMPLE CEM OUTPUT AVERAGED FOR A PARALLEL FLOW DRUM MIXER FIRING WASTE FUEL OIL

Period	O <sub>2</sub> (%V)	Concentration (C) (ppmvd)				Stack Gas Flow Rate (Q) (dscfm)	Emission Rate (E) (lb/hr)				Asphalt Production Rate (A) (ton/hr)
		SO <sub>2</sub>	NO <sub>x</sub>	CO	THC		SO <sub>2</sub>	NO <sub>x</sub>	CO	THC	
0830-1039	10.3	150.9	142.9	42.9	554.2	18,061	27.15	25.71	3.38	24.93	287
1355-1606	10.1	144.0	145.7	41.8	582.9	17,975	25.78	26.09	3.27	26.09	290
1236-1503	11.8	123.0	112.7	128.4	515.1	18,760	22.99	21.06	10.50	24.06	267

Source: EPA, 1991b.

Hourly emissions can be based on concentration measurements as shown in Equation 3.5-1 and Example 3.5-1.

$$E_x = \frac{(C * MW * Q * 60)}{(V * 10^6)} \quad (3.5-1)$$

where:

$E_x$	=	hourly emissions in lb/hr of pollutant x
$C$	=	pollutant concentration in ppmvd
$MW$	=	molecular weight of the pollutant (lb/lb-mole)
$Q$	=	stack gas volumetric flow rate in dscfm
60	=	60 min/hr
$V$	=	volume occupied by one mole of ideal gas at standard temperature and pressure (385.5 ft <sup>3</sup> /lb-mole @ 68°F and 1 atm)

Actual emissions in tons per year can be calculated by multiplying the emission rate in lb/hr by the number of actual annual operating hours (OpHrs) as shown in Equation 3.5-2 and Example 3.5-1.

$$E_{tpy,x} = E_x * OpHrs/2000 \quad (3.5-2)$$

where:

$E_{tpy,x}$	=	annual emissions in ton/yr of pollutant x
$E_x$	=	hourly emissions in lb/hr of pollutant x
OpHrs	=	annual operating hours in hr/yr

Emissions in pounds of pollutant per ton of asphalt produced can be calculated by dividing the emission rate in lb/hr by the asphalt production in rate (ton/hr) during the same period (Equation 3.5-3) as shown below. It should be noted that the emission factor calculated below assumes that the selected period (i.e., hour) is representative of annual operating conditions and longer time periods should be used when available. Use of the calculation is shown in Example 3.5-1.

$$E_{tpy,x} = E_x/A \quad (3.5-3)$$

where:

$$\begin{aligned} E_{\text{tpy},x} &= \text{emissions of pollutant } x \text{ (lb/ton) per ton of asphalt produced} \\ E_x &= \text{hourly emissions in lb/hr of pollutant } x \\ A &= \text{asphalt production (ton/hr)} \end{aligned}$$

### Example 3.5-1

This example shows how SO<sub>2</sub> emissions can be calculated using Equation 3.5-1 based on the average CEMS data for 8:30-10:39 shown in Table 3.5-1.

$$\begin{aligned} E_{\text{SO}_2} &= (C * MW * Q * 60)/(V * 10^6) \\ &= 150.9 * 64 * 18,061 * 60/(385.5 * 10^6) \\ &= 27.15 \text{ lb/hr} \end{aligned}$$

Emissions in ton/yr (based on a 1,200 hr/yr operating schedule) can then be calculated using Equation 3.5-2; however, based on the above period this estimate should be calculated from the average CEMS data for year using Equation 3.5-1:

$$\begin{aligned} E_{\text{tpy},\text{SO}_2} &= E_{\text{SO}_2} * \text{OpHrs}/2,000 \\ &= 27.15 * (1,200/2,000) \\ &= 16.29 \text{ ton/yr} \end{aligned}$$

Emissions, in terms of lb/ton asphalt produced, are calculated using Equation 3.5-3:

$$\begin{aligned} E_{\text{tpy},\text{SO}_2} &= E_{\text{SO}_2}/A \\ &= 9.46 * 10^{-2} \text{ lb SO}_2/\text{ton asphalt produced} \end{aligned}$$

## 5.2 PREDICTIVE EMISSION MONITORING

Emissions from the HMA process depend upon several variables, which are discussed in Section 3 of this chapter. For example, VOC process emissions for a given plant may vary with several parameters, including: the type of fuel burned; the relative quantities of asphalt constituents (e.g., RAP, crumb rubber, and emulsifiers); aggregate type and moisture content; the temperature of the asphalt constituents; the mixing zone temperature; and, fuel combustion rate. An example emissions monitoring that could be used to develop a PEM

protocol would need to account for the variability in these parameters and, consequently, may require a complex testing algorithm.

To develop this algorithm, correlation testing of the process variables could be conducted over a range of potential operating conditions using EPA Method 25 or Method 25A to measure THC emissions and EPA Method 6A or Method 6C to measure SO<sub>2</sub> emissions. Potential testing conditions covering several parameters are shown in Table 3.5-2. Based on the test data, a mathematical correlation can be developed which predicts emissions using these parameters. This method may be cost prohibitive for a single source.

**TABLE 3.5-2****PREDICTIVE EMISSION MONITORING ANALYSIS<sup>a</sup>**

<b>Test Number</b>	<b>Temperature of Asphalt Constituents</b>	<b>Mixing Zone Temperature</b>	<b>Fuel Firing Rate</b>
1	B	H	H
2	B	H	M
3	B	H	L
4	B	M	H
5	B	M	M
6	B	M	L
7	B	L	H
8	B	L	M
9	B	L	L

<sup>a</sup> H = high.  
M = medium.  
L = low.  
B = baseline.



# 6

## QUALITY ASSURANCE/QUALITY CONTROL

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The consistent use of standardized methods and procedures is essential in the compilation of reliable emission inventories. QA and QC of an inventory is accomplished through a set of procedures that ensure the quality and reliability of data collection and analysis. These procedures include the use of appropriate emission estimation techniques, applicable and reasonable assumptions, accuracy/logic checks of computer models, checks of calculations, and data reliability checks. Figure 3.6-1 provides an example checklist that could aid the inventory preparer at a HMA plant. Volume VI, *QA Procedures* of this series describes additional QA/QC methods and tools for performing these procedures.

Volume II, Chapter 1, *Introduction to Stationary Point Source Emission Inventory Development*, presents recommended standard procedures to follow that ensure the reported inventory data are complete and accurate. The QA/QC section of Chapter 1 should be consulted for current EIIP guidance for QA/QC checks for general procedures, recommended components of a QA plan, and recommended components for point source inventories. The QA plan discussion includes recommendations for data collection, analysis, handling, and reporting. The recommended QC procedures include checks for completeness, consistency, accuracy, and the use of approved standardized methods for emission calculations, where applicable. Chapter 1 also describes guidelines to follow in order to ensure the quality and validity of the data from manual and continuous emission monitoring methodologies used to estimate emissions.

### 6.1 CONSIDERATIONS FOR USING STACK TEST AND CEMS DATA

Data collected via CEMS, PEM, or stack tests must meet quality objectives. Stack test data must be reviewed to ensure that the test was conducted under normal operating conditions, or under maximum operating conditions in some states, and that it was generated according to an acceptable method for each pollutant of interest. Calculation and interpretation of accuracy for stack testing methods and CEMS are described in detail in *Quality Assurance Handbook for Air Pollution Measurements Systems: Volume III. Stationary Source Specific Methods (Interim Edition)*.

The acceptance criteria, limits, and values for each control parameter associated with manual sampling methods, such as dry gas meter calibration and leak rates, are summarized within the tabular format of the QA/QC section of Chapter 1. QC procedures for all instruments

Item	Y/N	Corrective Action (complete if "N"; describe, sign, and date)
1. Have the toxic emissions been calculated and reported using approved stack test methods or using the emission factors provided from AP-42, FIRE, and/or NAPA (National Asphalt Pavement Association)? Have asphalt production rates been included? Each facility should request from their state agency guidance on which test methods or emission factors should be used.		
2. Fugitive emissions are required for the inventory, but will not count towards a Title V determination unless the facility is NSPS affected. Presently, in the case of the asphalt plants, only particulate emissions for the process as defined in 40 CFR 60.90 are NSPS affected. Have fugitive emissions been calculated?		
3. If emission factors are used to calculate fuel usage emissions, have fuel usage rates been determined for the dryer and for the asphalt heater separately? If the AP-42 dryer emission factors are used, they already contain emissions from fuel combustion in the dryer.		
4. Again, request guidance from the state regulatory agency on whether or not to calculate toxic emissions from fuel usage. Most toxic emission factors usually are inclusive of the asphalt and the fuel. Has the state agency been contacted for guidance?		
5. Have stack parameters been provided for each stack or vent which emits criteria or toxic pollutants? This includes the fabric filter or scrubber installed on the asphalt dryer/mixer, the asphalt cement heaters, and any storage silos other than asphalt concrete storage.		

**FIGURE 3.6-1. EXAMPLE EMISSION INVENTORY DEVELOPMENT  
CHECKLIST FOR ASPHALT PLANTS**

Item	Y/N	Corrective Action (complete if "N"; describe, sign, and date)
<p>6. Check with the state regulatory agency to determine whether emissions should be calculated using <i>AP-42</i> emission factors:</p> <p><u>Dryer/Mix Type:</u></p> <p>Rotary Dryer (Batch Mix): Conventional Plant (3-05-002-01)  Drum (Mix) Dryer: Hot Asphalt Plant (3-05-002-05)</p> <p><u>Diesel Generators:</u> Industrial diesel reciprocating (2-02-001-02)</p> <p><u>Asphalt Heaters:</u></p> <p>"In Process Fuel Use Factors" (Residual, 3-05-002-07; Distillate, 3-05-002-08; Natural Gas, 3-05-002-06; LPG, 3-05-002-09).</p>		
<p>7. Have you considered storage piles (3-05-002-03)(includes handling of piles) from both Batch and Drum Plants?</p>		
<p>8. If required by the state, has a site diagram been included with the emission inventory? This should be a detailed plant drawing showing the location of sources/stacks with ID numbers for all processes, control equipment, and exhaust points.</p>		
<p>9. Have examples of all calculations been included?</p>		
<p>10. Have all conversions and units been reviewed and checked for accuracy?</p>		

FIGURE 3.6-1. (CONTINUED)

used to continuously collect emissions data are similar. The primary control check for precision of the continuous monitors is daily analysis of control standards. The CEMS acceptance criteria and control limits are listed within the tabular format of the QA/QC section of Chapter 1.

Quality assurance should be delineated in a Quality Assurance Plan (QAP) by the team conducting the test prior to each specific test. The main objective of any QA/QC effort for any program is to independently assess and document the precision, accuracy, and adequacy of emission data generated during sampling and analysis. It is essential that the emissions measurement program be performed by qualified personnel using proper test equipment. Also, valid test results require the use of appropriate and properly functioning test equipment and use of appropriate reference methods.

The QAP should be developed to assure that all testing and analytical data generated are scientifically valid, defensible, comparable, and of known and acceptable precision and accuracy. EPA guidance, is available for assistance in preparing any QAP (EPA, October, 1989).

## 6.2 CONSIDERATIONS FOR USING EMISSION FACTORS

The use of emission factors is straightforward when the relationship between process data and emissions is direct and relatively uncomplicated. When using emission factors, the user should be aware of the quality indicator associated with the value. Emission factors published within EPA documents and electronic tools have a quality rating applied to them. The lower the quality indicator, the more likely that a given emission factor may not be representative of the source type. When an emission factor for a specific source or category may not provide a reasonably adequate emission estimate, it is always better to rely on actual stack test or CEMS data, where available. The reliability and uncertainty of using emission factors as an emission estimation technique are discussed in detail in the QA/QC Section of Chapter 1.

## 6.3 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

One measure of emission inventory data quality is the DARS score. Four examples are given here to illustrate DARS scoring using the preferred and alternative methods. The DARS provides a numerical ranking on a scale of 1 to 10 for individual attributes of the emission factor and the activity data. Each score is based on what is known about the factor and the activity data, such as the specificity to the source category and the measurement technique employed. The composite attribute score for the emissions estimate can be viewed as a statement of the confidence that can be placed in the data. For a complete discussion of DARS and other rating systems, see the *QA Source Document* (Volume VI, Chapter 4) and

the QA/QC Section within Volume II Chapter 1, *Introduction to Stationary Point Sources Emission Inventory Development*.

Each of the examples below is hypothetical. A range is given where appropriate to cover different situations. The scores are assumed to apply to annual emissions from an HMA plant. Table 3.6-1 gives a set of scores for an estimate based on CEMS/PEM data. A perfect score of 1.0 is achievable using this method if data quality is very good. Note that maximum scores of 1.0 are automatic for the source definition and spatial congruity attributes. Likewise, the temporal congruity attribute receives a 1.0 if data capture is greater than 90 percent; this assumes that data are sampled adequately throughout the year. The measurement attribute score of 1.0 assumes that the pollutants of interest were measured directly. A lower score is given if the emissions are speciated using a profile, or if the emissions are used as a surrogate for another pollutant. Also, the measurement/method score can be less than 1.0 if the relative accuracy is poor (e.g., >10 percent), if the data are biased, or if data capture is closer to 90 percent than to 100 percent.

The use of stack sample data can give DARS scores as high as those for CEMS/PEM data. However, the sample size is usually too low to be considered completely representative of the range of possible emissions making a score of 1.0 for measurement/method unlikely. A typical DARS score for stack sample data is generally closer to the low end of the range shown in Table 3.6-2.

Two examples are given for emissions calculated using emission factors. For both of these examples, the activity data is assumed to be measured directly or indirectly. Table 3.6-3 applies to an emission factor developed from CEMS/PEM data from one dryer or mixer and then applied to a different dryer or mixer of similar design and age. Table 3.6-4 gives an example for an estimate made with an *AP-42* emission factor. The *AP-42* factor is a mean and could overestimate or underestimate emissions for any single unit in the population. Thus, the confidence that can be placed in emissions estimated for a specific unit with a general *AP-42* factor is lower than emissions based on source-specific data. This assumes that the source-specific data were developed while the HMA plant was operating under normal conditions. If it was not operated under normal conditions then the *AP-42* emission factor may be a better characterization of the emissions from the HMA plant.

The example in Table 3.6-3 shows that emission factors based on high-quality data from a similar unit will typically give better results than a general factor. The main criterion affecting the score is how similar the unit used to generate the factor is to the target dryer or mixer.

If sufficient data are available, the uncertainty in the estimate should be quantified. If sufficient data are not available, a qualitative analysis of uncertainty is still recommended. Some methods and examples are described in *QA Procedures* (Volume VI, Chapter 3).

**TABLE 3.6-1**  
**DARS SCORES: CEMS/PEM DATA<sup>a</sup>**

Attribute	Emission Factor Score	Activity Data Score	Composite Scores		Comment
			Range	Midpoint	
Measurement/ method	0.9 - 1.0	0.9 - 1.0	0.81 - 1.0	0.91	Lower scores given if relative accuracy poor (e.g., >10 percent) or data capture closer to 90 percent.
Source definition	1.0	1.0	1.0 - 1.0	1.0	
Spatial congruity	1.0	1.0	1.0 - 1.0	1.0	
Temporal congruity	1.0	1.0	1.0 - 1.0	1.0	
Weighted Score	0.98 - 1.0	0.98 - 1.0	0.95 - 1.0	0.98	

<sup>a</sup> Assumes data capture is 90 percent or better, representative of entire year, monitors sensors, and other equipment is properly maintained.

**TABLE 3.6-2**  
**DARS SCORES: STACK SAMPLE DATA<sup>a</sup>**

Attribute	Emission Factor Score	Activity Data Score	Composite Scores		Comment
			Range	Midpoint	
Measurement/method	0.7 - 1.0	0.7 - 1.0	0.49 - 1.0	0.745	
Source definition	1.0 - 1.0	1.0 - 1.0	1.0 - 1.0	1.0	
Spatial congruity	1.0 - 1.0	1.0 - 1.0	1.0 - 1.0	1.0	
Temporal congruity	0.7 - 1.0	0.7 - 1.0	0.49 - 1.0	0.745	Lower scores given if emissions vary temporally and sample does not cover range.
Weighted Score	0.85 - 1.0	0.85 - 1.0	0.75 - 1.0	0.878	

<sup>a</sup> Assumes use of EPA Reference Method, high quality data.

**TABLE 3.6-3****DARS SCORES: SOURCE-SPECIFIC EMISSION FACTOR<sup>a</sup>**

Attribute	Emission Factor Score	Activity Data Score	Composite Scores		Comment
			Range	Midpoint	
Measurement/method	0.9 - 1.0	0.8 - 1.0	0.72 - 1.0	0.86	Factor score for this attribute depends entirely on data quality.
Source definition	0.5 - 0.9	0.8 - 0.9	0.4 - 0.81	0.61	Factor score lowest if unit differs much from original source of data.
Spatial congruity	1.0 - 1.0	1.0 - 1.0	1.0 - 1.0	1.0	
Temporal congruity	1.0 - 1.0	0.5 - 0.9	0.5 - 0.9	0.7	
Weighted Score	0.85 - 0.98	0.78 - 0.95	0.66 - 0.93	0.79	

<sup>a</sup> Assumes factor developed from PEM or CEMS data from an identical emission unit (same manufacturer, model).



**TABLE 3.6-4**  
**DARS SCORES: AP-42 EMISSION FACTOR<sup>a</sup>**

Attribute	Emission Factor Score	Activity Data Score	Composite Scores		Comment
			Range	Midpoint	
Measurement/method	0.6 - 0.8	0.8 - 1.0	0.48 - 0.7	0.59	Score depends on quality and quantity of data points used to develop factor.
Source definition	0.5 - 0.9	0.8 - 0.9	0.4 - 0.81	0.605	Emission factor score will be low if variability in source population is high.
Spatial congruity	0.6 - 0.8	1.0 - 1.0	0.6 - 0.8	0.7	Factor score lower if geographic location has significant effect on emissions.
Temporal congruity	0.5 - 0.9	0.5 - 0.9	0.25 - 0.81	0.53	Lower scores given if emissions vary temporally and sample does not cover range.
Weighted Score	0.55 - 0.85	0.78 - 0.95	0.43 - 0.78	0.61	

<sup>a</sup> Assumes activity data (e.g., fuel use) or surrogate is measured directly in some manner.

The reader should note that the presentation of the DARS scores here is shown as a hypothetical example, only. Although the highest DARS score results from the use of CEMS, this estimation technique will not practically be applied or used by the majority of facilities operating. Due to technical feasibility issues and costs incurred by applying CEMS to a HMA plant, stack testing or emission factors may provide the best choice when selecting an appropriate method for estimating emissions (even though stack testing or emission factors did not receive the highest DARS score). The reader should always contact their state regulatory agency for approval of selected methodologies or techniques. Also, it should be noted that this hypothetical application of DARS does not mandate any emission estimation method, but only offers the reader a means for selecting any one method over another.

## DATA CODING PROCEDURES

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This section describes the methods and codes available for characterizing emission sources at HMA facilities. Consistent categorization and coding will result in greater uniformity among inventories. The SCCs are the building blocks on which point source emissions data are structured. Each SCC represents a unique process or function within a source category that is logically associated with an emission point. Without an appropriate SCC, a process cannot be accurately identified for retrieval purposes. In addition, the procedures described here will assist the reader preparing data for input to the Aerometric Information Retrieval System (AIRS) or a similar database management system. For example, the use of the SCCs provided in Table 3.7-1 are recommended for describing HMA operations. Refer to CHIEF for a complete listing of SCCs for HMA plants. While the codes presented here are currently in use, they may change based on further refinement by the emission inventory user community. As part of the EIIP, a common emissions data exchange format is being developed to facilitate data transfer between industry, states, and EPA. Details on SCCs for specific emission sources are as follows:

- **Process Emissions:** For asphaltic concrete production processes, be careful to use only one SCC for each process. Use the codes for either the batch or continuous process or for the drum mix process, depending on which process is used. The process-specific codes should be used as often as possible; however, "Entire Unit" and "General" codes are available. If the "Entire Unit" code is used, do not use the chemical-specific or process-specific codes as this would double-count emissions. *AP-42* emission factors for dryer emissions include all stack emissions (including products of combustion from the dryer burner).
- **In-Process Fuel:** In-process fuel includes SCCs for asphalt cement heaters. These emissions are separate and apart from dryer emissions.
- **Generators:** Diesel generators may be used at portable HMA plants to generate electricity. These emissions are not included in emission factors for process emissions.

- **Storage Tanks:** Storage tanks may be used in the asphaltic concrete production process to store fuel such as oil. Potential emissions from storage tanks will likely be insignificant. The codes in Table 3.7-1 are recommended to describe fuel storage emissions.
- **Fugitive Emissions:** Fugitive emissions from asphaltic concrete production result primarily from the storage and handling of raw materials and finished product. The miscellaneous codes may be used for fugitive emission sources without a unique code. Remember to use the comment section to describe the emissions.

Control device codes applicable to asphaltic concrete production are presented in Table 3.7-2. These should be used to enter the type of applicable emissions control device into the AIRS Facility Subsystem (AFS). The "099" control code may be used for miscellaneous control devices that do not have a unique identification code.

If there are significant sources of fugitive emissions within the facility, or sources that have not been specifically discussed thus far, they should be included in the emissions estimates if required by the state. Conditions vary from plant to plant, thus, each specific case cannot be discussed within the context of this document.

TABLE 3.7-1

**SOURCE CLASSIFICATION CODES FOR ASPHALTIC CONCRETE  
PRODUCTION (SIC CODE 2951)**

Source Description	Process Description	SCC	Units
Process Emissions			
Batch or continuous mix process	Rotary dryer	3-05-002-01	Tons HMA produced
	Hot elevators, screens, bins, and mixer	3-05-002-02	Tons aggregate processed
Drum mix process	Drum mixer: hot asphalt plants	3-05-002-05	Tons HMA produced
General process	General process/specify in comments	3-05-002-99	Tons produced
	In-place recycling - propane	3-05-002-15	Tons produced
In-Process Fuel			
Asphalt heater fuel use	Residual oil	3-05-002-07	1000 gallons burned
	Distillate oil	3-05-002-08	1000 gallons burned
	Natural gas	3-05-002-06	Million ft <sup>3</sup> burned
	Waste oil	3-05-002-10	1000 gallons burned
	Liquid petroleum gas	3-05-002-09	1000 gallons burned
Generators			
Diesel	Reciprocating	2-02-001-02	Horsepower hours
Fugitive Emissions			
Fugitive emissions	Raw material storage piles	3-05-002-03	Tons aggregate processed
	Cold aggregate handling	3-05-002-04	Tons aggregate processed
	Storage silo	3-05-002-13	Tons HMA produced
	Truck load-out	3-05-002-14	Tons HMA loaded
	Miscellaneous fugitive emissions	3-05-888-01 to 05	Vehicle miles travelled
	Haul roads - general	3-05-002-90	Tons product

**TABLE 3.7-2**  
**AIRS CONTROL DEVICE CODES**

<b>Control Device</b>	<b>Code</b>
Settling chamber: high-efficiency	004
Settling chamber: medium-efficiency	005
Settling chamber: low-efficiency	006
Single cyclone	075
Multiple cyclone	076
Centrifugal collector: high-efficiency	007
Centrifugal collector: medium-efficiency	008
Centrifugal collector: low-efficiency	009
Fabric filter: high temperature	016
Fabric filter: medium temperature	017
Fabric filter: low temperature	018
Wet fan	085
Spray tower	052
Venturi scrubber	053
Baffle spray tower	052
Miscellaneous control device	099

Source: EPA, January 1992.

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## **APPENDIX A**

# **EXAMPLE DATA COLLECTION FORM AND INSTRUCTIONS FOR HOT-MIX ASPHALT PLANTS**

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## **EXAMPLE DATA COLLECTION FORM INSTRUCTIONS**

1. This form may be used as a work sheet to aid the plant engineer in collecting the information necessary to calculate emissions from HMA plants. The information requested on the form relates to the methods (described in Sections 3 through 5) for quantifying emissions. This form may also be used by the regulatory agency to assist in area wide inventory preparation.
2. The completed forms should be maintained in a reference file by the plant engineer with other supporting documentation.
3. The information requested on these forms is needed to complete emission calculations. If the information requested does not apply to a particular dryer, mixer, or unit, write "NA" in the blank.
4. If you want to modify the form to better serve your needs, an electronic copy of the form may be obtained through the EIIP on the CHIEF system .
5. If hourly or monthly fuel use information is not available, enter the information in another unit (quarterly or yearly). Be sure to indicate on the form what the unit of measure is.
6. Use the comments field on the form to record all useful information that will allow your work to be reviewed and reconstructed.

**EXAMPLE DATA COLLECTION FORM - HOT-MIX ASPHALT PLANTS**

<b>GENERAL INFORMATION</b>	
Facility/Plant Name:	
SIC Code:	
SCC:	
SCC Description:	
Location:	
County:	
City:	
State:	
Parent Company Address:	
Plant Geographical Coordinates (if portable, state so):	
Latitude:	
Longitude:	
UTM Zone:	
UTM Easting:	
UTM Northing:	
Contact Name:	
Title:	
Telephone Number:	
Source ID Number:	AIRS or FID?
Type of Plant (i.e., batch, drum):	
Permit Number:	
Permitted Hours of Operation (per year):	
Actual Hours of Operation (per year):	
Hours/Day:	
Days/Weeks:	
Weeks/Year:	

**EXAMPLE DATA COLLECTION FORM - HOT-MIX ASPHALT PLANTS**

<b>COMBUSTION OPERATIONS</b>				
ASPHALT CEMENT HEATERS:				
Unit ID No.:	Fuel A	Fuel B	Fuel C	Comments
Fuel Type:				
Year:				
Maximum Hourly Fuel Use (units):				
Total Annual Fuel Use (units):				
Maximum Capacity of Heater(s) (Million Btu/hr):				

Note: Complete this form for each type of fuel used and for each unit.

**EXAMPLE DATA COLLECTION FORM - HOT-MIX ASPHALT PLANTS**

<b>COMBUSTION OPERATIONS</b>				
<b>DRYERS:</b>				
Unit ID No.:	Fuel A	Fuel B	Fuel C	Comments
Fuel Type:				
Year:				
Composition (% sulfur)				
Composition (metals)				
Maximum Hourly Fuel Use (units):				
Monthly Fuel Use (units):				
January:				
February:				
March:				
April:				
May:				
June:				
July:				
August:				
September:				
October:				
November:				
December:				
Total Annual Fuel Use (units):				



**EXAMPLE DATA COLLECTION FORM - HOT-MIX ASPHALT PLANTS**

<b>GENERATORS:</b>				
Size: Horsepower or kilowatts:				
Unit ID:	Fuel A	Fuel B	Fuel C	Comments
Fuel Type:				
Year:				
Maximum Hourly Fuel Use (units):				
Total Annual Fuel Use (units):				
<b>STACK/VENT INFORMATION</b>				
Please fill out the following information for each stack/vent. Attach additional sheets as needed.				
STACK PARAMETER	STACK ID NUMBER	STACK ID NUMBER	STACK ID NUMBER	
Source(s) Vented:				
Latitude/Longitude:				
UTM Zone:				
UTM Easting:				
UTM Northing:				
Height (feet):				
Diameter (feet):				
Temperature (°F):				
Velocity (FPS):				
Flow Rate (ACFM):				
Stack/Vent Direction: (vert./horiz./fugitive)	(circle one) V H F	(circle one) V H F	(circle one) V H F	
Stk. Capped (yes/no):				

**EXAMPLE DATA COLLECTION FORM - HOT-MIX ASPHALT PLANTS**

<b>PRODUCTION OPERATIONS</b>			<b>COMMENTS</b>
Year:			
Asphalt Produced (tons):			
Maximum Design Capacity of Plants (tons/hr) (This should be standardized at 5% moisture):			
Liquid Asphaltic Cement Used (tons):			
Tons of RAP Processed:			
Tons of Mineral Filler Used from Silos:			
<b>AIR POLLUTION CONTROL EQUIPMENT</b>			
Please fill out the following information for each control device. Attach additional sheets as needed.			
Control Type	Location	Efficiency (%)	How calculated?
EXAMPLE: Fabric Filter	Dryer Exhaust	99	Vendor's specs

**Note:** Please copy blank form and attach additional sheets as needed.

## EMISSION ESTIMATION RESULTS

Unit ID No.: \_\_\_\_\_

Pollutant	Emission Estimation Method <sup>a</sup>	Emission Factor Throughput	Emission Factor <sup>b</sup>	Emissions Factor Units	Annual Emissions	Emission Units	Comments
VOC							
NO <sub>x</sub>							
CO							
SO <sub>2</sub>							
PM <sub>10</sub>							
Total Particulate							
Hazardous Air Pollutants (list individually)							

<sup>a</sup> Use the following codes to indicate which emission estimation method is used for each pollutant:

CEMS/PEM = CEM/PEM

Emission Factor = EF

Stack Test Data = ST

Other (indicate) = O

Fuel Analysis = FA

<sup>b</sup> Where applicable, enter the emission factor and provide the full citation of the reference or source of information from where the emission factor came. Include edition, version, table, and page numbers if AP-42 is used.

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**VOLUME II: CHAPTER 4**

# **PREFERRED AND ALTERNATIVE METHODS FOR ESTIMATING FUGITIVE EMISSIONS FROM EQUIPMENT LEAKS**

**Final Report**

**November 1996**



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Prepared for:  
Point Sources Committee  
Emission Inventory Improvement Program

## **DISCLAIMER**

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

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# 1

## INTRODUCTION

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The purposes of this document are to present general information on methodologies and/or approaches for estimating air emissions from equipment leaks in a clear and concise manner and to provide specific example calculations to aid in the preparation and review of emission inventories.

Because documents describing procedures for estimating emissions from equipment leaks are readily available, duplication of detailed information will be avoided in this document. The reader is referred to the following reports that were used to develop this document:

- Environmental Protection Agency (EPA). November 1995. *Protocol for Equipment Leak Emission Estimates*. EPA-453/R-95-017; U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina;
- Chemical Manufacturers Association (CMA). 1989. *Improving Air Quality: Guidance for Estimating Fugitive Emissions*. Second Edition. Washington, DC; and,

During the development of this guideline document, results of recent studies developed by the EPA for the petroleum industry were incorporated (Epperson, January, 1995). This information is available on the Office of Air Quality Planning and Standards (OAQPS) Technology Transfer Network (TTN) (under the Clearinghouse for Inventories and Emission Factors [CHIEF]).

Section 2 of this chapter contains a general description of the equipment leak sources, such as valves, pumps, and compressors and also includes information on equipment leak control techniques and efficiencies. Section 3 of this chapter provides an overview of available approaches for estimating emissions from equipment leaks. Four main approaches are discussed and compared in Section 3: (1) average emission factor; (2) screening ranges; (3) EPA correlation equation; and (4) unit-specific correlation equations. Also included in this section are descriptions of available procedures for collecting equipment leaks data and a comparison of available emission estimation approaches. Section 4 presents the preferred method for estimating emissions, while Section 5 presents alternative emission estimation methods. Quality assurance and control procedures are described in Section 6 and data coding procedures are discussed in Section 7. References are listed in Section 8.

Appendix A presents information on how to estimate the control effectiveness of leak detection and repair (LDAR) programs. Appendix B presents additional information on response factors (RFs) and some guidelines on how to evaluate whether an RF correction to a screening value should be made. Appendix C of this chapter presents general information on methods and calculation procedures for mass emissions sampling (bagging). Appendix D presents an example data collection form that can be used for gathering information to estimate fugitive emissions from equipment leaks.

# 2

## GENERAL SOURCE CATEGORY DESCRIPTION

---

### 2.1 SOURCE CATEGORY DESCRIPTION

Emissions occur from process equipment whenever components in the liquid or gas stream leak. These emissions generally occur randomly and are difficult to predict. In addition, these emissions may be intermittent and vary in intensity over time. Therefore, measurements of equipment leak emissions actually represent a "snapshot" of the leaking process. There are several potential sources of equipment leak emissions. Components such as pumps, valves, pressure relief valves, flanges, agitators, and compressors are potential sources that can leak due to seal failure. Other sources, such as open-ended lines, and sampling connections may leak to the atmosphere for reasons other than faulty seals. The majority of data collected for estimating equipment leak emissions has been for total organic compounds and non-methane organic compounds. Equipment leak emission data have been collected from the following industry segments:

- Synthetic Organic Chemical Manufacturing Industry (SOCMI);
- Petroleum Refineries;
- Petroleum Marketing Terminals; and
- Oil and Gas Production Facilities.

Each of these emission sources is briefly described in this section. A more detailed discussion of these sources can be found in the *Protocol for Equipment Leak Emission Estimates* (EPA, November 1995) and the *Equipment Leaks Enabling Document* (EPA, July 1992).

#### 2.1.1 PUMPS

Pumps are used extensively in the petroleum and chemical industries for the movement of liquids. The centrifugal pump is the most widely used pump type in the chemical industry; however, other types, such as the positive displacement (reciprocating) pump, are also used. Chemicals transferred by pump can leak at the point of contact between the moving shaft and the stationary casing. Consequently, all pumps except the sealless type, such as canned-motor, magnetic drive, and diaphragm pumps, require a seal at the point where the shaft penetrates the housing in order to isolate the pumped fluid from the environment.

Two generic types of seals, packed and mechanical, are used on pumps. Packed seals can be used on both reciprocating and centrifugal pumps. A packed seal consists of a cavity ("stuffing box") in the pump casing filled with packing gland to form a seal around the shaft. Mechanical seals are limited in application to pumps with rotating shafts. There are single and dual mechanical seals, with many variations to their basic design and arrangement, but all have a lapped seal face between a stationary element and a rotating seal ring.

### **2.1.2 VALVES**

Except for connectors, valves are the most common and numerous process equipment type found in the petroleum and chemical industries. Valves are available in many designs, and most contain a valve stem that operates to restrict or allow fluid flow. Typically, the stem is sealed by a packing gland or O-ring to prevent leakage of process fluid to the atmosphere. Emissions from valves occur at the stem or gland area of the valve body when the packing or O-ring in the valve fails.

### **2.1.3 COMPRESSORS**

Compressors provide motive force for transporting gases through a process unit in much the same way that pumps transport liquids. Compressors are typically driven with rotating or reciprocating shafts. Thus, the sealing mechanisms for compressors are similar to those for pumps (i.e., packed and mechanical seals).

### **2.1.4 PRESSURE RELIEF DEVICES**

Pressure relief devices are safety devices commonly used in petroleum and chemical facilities to prevent operating pressures from exceeding the maximum allowable working pressures of the process equipment. Note that it is not considered an equipment leak-type emission when a pressure relief device functions as designed during an over pressure incident allowing pressure to be reduced. Equipment leaks from pressure relief devices occur when material escapes from the pressure relief device during normal operation. The most common pressure relief valve (PRV) is spring-loaded. The PRV is designed to open when the operating pressure exceeds a set pressure and to reseal after the operating pressure has decreased to below the set pressure. Another pressure relief device is a rupture disk (RD) which does not result in equipment leak emissions. The disks are designed to remain whole and intact, and burst at a set pressure.

### **2.1.5 CONNECTORS AND FLANGES**

Connectors and flanges are used to join sections of piping and equipment. They are used wherever pipes or other equipment (such as vessels, pumps, valves, and heat exchangers) require isolation or removal. Flanges are bolted, gasket-sealed connectors and are normally



used for pipes with diameters of 2.0 inches or greater. The primary causes of flange leakage are poor installation, aging and deterioration of the sealant, and thermal stress. Flanges can also leak if improper gasket material is chosen.

Threaded fittings (connectors) are made by cutting threads into the outside end of one piece (male) and the inside end of another piece (female). These male and female parts are then screwed together like a nut and bolt. Threaded fittings are normally used to connect piping and equipment having diameters of 2.0 inches or less. Seals for threaded fittings are made by coating the male threads with a sealant before joining it to the female piece. The sealant may be a polymeric tape, brush-on paste, or other spreadable material that acts like glue in the joint. These sealants typically need to be replaced each time the joint is broken. Emissions can occur as the sealant ages and eventually cracks. Leakage can also occur as the result of poor assembly or sealant application, or from thermal stress on the piping and fittings.

In the 1993 petroleum industry studies, flanges were analyzed separately from connectors. Non-flanged connectors (or just connectors) were defined as plugs, screwed or threaded connectors, and union connectors that ranged in diameter from 0.5 to 8.0 inches, but were typically less than 3.0 inches in diameter. Flanged connectors (flanges) were larger, with diameters in some cases of 22.0 inches or more.

### **2.1.6 AGITATORS**

Agitators are used in the chemical industry to stir or blend chemicals. Four seal arrangements are commonly used with agitators: packed seals, mechanical seals, hydraulic seals, and lip seals. Packed and mechanical seals for agitators are similar in design and application to packed and mechanical seals for pumps. In a hydraulic seal, an annular cup attached to the process vessel contains a liquid that contracts an inverted cup attached to the rotating agitator shaft. Although the simplest agitator shaft seal, the hydraulic seal, is limited to low temperature/low pressure applications, and can handle only very small pressure changes. A lip seal consists of a spring-loaded, nonlubricated elastomer element, and is limited in application to low-pressure, top-entering agitators.

### **2.1.7 OPEN-ENDED LINES**

Some valves are installed in a system so that they function with the downstream line open to the atmosphere. A faulty valve seat or incompletely closed valve on such an open-ended line would result in a leakage through the open end.

### **2.1.8 SAMPLING CONNECTIONS**

Sampling connections are used to obtain samples from within the process. Emissions occur as a result of purging the sampling line to obtain a representative sample of the process fluid.

## **2.2 POLLUTANT COVERAGE**

### **2.2.1 TOTAL ORGANIC COMPOUNDS**

The majority of data collected for estimating equipment leaks within the petroleum and gas industries and the SOCMII has been for total organic compounds and non-methane organic compounds. Therefore, the emission factors and correlations developed for emission estimation approaches are intended to be used for estimating total organic compound (TOC) emissions.

### **2.2.2 SPECIATED ORGANICS/HAZARDOUS AND TOXIC AIR POLLUTANTS**

Because material in equipment within a process unit is often a mixture of several chemicals, equipment leak emission estimates for specific volatile organic compounds (VOCs), hazardous air pollutants (HAPs), and/or pollutants under Section 112(r) of the Clean Air Act, as amended can be obtained by multiplying the TOC emissions from a particular equipment times the ratio of the concentration of the specific VOC/pollutant to the TOC concentration, both in weight percent. An assumption in the above estimation is that the weight percent of the chemicals in the mixture contained in the equipment will equal the weight percent of the chemicals in the leaking material. In general, this assumption should be accurate for single-phase streams containing any gas/vapor material or liquid mixtures containing constituents of similar volatilities. Engineering judgement should be used to estimate emissions of individual chemical species, in cases when:

- The material in the equipment piece is a liquid mixture of constituents with varying volatilities; or
- It is suspected that the leaking vapor will have different concentrations than the liquid.

### **2.2.3 INORGANIC COMPOUNDS**

The emission estimation approaches developed for estimating TOC emissions may be used to estimate emissions of inorganic compounds--particularly for volatile compounds or those present as a gas/vapor. Also, in the event that there is no approach available to estimate the concentration of the inorganic compound at the leak interface, the average emission factors developed for organic compounds can be used; however, the accuracy of the emission estimate will be unknown.

## **2.3 ESTIMATION OF CONTROL EFFICIENCIES FOR EQUIPMENT LEAK CONTROL TECHNIQUES**

Two primary techniques are used to reduce equipment leak emissions: (1) modifying or replacing existing equipment, and (2) implementing an LDAR program. Equipment modifications are applicable for each of the leaking equipment described in this section. An LDAR program is a structured program to detect and repair equipment that are identified as leaking; however, it is more effective on some equipment than others.

The use of equipment modifications and equipment included in an LDAR program are predicated by state and federal regulations that facilities/process units are required to meet. In most equipment leak regulations, a combination of equipment modifications and LDAR requirements are used. Table 4.A-1 in Appendix A of this chapter summarizes requirements in several federal equipment leak control regulations.

### **2.3.1 REPLACEMENT/MODIFICATION OF EXISTING EQUIPMENT**

Controlling emissions by modifying existing equipment is achieved by either installing additional equipment that eliminates or reduces emissions, or replacing existing equipment with sealless types. Equipment modifications that can be used for each type of equipment described in this section, and their corresponding emission control efficiencies are presented in Table 4.2-1. A closed-vent system is a typical modification for pumps, compressors, and pressure relief devices. A closed-vent system captures leaking vapors and routes them to a control device. The control efficiency of a closed-vent system depends on the efficiency of the vapor transport system and the efficiency of the control device. A closed-vent system can be installed on a single piece of equipment or on a group of equipment pieces. A description of the controls by equipment type are briefly presented below.

#### ***Pumps***

Equipment modifications that are control options for pumps include: (1) routing leaking vapors to a closed-vent system, (2) installing a dual mechanical seal containing a barrier fluid, or (3) replacing the existing pump with a sealless type. Dual mechanical seals and sealless pumps are discussed in detail in Chapter 5 of the *Equipment Leaks Enabling Document* (EPA, July 1992). The control efficiency of sealless pumps and a dual mechanical seal with a barrier fluid at a higher pressure than the pumped fluid is essentially 100 percent, assuming both the inner and outer seal do not fail simultaneously.

**TABLE 4.2-1**  
**SUMMARY OF EQUIPMENT MODIFICATIONS**

<b>Equipment Type</b>	<b>Modification</b>	<b>Approximate Control Efficiency (%)</b>
Pumps	Sealless design	100 <sup>a</sup>
	Closed-vent system	90 <sup>b</sup>
	Dual mechanical seal with barrier fluid maintained at a higher pressure than the pumped fluid	100
Valves	Sealless design	100 <sup>a</sup>
Compressors	Closed-vent system	90 <sup>b</sup>
	Dual mechanical seal with barrier fluid maintained at a higher pressure than the compressed gas	100
Pressure relief devices	Closed-vent system	<sup>c</sup>
	Rupture disk assembly	100
Connectors	Weld together	100
Open-ended lines	Blind, cap, plug, or second valve	100
Sampling connections	Closed-loop sampling	100

<sup>a</sup> Sealless equipment can be a large source of emissions in the event of equipment failure.

<sup>b</sup> Actual efficiency of a closed-vent system depends on percentage of vapors collected and the efficiency of the control device to which the vapors are routed.

<sup>c</sup> Control efficiency of closed vent-systems installed on a pressure relief device may be lower than other closed-vent systems because they must be designed to handle both potentially large and small volumes of vapor.

**Valves**

Emissions from process valves can be eliminated if the valve stem can be isolated from the process fluid, (i.e., using sealless valves). Two types of sealless valves, diaphragm valves and sealed bellows, are available. The control efficiency of both diaphragm and sealed bellowed valves is essentially 100 percent.

**Compressors**

Emissions from compressors may be reduced by collecting and controlling the emissions from the seal using a closed-vent system or by improving seal performance by using a dual mechanical seal system similar to pumps. The dual mechanical seal system has an emissions control efficiency of 100 percent, assuming both the inner and outer seal do not fail simultaneously.

**Pressure Relief Valves**

Equipment leaks from pressure relief valves (PRVs) occur as a result of improper reseating of the valve after a release, or if the process is operating too close to the set pressure of the PRV and the PRV does not maintain the seal. There are two primary equipment modifications that can be used for controlling equipment leaks from pressure relief devices: (1) a closed-vent system, or (2) use of a rupture disk in conjunction with the PRV.

The equipment leak control efficiency for a closed-vent system installed on a PRV may not be as high as what can be achieved for other pieces of equipment because emissions from PRVs can have variable flow during an overpressure situation and it may be difficult to design a control device to efficiently handle both high and low flow emissions. Rupture disks can be installed upstream of a PRV to prevent fugitive emissions through the PRV seat. The control efficiency of a rupture disk/PRV combination is essentially 100 percent when operated and maintained properly.

**Connectors and Flanges**

In cases where connectors are not required for safety, maintenance, process modification, or periodic equipment removal, emissions can be eliminated by welding the connectors together.

**Open-Ended Lines**

Emissions from open-ended lines can be controlled by properly installing a cap, plug, or second valve to the open end. The control efficiency of these measures is essentially 100 percent.

### ***Sampling Connections***

Emissions from sampling connections can be reduced by using a closed-loop sampling system or by collecting the purged process fluid and transferring it to a control device or back to the process. The efficiency of a closed-loop system is 100 percent.

### **2.3.2 LEAK DETECTION AND REPAIR (LDAR) PROGRAMS**

An LDAR program is a structured program to detect and repair equipment that is identified as leaking. A portable screening device is used to identify (monitor) pieces of equipment that are emitting sufficient amounts of material to warrant reduction of the emissions through simple repair techniques. These programs are best applied to equipment types that can be repaired on-line, resulting in immediate emissions reduction.

An LDAR program may include most types of equipment leaks; however, it is best-suited to valves and pumps and can also be implemented for connectors. For other equipment types, an LDAR program is not as applicable. Compressors are repaired in a manner similar to pumps; however, because compressors ordinarily do not have a spare for bypass, a process unit shutdown may be required for repair. Open-ended lines are most easily controlled by equipment modifications. Emissions from sampling connections can only be reduced by changing the method of collecting the sample, and cannot be reduced by an LDAR program. Safety considerations may preclude the use on an LDAR program on pressure relief valves.

The control efficiency of an LDAR program is dependent on three factors: (1) how a leak is defined, (2) the monitoring frequency of the LDAR program, and (3) the final leak frequency after the LDAR program is implemented. The leak definition is the screening value measured by a portable screening device at which a leak is indicated if a piece of equipment screens equal to or greater than that value. Screening values are measured as concentrations in parts per million by volume (ppmv). The leak definition is a given part of an LDAR program and can either be defined by the facility implementing the program or by an equipment standard to which the facility must comply. Table 4.A-1 in Appendix A of this document provides equipment leak screening values for several equipment leak control programs. The monitoring frequency is the number of times a year (daily, weekly, monthly, quarterly, yearly) that equipment are monitored with a portable screening device. The monitoring frequency may be estimated from the initial leak frequency before the LDAR program is implemented, and the final leak frequency after the LDAR program is implemented. The leak frequency is the fraction of equipment with screening values equal to or greater than the leak definition. The LDAR program control efficiency approach is based on the relationship between the percentage of equipment pieces that are leaking and the corresponding average leak rate for all of the equipment.

Most federal equipment leak control programs have quarterly or monthly monitoring requirements. However, the LDAR monitoring frequency and leak definitions at some state equipment leak control programs may be different from federal programs. During the planning of a LDAR program, it is recommended to contact the local environmental agency to find out about their LDAR program guidelines and/or requirements.

The EPA has developed control efficiencies for equipment monitored at specified leak definitions and frequencies. Tables 4.2-2 and 4.2-3 summarize the control efficiencies for equipment that are monitored quarterly and monthly at a leak definition of 10,000 ppmv, and equipment meeting the LDAR requirements of the National Emission Standard for Hazardous Air Pollutants (NESHAP) for hazardous organics known as the Hazardous Organic NESHAP (HON). Although it was developed for the SOCMI, it is the basis for most new equipment leak regulations for other industries. Appendix A presents information on how to develop process/facility-specific control efficiencies.

TABLE 4.2-2

## CONTROL EFFECTIVENESS FOR AN LDAR PROGRAM AT A SOCFI PROCESS UNIT

Equipment Type and Service	Control Effectiveness (%)		
	Monthly Monitoring 10,000 ppmv Leak Definition	Quarterly Monitoring 10,000 ppmv Leak Definition	HON <sup>a</sup>
Valves - gas	87	67	92
Valves - light liquid	84	61	88
Pumps - light liquid	69	45	75
Compressors - gas	b	b	93
Connectors - gas and light liquid	b	33	b
Pressure relief devices - gas	b	44	b

<sup>a</sup> Control effectiveness attributed to the requirements of the HON equipment leak regulation is estimated based on equipment-specific leak definitions and performance levels.

<sup>b</sup> Data are not available to estimate control effectiveness.



TABLE 4.2-3

**CONTROL EFFECTIVENESS FOR LDAR COMPONENT MONITORING FREQUENCIES FOR  
PETROLEUM REFINERIES**

Equipment Type and Service	Control Effectiveness (%)		
	Monthly Monitoring 10,000 ppmv Leak Definition <sup>a</sup>	Quarterly Monitoring 10,000 ppmv Leak Definition <sup>a,b</sup>	HON <sup>a,c</sup>
Valves - gas	88	70	96
Valves - light liquid	76	61	95
Pumps - light liquid	68	45	88
Compressors - gas	d	33	e
Connectors - gas and light liquid	f	f	81
Pressure relief devices - gas	d	44	e

<sup>a</sup> Source: EPA, July 1992.

<sup>b</sup> Source: EPA, April 1982.

<sup>c</sup> Control effectiveness attributed to the requirements of the HON equipment leak regulation is estimated based on equipment-specific leak definitions and performance levels.

<sup>d</sup> Monthly monitoring of component is not required in any control program.

<sup>e</sup> Rule requires equipment modifications instead of LDAR.

<sup>f</sup> Information not available.

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# 3

## OVERVIEW OF AVAILABLE METHODS

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This section contains general information on the four basic approaches for estimating equipment leak emissions. The approach used is dependent upon available data, available resources to develop additional data, and the degree of accuracy needed in the estimate.

Regulatory considerations should also be taken into account in selecting an emission estimation approach. These considerations may include air toxic evaluations, nonattainment emission inventory reporting requirements, permit reporting requirements, and employee exposure concerns.

Each approach is briefly described including its corresponding data requirements. Since data collection procedures will impact the accuracy of the emission estimate, this section also includes a general description of the two variable procedures for collecting equipment leaks data, screening and bagging procedures, and available monitoring methods. Finally, a general description for estimating control efficiencies for equipment leak control techniques is presented. Table 4.3-1 lists the variables and symbols used in the following discussions on emissions estimates.

### 3.1 EMISSION ESTIMATION APPROACHES

There are four basic approaches for estimating emissions from equipment leaks in a specific processing unit. The approaches, in order of increasing refinement, are:

- Average emission factor approach;
- Screening ranges approach;
- EPA correlation approach; and
- Unit-specific correlation approach.

The approaches increase in complexity and in the amount of data collection and analysis required. All the approaches require some data collection, data analysis and/or statistical evaluation.

These approaches range from simply applying accurate equipment counts to average emission factors to the more complex project of developing unit-specific correlations of mass emission

**TABLE 4.3-1**  
**LIST OF VARIABLES AND SYMBOLS**

Variable	Symbol	Units
TOC mass emissions	$E_{\text{TOC}}$	kg/hr of TOC
VOC mass emissions	$E_{\text{VOC}}$	kg/hr of VOC
Mass emissions of organic chemical x	$E_x$	kg/hr of organic chemical x
Concentration of TOCs	$WP_{\text{TOC}}$	weight percent of TOCs
VOC concentration	$WP_{\text{VOC}}$	weight percent of VOCs
Concentration of organic chemical x	$WP_x$	weight percent of organic chemical x
Average emission factor	$F_A$	typically, kg/hr per source
Emission factor for screening value $\geq 10,000$ ppmv	$F_G$	kg/hr per source
Emission factor for screening value $< 10,000$ ppmv	$F_L$	kg/hr per source
Concentration from screening value	SV	ppmv

rates and screening values. In general, the more refined approaches require more data and provide more accurate emission estimates for a process unit. Also, the more refined approaches, especially the unit-specific correlation approach which requires bagging data, require a larger budget to implement the program and develop the correlation equations.

Figure 4.3-1 shows an overview of the data collection and analysis required to apply each of the above approaches. All of the approaches require an accurate count of equipment components by the type of equipment (e.g., valves, pumps, connectors), and for some of the equipment types, the count must be further described by service (e.g., heavy liquid, light liquid, and gas).

The chemical industry has developed alternative methods for estimating equipment component count (CMA, 1989). One of the methods calls for an accurate count of the number of pumps in the process and the service of the pumps. Equipment components in the entire process are then estimated through use of the number of pumps. Another method calls for an accurate count of valves directly associated with a specific piece of equipment using process flow sheets; and then based on the number of valves, the number of flanges and fittings are estimated using ratios (e.g., flanges/valves). A careful selection/development of the methodology used to quantify the equipment component count should be made to accurately reflect the equipment leak emission estimates for any facilities and/or process units.

Except for the average emission factor approach, all of the approaches require screening data. Screening data are collected by using a portable monitoring instrument to sample air from potential leak interfaces on individual pieces of equipment. A screening value is a measure of the concentration of leaking compounds in the ambient air that provides an indication of the leak rate from an equipment piece, and is measured in units of parts per million by volume (ppmv). See "Source Screening" in this section for details about screening procedures.

In addition to equipment counts and screening data, the unit-specific correlation approach requires bagging data. Bagging data consist of screening values and their associated measured leak rates. A leak rate is measured by enclosing an equipment piece in a bag to determine the actual mass emission rate of the leak. The screening values and measured leak rates from several pieces of equipment are used to develop a unit-specific correlation. The resulting leak rate/screening value correlation predicts the mass emission rate as a function of the screening value. See "Mass Emissions Sampling (Bagging)" in this section for details about bagging procedures.

These approaches are applicable to any chemical- and petroleum-handling facility. However, more than one set of emission factors or correlations have been developed by the EPA and other regulatory agencies, depending upon the type of process unit being considered.

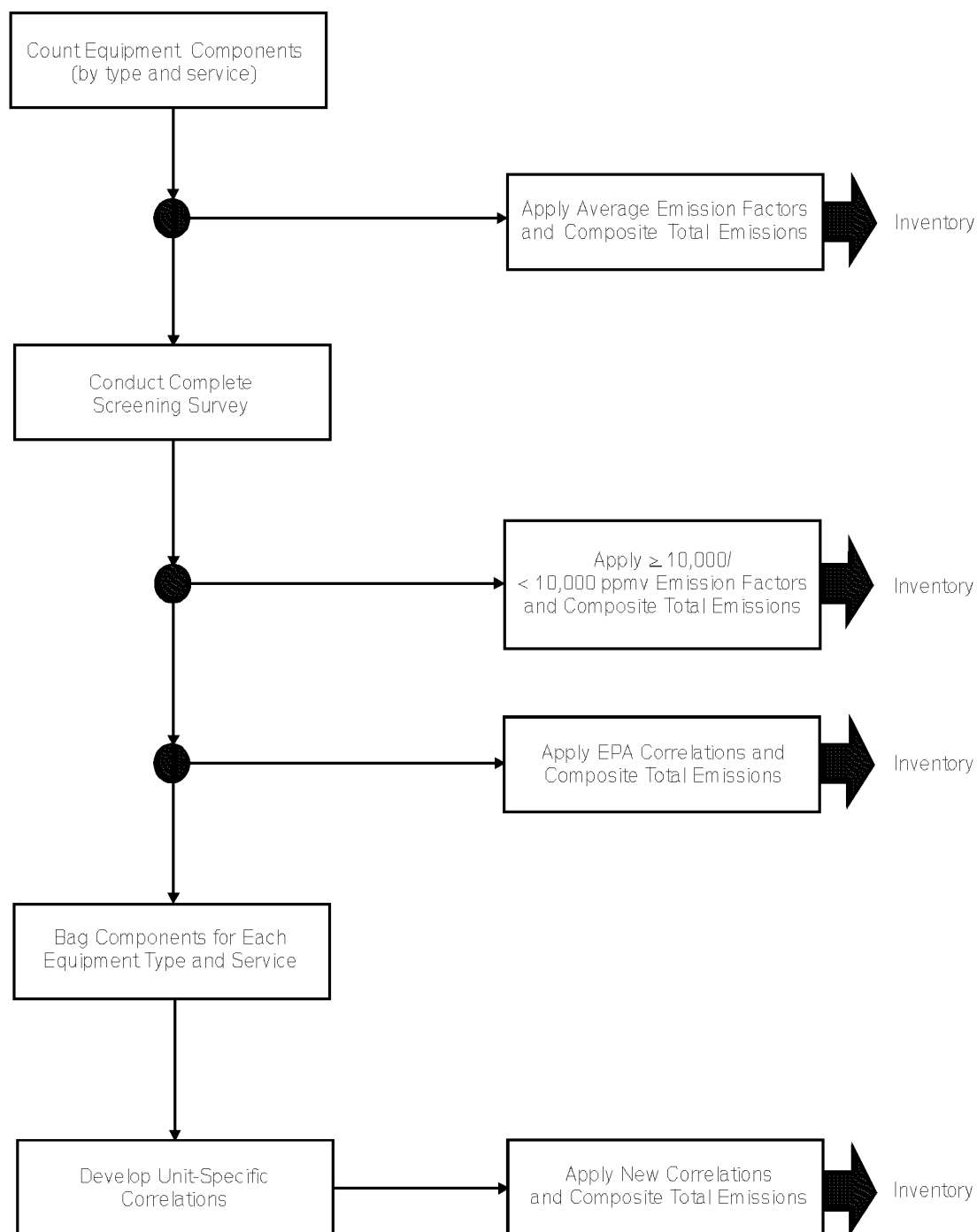


Figure 4.3-1. Overview of Data Collection and Analysis Approaches For Developing Equipment Leak Emissions Inventory

EPA data collection on emissions from equipment leaks in SOCFI facilities, refineries, oil and gas production operations, and marketing terminals has yielded emission factors and correlations for these source categories. Emission factors and correlations for oil and gas production facilities, including well heads, have also been developed by regulatory agencies and the American Petroleum Institute (CARB, August 1989; API, 1993).

For process units in source categories for which emission factors and/or correlations have not been developed, the factors and/or correlations already developed can be utilized. However, appropriate evidence should indicate that the existing emission factors and correlations are applicable to the source category in question. Criteria for determining the appropriateness of applying existing emission factors and correlations to another source category may include one or more of the following: (1) process design; (2) process operation parameters (i.e., pressure and temperature); (3) types of equipment used; and, (4) types of material handled. For example, in most cases, SOCFI emission factors and correlations are applicable for estimating equipment leak emissions from the polymer and resin manufacturing industry. This is because, in general, these two industries have comparable process design and comparable process operations; they use the same types of equipment and they tend to use similar feedstock with similar operations, molecular weight, density, and viscosity. Therefore, response factors should also be similar for screening values.

In estimating emissions for a given process unit, all equipment components must be screened for each class of components. However, in some cases, equipment is difficult or unsafe to screen or it is not possible to screen every equipment piece due to cost considerations. The latter is particularly true for connectors. The *Protocol for Equipment Leak Emission Estimates* (EPA, November 1995) provides criteria for determining how many connectors must be screened to constitute a large enough sample size to identify the screening value distribution for connectors. However, if the process unit to be screened is subject to a standard which requires the screening of connectors, then all connectors must be screened. If the criteria presented in the *Protocol* document are met, the average emission rate for connectors that were connected can be applied to connectors that were not screened. For equipment types other than connectors, including difficult or unsafe-to-screen equipment, that are not monitored, the average emission factor approach or the average emission rate for the equipment components that were screened can be used to estimate emissions.

Also, screening data collected at several different times can be used for estimating emissions, as long as the elapsed time between values obtained is known. For example, if quarterly monitoring is performed on a valve, four screening values will be obtained from the valve in an annual period. The annual emissions from the valve should be calculated by determining the emissions for each quarter based on the operational hours for the quarter, and summing the quarterly emission together to get entire year emissions.

## 3.2 SPECIATING EMISSIONS

In some cases, it may be necessary to estimate emissions of a specific VOC in a mixture of several chemicals. The equations developed for each one of the approaches (see Sections 4 and 5) are used to estimate total VOC emissions; the following equation is used to speciate emissions from a single equipment piece:

$$E_x = E_{\text{TOC}} \times \text{WP}_x / \text{WP}_{\text{TOC}} \quad (4.3-1)$$

where:

$E_x$	=	The mass emissions of organic chemical "x" from the equipment (kg/hr);
$E_{\text{TOC}}$	=	The TOC mass emissions from the equipment (kg/hr) calculated from either the Average Emission Factor, Screening Ranges, EPA Correlation, or Unit-Specific Correlation approaches;
$\text{WP}_x$	=	The concentration of organic chemical x in the equipment in weight percent; and
$\text{WP}_{\text{TOC}}$	=	The TOC concentration in the equipment in weight percent.

An assumption in the above equation is that the weight percent of the chemicals in the mixture contained in the equipment will equal the weight percent of the chemicals in the leaking material. In general, this assumption should be accurate for single-phase streams containing any gas/vapor material or liquid mixtures containing constituents of similar volatilities.

Engineering judgement should be used to estimate emissions of individual chemical species from liquid mixtures of constituents with varying volatilities or in cases where it is suspected that the leaking vapor has different concentrations than the liquid.

## 3.3 ORGANIC COMPOUND EMISSION ESTIMATES FROM EQUIPMENT CONTAINING NON-VOCs

A very similar approach to the one used to speciate emissions can be used to estimate organic compound emissions from equipment containing organic compounds not classified as VOCs. Because the concentrations of these compounds (such as methane or ethane) are included with VOC concentrations in the screening value, the emissions associated with the screening value will include emissions of the "non-VOCs."

Once TOC emissions have been estimated, the organic compound emissions from a group of equipment containing similar composition can be calculated using the equation:



$$E_{\text{VOC}} = E_{\text{TOC}} \times \text{WP}_{\text{VOC}}/\text{WP}_{\text{TOC}} \quad (4.3-2)$$

where:

$E_{\text{VOC}}$	=	The VOC mass emissions from the equipment (kg/hr);
$E_{\text{TOC}}$	=	The TOC mass emissions from the equipment (kg/hr) calculated from either the Average Emission Factor, Screening Ranges, EPA Correlation, or Unit-Specific Correlation approaches;
$\text{WP}_{\text{VOC}}$	=	The concentration of VOC in the equipment in weight percent; and
$\text{WP}_{\text{TOC}}$	=	The TOC concentration in the equipment in weight percent.

### 3.4 INORGANIC COMPOUND EMISSION ESTIMATES

The emission factors and correlations presented in this document are intended to be applied to estimate emissions of total organic compounds. However, in some cases, it may be necessary to estimate equipment leak emissions of inorganic compounds, particularly for those existing as gas/vapor or for volatile compounds.

Equipment leak emission estimates of inorganic compounds can be obtained by the following methods:

- Develop unit-specific correlations;
- Use a portable monitoring instrument to obtain actual concentrations of the inorganic compounds and then enter the screening values obtained into the applicable correlations developed by the EPA;
- Use the screening values obtained above and apply the emission factors corresponding to that screening range; or
- Multiply the average emission factor by the component count to estimate the leak rate.

Also, surrogate measurements can be used to estimate emissions of inorganic compounds. For example, potassium iodide (KI) or a similar salt solution is an indicator for equipment leaks from acid (hydrochloric acid [HCl], hydrofluoric acid [HF]) process lines.

### 3.5 DESCRIPTION OF AVAILABLE PROCEDURES FOR COLLECTING EQUIPMENT LEAKS DATA

The *Protocol* document (EPA, November 1995) provides a consistent approach for collecting equipment leaks data, which will ensure the development of acceptable emission factors and/or correlation equations for emission estimation purposes. Recognizing the importance of the above statement, general information on the two available procedures for collecting equipment leaks data, screening and bagging, is presented in this section.

#### 3.5.1 SOURCE SCREENING

This part of the section provides general information for conducting a screening program on-site and provides a short description of the type of portable analyzers that can be used when conducting screening surveys.

Source screening is performed with a portable organic compound analyzer (screening device). The *Protocol* document (EPA, November 1995) requires that the portable analyzer probe opening be placed at the leak interface of the equipment component to obtain a "screening" value. The screening value is an indication of the concentration level of any leaking material at the leak interface.

Some state and local agencies may require different screening procedures with respect to the distance between the probe and the leak interface. The reader should contact their state or local agency to determine the appropriate screening guidelines. However, use of the leak rate correlations require screening values gathered as closely as practicable to the leak interface.

The main objective of a screening program is to measure organic compound concentration at any potential leak point associated with a process unit. A list of equipment types that are potential sources of equipment leak emissions is provided in Table 4.3-2.

The first step is to define the process unit boundaries and obtain a component count of the equipment that could release fugitive emissions. A process unit can be defined as the smallest set of process equipment that can operate independently and includes all operations necessary to achieve its process objective. The use of a simplified flow diagram of the process is recommended to note the process streams. The actual screening data collection can be done efficiently by systematically following each stream.

The procedures outlined in EPA Reference Method 21 — *Determination of Volatile Organic Compound Leaks* (40 CFR 60, Appendix A) should be followed to screen each equipment type that has been identified. The *Protocol* document (EPA, November 1995) describes the location on each type of equipment where screening efforts should be concentrated. For equipment with no moving parts at the leak interface, the probe should be placed directly on

**TABLE 4.3-2**  
**EQUIPMENT LEAK EMISSION SOURCES**

<b>Equipment Types</b>
Pump seals
Compressor seals
Valves
Pressure relief devices
Flanges
Connectors
Open-ended lines
Agitator seals
Other <sup>a</sup>
<b>Services</b>
Gas/vapor
Light liquid
Heavy liquid

<sup>a</sup> Includes instruments, loading arms, stuffing boxes, vents, dump lever arms, diaphragms, drains, hatches, meters, polished rods, and vents.

the leak interface (perpendicular, not tangential, to the leak potential interface). On the other hand, for equipment with moving parts, the probe should be placed approximately 1 centimeter off from the leak interface (EPA, November 1995). The Chemical Manufacturers Association has also made some suggestions to maintain good screening practices (CMA, 1989). Recent ongoing efforts by the American Petroleum Institute have also been focused on increasing the accuracy of screening readings.

Various portable organic compound detection devices can be used to measure concentration levels at the equipment leak interface. Any analyzer can be used provided it meets the specifications and performance criteria set forth in EPA Reference Method 21.

Reference Method 21 requires that the analyzer meet the following specifications:

- The VOC detector should respond to those organic compounds being processed (determined by the response factor [RF]);
- Both the linear response range and the measurable range of the instrument for the VOC to be measured and the calibration gas must encompass the leak definition concentration specified in the regulation;
- The scale of the analyzer meter must be readable to  $\pm 2.5$  percent of the specified leak definition concentration;
- The analyzer must be equipped with an electrically driven pump so that a continuous sample is provided at a nominal flow rate of between 0.1 and 3.0 liters per minute;
- The analyzer must be intrinsically safe for operation in explosive atmospheres; and
- The analyzer must be equipped with a probe or probe extension for sampling not to exceed 0.25 inch in outside diameter, with a single end opening for admission of sample.

Note that the suction flow rate span allowed by Reference Method 21 is intended to accommodate a wide variety of instruments, and manufacturers guidelines for appropriate suction flow rate should be followed.

In addition to the specifications for analyzers, each analyzer must meet instrument performance criteria, including instrument response factor, instrument response time, and calibration precision. Table 4.3-3 presents the performance criteria requirements that portable organic compound detectors must meet to be accepted for use in a screening program.

TABLE 4.3-3

**EPA REFERENCE METHOD 21 PERFORMANCE CRITERIA FOR PORTABLE  
ORGANIC COMPOUND DETECTORS<sup>a</sup>**

Criteria	Requirement	Time Interval
Instrument response factor <sup>b</sup>	Must be <10 unless correction curve is used	One time, before detector is put in service.
Instrument response time <sup>c</sup>	Must be ≤30 seconds	One time, before detector is put in service. If modification to sample pumping or flow configuration is made, a new test is required.
Calibration precision <sup>d</sup>	Must be ≤10 percent of calibration gas value	Before detector is put in service and at 3-month intervals or next use, whichever is later.

<sup>a</sup> Source: 40 CFR Part 60, Appendix A, EPA Reference Method 21. These performance criteria must be met in order to use the portable analyzer in question for screening.

<sup>b</sup> The response factor is the ratio of the known concentration of a VOC to the observed meter reading when measured using an instrument calibrated with the reference compound specified in the applicable regulation.

<sup>c</sup> The response time is the time interval from a step change in VOC concentration at the input of the sampling system to the time at which 90 percent of the corresponding final value is reached as displayed on the instrument readout meter.

<sup>d</sup> The precision is the degree of agreement between measurements of the same known value, expressed as the relative percentage of the average difference between the meter readings and the known concentration to the known concentration; i.e., between two meter readings of a sample of known concentration.

Table 4.3-4 lists several portable organic compound detection instruments, their manufacturers, model number, pollutants detected, principle of operation, and range. Figure 4.3-2 shows the HW-101 (HNU Systems, Inc.) instrument, Figure 4.3-3 shows the Foxboro OVA-108, and Figure 4.3-4 shows the Foxboro TVA-1000. When a monitoring device does not meet all of the EPA Reference Method 21 requirements, it can still be used for the purpose of estimating emissions if its reliability is documented. For information on operating principles and limitations of portable organic compound detection devices, as well as specifications and performance criteria, please refer to the *Protocol for Equipment Leak Emission Estimates* document (EPA, November 1995).

Data loggers are available for use with portable organic compound detection devices to aid in the collection of screening data and in downloading the data to a computer. Database management programs are also available to aid in screening data inventory management and compiling emissions. Contact the American Petroleum Institute or state and local agencies for more information about data loggers and database management programs.

As mentioned earlier, screening values are obtained by using a portable monitoring instrument to detect TOCs at an equipment leak interface. However, portable monitoring instruments used to detect TOC concentrations do not respond to different organic compounds equally. To correct screening values to compensate for variations in a monitor's response to different compounds, response factors (RFs) have been developed. An RF relates measured concentrations to actual concentrations for specific compounds using specific instruments.

Appendix B of this chapter presents additional information on response factors and includes some guidelines on how to evaluate whether an RF correction to a screening value should be made.

### 3.5.2 MASS EMISSIONS SAMPLING (BAGGING)

An equipment component is bagged by enclosing the component to collect leaking vapors. A bag (or tent) made of material that is impermeable to the compound(s) of interest is constructed around the leak interface of the piece of the equipment.

A known rate of carrier gas is introduced into the bag. A sample of the gas from the bag is collected and analyzed to determine the concentration (in parts per million by volume [ppmv]) of leaking material. The concentration is measured using laboratory instrumentation and procedures. The use of analytical instrumentation in a laboratory is critical to accurately estimate mass emissions. A gas chromatograph (GC) equipped with a flame ionization detector or electron capture detector is commonly used to identify individual constituents of a sample (EPA, November 1995).

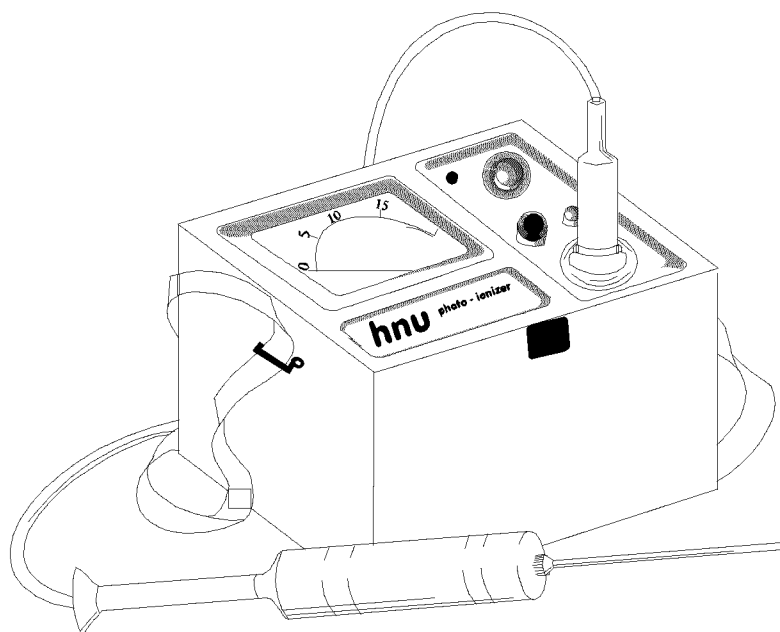
Appendix C of this chapter presents general information on the methods generally employed in sampling source enclosures (vacuum and blow-through methods) and presents the

TABLE 4.3-4

## PORTABLE ORGANIC COMPOUND DETECTION INSTRUMENTS

Manufacturer	Model Number	Pollutant(s) Detected	Detection Technique	Range
Bacharach Instrument Co., Santa Clara, California	L	Combustible gases	Catalytic combustion	0 - 100% LEL <sup>a</sup>
	TLV Sniffer	Combustible gases	Catalytic combustion	0 - 1,000 and 0 - 10,000 ppm
Foxboro S. Norwalk, Connecticut	OVA-128	Most organic compounds	FID/GC <sup>b</sup>	0 - 1,000 ppm
	OVA-108	Most organic compounds	FID/GC	0 - 10,000 ppm
	Miran IBX	Compounds that absorb infrared radiation	NDIR <sup>c</sup>	Compound specific
	TVA-1000	Most organic and inorganic compounds	Photoionization and FID/GC	0.5-2,000 ppm (photoionization) 1-50,000 ppm (FID/GC)
Health Consultants	Detecto- PAK III	Most organic compounds	FID/GC	0 - 10,000 ppm
HNU Systems, Inc. Newton Upper Falls, Massachusetts	HW-101	Chlorinated hydrocarbons, aromatics, aldehydes, ketones, any substance that ultraviolet light ionizes	Photoionization	0 - 20, 0 - 200 and 0 - 2,000 ppm
Mine Safety Appliances Co., Pittsburgh, Pennsylvania	40	Combustible gases	Catalytic combustion	0 - 10% and 0 - 100% LEL
Survey and Analysis, Inc., Northboro, Massachusetts	On Mark Model 5	Combustible gases	Thermal conductivity	0 - 5% and 0 - 100% LEL
Rae Systems Sunnyvale, California	MiniRAE PGM-75K	Chlorinated hydrocarbons, aromatics, aldehydes, ketones, any substance that ultraviolet light ionizes	Photoionization	0 - 1,999 ppm

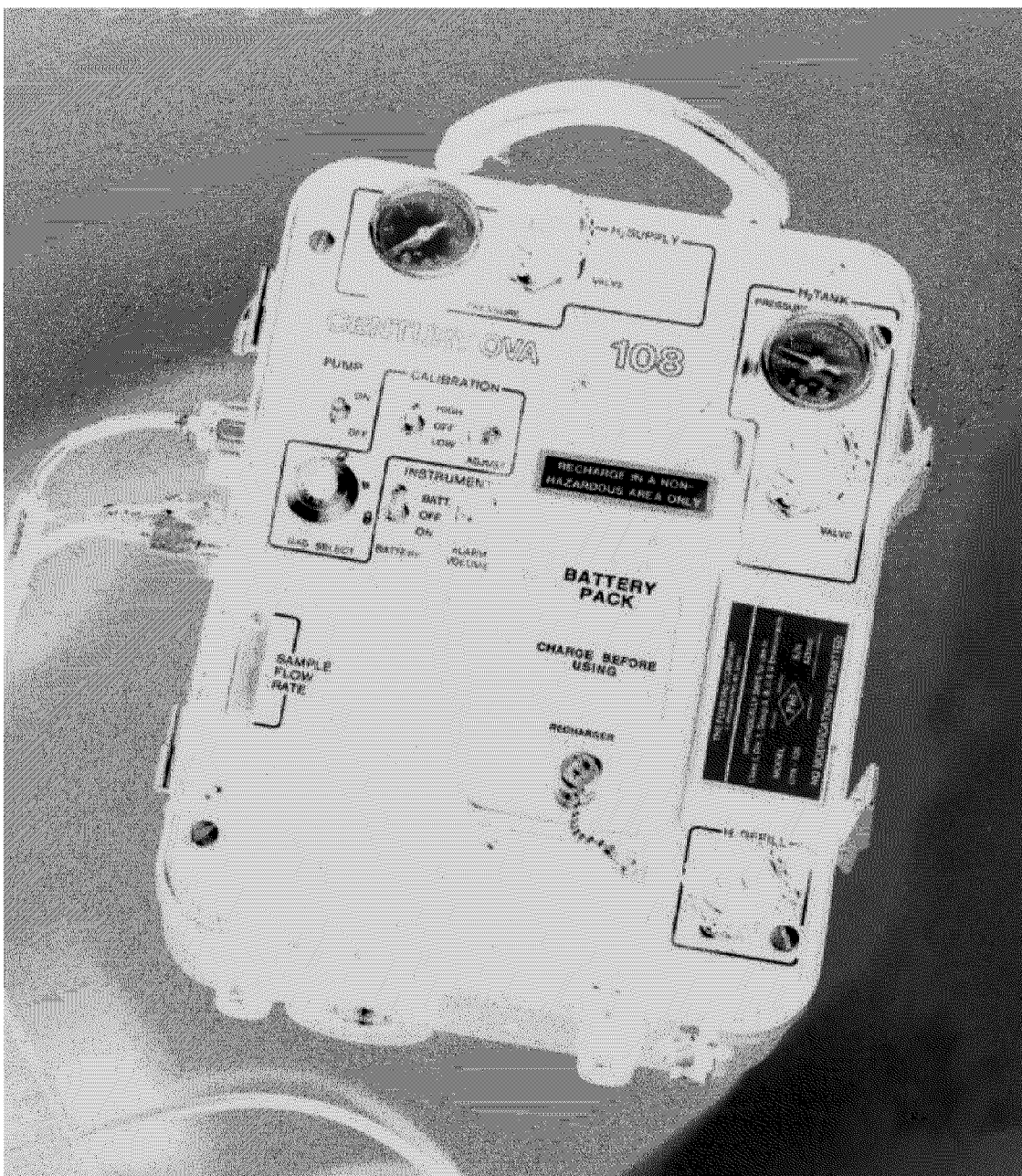
<sup>a</sup> LEL = Lower explosive limit.<sup>b</sup> FID/GC = Flame ionization detection/gas chromatography.<sup>c</sup> NDIR = Nondispersive infrared analysis.



950236-LN-CRTP

**FIGURE 4.3-2. HW-101 PORTABLE ORGANIC COMPOUND DETECTION INSTRUMENT  
(HNU SYSTEM, INC.)**





**FIGURE 4.3-3. OVA-108 PORTABLE ORGANIC COMPOUND DETECTION INSTRUMENT (FOXBORO)**



**FIGURE 4.3-4. TVA-1000 PORTABLE ORGANIC/INORGANIC COMPOUND  
DETECTION INSTRUMENT (FOXBORO)**

calculation procedures for leak rates when using both methods.

The *Protocol for Equipment Leak Emission Estimates* document provides detailed information on sampling methods for bagging equipment, considerations for bagging each equipment type and analytical techniques (EPA, November 1995).

### **3.6 COMPARISON OF AVAILABLE EMISSION ESTIMATION METHODOLOGIES/APPROACHES**

Table 4.3-5 identifies the preferred and alternative emission estimation approaches for equipment leaks, and presents their advantages and disadvantages. All four emission estimation approaches presented are more appropriately applied to the estimation of emissions from equipment population rather than individual equipment pieces.

The preferred approach for estimating fugitive emissions from equipment leaks is to use the EPA correlation equations that relate screening values to mass emission rates. The selection of the preferred method for emission estimation purposes is based on the degree of accuracy obtained and the amount of resources and cost associated with the method.

Because the equipment leak emissions may occur randomly, intermittently, and vary in intensity over time, the "snapshot" of emissions from a given leak indicated by screening and/or bagging results, which are used either to develop or apply all of the approaches, may or may not be representative of the individual leak. However, by taking measurements from several pieces of a given equipment type, the snapshots of individual deviations from the actual leaks offset one another such that the ensemble of leaks should be representative. All of these approaches are imperfect tools for estimating fugitive emissions from equipment leaks; however, they are the best tools available. The best of these tools, the preferred method, can be expected to account for approximately 50 to 70 percent of the variability of the snapshot ensemble of equipment leak emissions.

TABLE 4.3-5

**SUMMARY OF THE ADVANTAGES AND DISADVANTAGES OF PREFERRED AND  
ALTERNATIVE EMISSION ESTIMATION APPROACHES FOR EQUIPMENT LEAKS**

<b>Preferred Emission Estimation Approach</b>	<b>Alternative Emission Estimation Approach</b>	<b>Advantages</b>	<b>Disadvantages</b>
EPA Correlation Equations		<p>Provides a refined emission estimate when actual screening values are available.</p> <p>Provides a continuous function over the entire range of screening values instead of discrete intervals.</p>	<p>Screening value measurements used with these correlations should have the same format as the one followed to develop the correlations (OVA<sup>a</sup>/methane).</p> <p>The development of an instrument response curve may be needed to relate screening values to actual concentration.</p>
	Average Emission Factors	In the absence of screening data, offers good indication of equipment leak emission rates from equipment in a process unit.	<p>They are not necessarily an accurate indication of the mass emission rate from an individual piece of equipment. Average emission factors do not reflect different site-specific conditions among process units within a source category.</p> <p>May present the largest potential error (among the other approaches) when applied to estimate emissions from equipment populations.</p>
	Screening Ranges	<p>Offers some refinement over the Average Emission Factor approach.</p> <p>Allows some adjustment for individual unit conditions and operation.</p>	Available data indicate that measured mass emission rates can vary considerably from the rates predicted by the use of these emission factors.
	Process- Unit Specific Correlation	The correlations are developed on a process unit basis to minimize the error associated with different leak rate characteristics between units.	High cost.

<sup>a</sup> Organic vapor analyzer.

# 4

## PREFERRED METHOD FOR ESTIMATING EMISSIONS

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The EPA correlation equation approach is the preferred method when actual screening values are available. This approach involves entering the screening value into the correlation equation, which predicts the mass emission rate based on the screening value. For new sources, when no actual screening values are available, average emission factors can be used temporarily to determine fugitive emissions from equipment leaks until specific and/or better data are available. However, it is recommended that the local environmental agency be contacted to discuss the best approach and assumptions when data are not available.

This approach offers a good refinement to estimating emissions from equipment leaks by providing an equation to predict mass emission rate as a function of screening value for a particular equipment type. This approach is most valid for estimating emissions from a population of equipment and is not intended for estimating emissions from an individual equipment piece over a short time period (i.e., 1 hour). EPA correlation equations relating screening values to mass emission rates have been developed by the EPA for SOCFI process units and for the petroleum industry (EPA, November 1995).

Correlations for SOCFI are available for: (1) gas valves; (2) light liquid valves; (3) connectors; (4) single equation for light liquid pump seals. Correlation equations, for the petroleum industry that apply to refineries, marketing terminals, and oil and gas production operations data are available for: (1) valves; (2) connectors; (3) flanges; and (4) pump seals; (5) open-ended lines; and (6) other. The petroleum industry correlations apply to all services for a given equipment type.

An example of the EPA correlation equation approach is demonstrated for Streams A and B described in Table 4.4-1. This example is for a hypothetical chemical processing facility and is shown for the sole purpose of demonstrating the emission estimating techniques described in this chapter. As mentioned before, the correlation approach involves entering screening values into a correlation equation to generate an emission rate for each equipment piece. In Table 4.4-2, example screening values and the resulting emissions for each individual equipment piece are presented. Emissions from the pump that was not screened are estimated using the corresponding average emission factor.

TABLE 4.4-1

SAMPLE DATA FOR EXAMPLE CALCULATIONS<sup>a</sup>

Stream ID	Equipment Type/Service	Equipment Count	Hours of Operation <sup>b</sup> (hr/yr)	Stream Composition	
				Constituent	Weight Fraction
A	Pumps/light liquid	15	8,760	Ethyl acrylate	0.80
				Water	0.20
B	Pumps/light liquid	12	4,380	Ethyl acrylate	0.10
				Styrene	0.90
C	Valves/gas	40	8,760	Ethyl acrylate	0.65
				Ethane	0.25
				Water vapor	0.10

<sup>a</sup> Source: EPA, November 1995, Table A-1.

<sup>b</sup> Hours of operation include all of the time in which material is contained in the equipment.

**TABLE 4.4-2**  
**EPA CORRELATION EQUATION METHOD<sup>a</sup>**

Equipment ID <sup>b</sup>	Screening Value (ppmv)	VOC Mass Emissions <sup>c</sup> (kg/yr)
A-1	0	0.066
A-2	0	0.066
A-3	0	0.066
A-4	0	0.066
A-5	0	0.066
A-6	20	2.0
A-7	50	4.2
A-8	50	4.2
A-9	100	7.4
A-10	100	7.4
A-11	200	13
A-12	400	23
A-13	1,000	49
A-14	2,000	87
A-15	5,000	190
<b>Total Stream A Emissions:</b>		<b>390</b>
B-1	0	0.033
B-2	0	0.033
B-3	0	0.033
B-4	10	0.55
B-5	30	1.4
B-6	250	7.9
B-7	500	14
B-8	2,000	44
B-9	5,000	93
B-10	8,000	140
B-11	25,000	350
B-12 (100% VOC) <sup>d</sup>	Not screened	87
<b>Total Stream B Emissions:</b>		<b>740</b>
<b>Total Emissions</b>		<b>1,130</b>

<sup>a</sup> Source: EPA, November, 1995, Table A-4.

<sup>b</sup> Equipment type: Light liquid pumps.

Correlation equation: Leak rate (kg/hr) =  $1.90 \times 10^{-5} \times (\text{Screening Value})^{0.824}$ ; Default-zero mass emission rate:  $7.49 \times 10^{-6}$  kg/hr.

Hours of operation: Stream A = 8,760; Stream B = 4,380.

<sup>c</sup> VOC Emissions = (correlation equation or default-zero emission rate)  $\times$  (WP<sub>VOC</sub>/WP<sub>TOC</sub>)  $\times$  (hours of operation).

<sup>d</sup> VOC Emissions = (average emission factor)  $\times$  (wt. fraction of TOC)  $\times$  (WP<sub>VOC</sub>/WP<sub>TOC</sub>)  $\times$  (hours of operation).

VOC emission estimates using the EPA correlation equation approach are 1,130 kg/yr. On the other hand, VOC emission estimates using the average emission factor approach and screening value range for the same Streams A and B included in Table 4.4-1 are 3,138 and 1,480 kg/yr, respectively (see Section 5, Tables 4.5-3 and 4.5-4).

The leak rate/screening value correlations, default zero emission rates, and pegged emission rates are presented in Table 4.4-3 for SOCFI and in Table 4.4-4 for the petroleum industry. Example calculations utilizing the information presented in Tables 4.4-2 through 4.4-3 are demonstrated in Example 4.4-1.

The EPA correlation equations can be used to estimate emissions when the adjusted screening value (adjusted for the background concentration) is not a "pegged" screening value (the screening value that represents the upper detection limit of the monitoring device) or a "zero" screening value (the screening value that represents the minimum detection limit of the monitoring device). All non-zero and non-pegged screening values can be entered directly into the EPA correlation equation to predict the mass emissions (kg/hr) associated with the adjusted screening value (ppmv) measured by the monitoring device.

The correlation equations mathematically predict zero emissions for zero screening values (note that any screening value that is less than or equal to ambient [background] concentration is considered a screening value of zero). However, data collected by EPA show this prediction to be incorrect. Mass emissions have been measured from equipment having a screening value of zero. This is because the lower detection limit of the monitoring devices used is larger than zero and because of the difficulty in taking precise measurements close to zero. The default-zero emission rates are applicable only when the minimum detection limit of the portable monitoring device is 1 ppmv or less above background. In cases where a monitoring device has a minimum detection limit greater than 1 ppmv, the available default-zero emission leak rates presented in Tables 4.4-3 and 4.4-4 of this section are not applicable. For these cases, an alternative approach for determining a default-zero leak rate is to (1) determine one-half the minimum screening value of the monitoring device, and (2) enter this screening value into the applicable correlation to determine the associated default-zero leak rate.

In instances of pegged screening values, the true screening value is unknown and use of the correlation equation is not appropriate. Pegged emission rates have been developed using mass emissions data associated with known screening values of 10,000 ppmv or greater and for known screening values of 100,000 ppmv or greater. When the monitoring device is pegged at either of these levels, the appropriate pegged emission rate should be used to estimate the mass emissions of the component.



TABLE 4.4-3

**CORRELATION EQUATIONS, DEFAULT ZERO EMISSION RATES, AND PEGGED EMISSION RATES FOR  
ESTIMATING SOCM TOC EMISSION RATES<sup>a</sup>**

Equipment Type	Default Zero Emission Rate (kg/hr per source)	Pegged Emission Rates (kg/hr per source)		Correlation Equation (kg/hr per source) <sup>b</sup>
		10,000 ppmv	100,000 ppmv	
Gas valves	6.6E-07	0.024	0.11	Leak Rate = $1.87\text{E-}06 \times (\text{SV})^{0.873}$
Light liquid valves	4.9E-07	0.036	0.15	Leak Rate = $6.41\text{E-}06 \times (\text{SV})^{0.797}$
Light liquid pumps <sup>c</sup>	7.5E-06	0.14	0.62	Leak Rate = $1.90\text{E-}05 \times (\text{SV})^{0.824}$
Connectors	6.1E-07	0.044	0.22	Leak Rate = $3.05\text{E-}06 \times (\text{SV})^{0.885}$

<sup>a</sup> Source: EPA, November 1995, Tables 2-9, 2-11, and 2-13. To estimate emissions: Use the default zero emission rates only when the screening value (adjusted for background) equals 0.0 ppmv; otherwise use the correlation equations. If the monitoring device registers a pegged value, use the appropriate pegged emission rate.

<sup>b</sup> SV is the screening value (ppmv) measured by the monitoring device.

<sup>c</sup> The emission estimates for light liquid pump seals can be applied to compressor seals, pressure relief valves, agitator seals, and heavy liquid pumps.

TABLE 4.4-4

**CORRELATION EQUATIONS, DEFAULT ZERO EMISSION RATES, AND PEGGED EMISSION RATES FOR ESTIMATING PETROLEUM INDUSTRY TOC EMISSION RATES<sup>a</sup>**

Equipment Type/Service	Default Zero Emission Rate (kg/hr per source) <sup>b</sup>	Pegged Emission Rates (kg/hr per source) <sup>c</sup>		Correlation Equation (kg/hr per source) <sup>d</sup>
		10,000 ppmv	100,000 ppmv	
Connector/All	7.5E-06	0.028	0.030	Leak Rate = $1.51\text{E-}06 \times (\text{SV})^{0.735}$
Flange/All	3.1E-07	0.085	0.084	Leak Rate = $4.44\text{E-}06 \times (\text{SV})^{0.703}$
Open-Ended Line/All	2.0E-06	0.030	0.079	Leak Rate = $2.16\text{E-}06 \times (\text{SV})^{0.704}$
Pump/All	2.4E-05	0.074	0.160 <sup>e</sup>	Leak Rate = $4.82\text{E-}05 \times (\text{SV})^{0.610}$
Valve/All	7.8E-06	0.064	0.140	Leak Rate = $2.28\text{E-}06 \times (\text{SV})^{0.746}$
Other <sup>f</sup> /All	4.0E-06	0.073	0.110	Leak Rate = $1.32\text{E-}05 \times (\text{SV})^{0.589}$

<sup>a</sup> Source: EPA, November 1995, Tables 2-10, 2-12, and 2-14. Developed from the combined 1993 refinery, marketing terminal, and oil and gas production operations data. To estimate emissions: use the default zero emission rates only when the screening value (adjusted for background) equals 0.0 ppmv; otherwise use the correlation equations. If the monitoring device registers a pegged value, use the appropriate pegged emission rate.

<sup>b</sup> Default zero emission rates were based on the combined 1993 refinery and marketing terminal data only (default zero data were not collected from oil and gas production facilities).

<sup>c</sup> The 10,000 ppmv pegged emission rate was based on components screened at greater than 10,000 ppmv; however, in some cases, most of the data could have come from components screened at greater than 100,000 ppmv, thereby resulting in similar pegged emission rates for both the 10,000 and 100,000 ppmv pegged levels (e.g., connector and flanges).

<sup>d</sup> SV is the screening value (ppmv) measured by the monitoring device.

<sup>e</sup> Only two data points were available for the pump 100,000 ppmv pegged emission rate; therefore, the ratio of the pump 10,000 ppmv pegged emission rate to the overall 10,000 ppmv pegged emission rate was multiplied by the overall 100,000 ppmv pegged emission rate to approximate the pump 100,000 ppmv pegged emission rate.

<sup>f</sup> The other equipment type includes instruments, loading arms, pressure relief valves, stuffing boxes, vents, compressors, and dump lever arms.

Example 4.4-1:

- Stream A, Equipment IDs: A-1, A-2, A-3, A-4, and A-5  
 Equipment Type: Light-liquid Pumps  
 Hours of Operation: 8,760 hours  
 SV (Screening value) = 0 ppmv  
 SOCM default-zero TOC emission rate (kg/hr/source)  

$$= 7.5 \times 10^{-6} \quad \text{(from Table 4.4-3)}$$
 VOC emissions per equipment ID (kg/yr)  

$$= 7.5 \times 10^{-6} \text{ kg/hr} \times (0.80/0.80) \times 8,760 \text{ hr}$$

$$= 0.066$$
- Stream A, Equipment ID: A-6  
 Equipment Type: Light-liquid Pumps  
 Hours of Operation: 8,760 hours  
 SV (Screening value) = 20 ppmv  
 SOCM Correlation Equation:  
 TOC Leak Rate (kg/hr)  

$$= 1.90 \times 10^{-5} (\text{SV})^{0.824} \quad \text{(from Table 4.4-3)}$$

$$= 1.90 \times 10^{-5} (20)^{0.824}$$

$$= 2.24 \times 10^{-4}$$
 VOC emissions (kg/yr)  

$$= 2.24 \times 10^{-4} \text{ kg/hr} \times 8,760 \text{ hr} \times (0.80/0.80)$$

$$= 2.0$$
- Stream A, Equipment IDs: A-7 and A-8  
 Equipment Type: Light-liquid Pumps  
 SV (Screening value) = 50 ppmv  
 SOCM Correlation Equation:  
 TOC Leak Rate (kg/hr)  

$$= 1.90 \times 10^{-5} (\text{SV})^{0.824} \quad \text{(from Table 4.4-3)}$$

$$= 1.90 \times 10^{-5} (50)^{0.824}$$

$$= 4.77 \times 10^{-4}$$
 VOC emissions (kg/yr)  

$$= 4.77 \times 10^{-4} \text{ kg/hr} \times 8,760 \text{ hr} \times (0.80/0.80)$$

$$= 4.2$$

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# 5

## ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

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The alternative methods for estimating emissions from equipment leaks are the following (in no specific order of preference):

- Average emission factor approach;
- Screening ranges approach; and
- Unit-specific correlation approach.

### 5.1 EMISSION CALCULATIONS USING THE AVERAGE EMISSION FACTOR APPROACH

The average emission factor approach is commonly used to calculate emissions when site-specific screening data are unavailable.

To estimate emissions using the average emission factor approach, the TOC concentration in weight percent within the equipment is needed. The TOC concentration in the equipment is important because equipment (and VOC or HAP concentrations if speciation is to be performed) with higher TOC concentrations tend to have higher TOC leak rates. The various equipment should be grouped into "streams," such that all equipment within a stream has approximately the same TOC weight percent.

This approach for estimating emissions allows use of average emission factors developed by the EPA in combination with unit-specific data that are relatively simple to obtain. These data include: (1) the number of each type of component in a unit (valve, connector, etc.); (2) the service each component is in (gas, light liquid, or heavy liquid); (3) the TOC concentration of the stream; and (4) the time period each component was in that service.

EPA average emission factors have been developed for SOCM process units, refineries, marketing terminals, and oil and gas production operations (EPA, November 1995). The method used by the EPA to develop emission factors for individual equipment leak emission sources is described in the *Protocol for Equipment Leak Emission Estimates* (EPA, November 1995). Tables 4.5-1 and 4.5-2 show the average emission factors for SOCM process units and refineries, respectively.

**TABLE 4.5-1**  
**SOCMI AVERAGE EMISSION FACTORS<sup>a</sup>**

<b>Equipment Type</b>	<b>Service</b>	<b>Emission Factor (kg/hr per source)<sup>b</sup></b>
Valves	Gas	0.00597
	Light liquid	0.00403
	Heavy liquid	0.00023
Pump seals <sup>c</sup>	Light liquid	0.0199
	Heavy liquid	0.00862
Compressor seals	Gas	0.228
Pressure relief valves	Gas	0.104
Connectors	All	0.00183
Open-ended lines	All	0.0017
Sampling connections	All	0.0150

<sup>a</sup> Source: EPA, November 1995, Table 2-1.

<sup>b</sup> These factors are for TOC emission rates.

<sup>c</sup> The light liquid pump seal factor can be used to estimate the leak rate from agitator seals.

**TABLE 4.5-2**  
**REFINERY AVERAGE EMISSION FACTORS<sup>a</sup>**

<b>Equipment Type</b>	<b>Service</b>	<b>Emission Factor (kg/hr per source)<sup>b</sup></b>
Valves	Gas	0.0268
	Light liquid	0.0109
	Heavy liquid <sup>d</sup>	0.00023
Pump seals <sup>c</sup>	Light liquid	0.114
	Heavy liquid <sup>d</sup>	0.021
Compressor seals	Gas	0.636
Pressure relief valves	Gas	0.16
Connectors	All	0.00025
Open-ended lines	All	0.0023
Sampling connections	All	0.0150

<sup>a</sup> Source: EPA, November 1995, Table 2-2. Based on data gathered in the 1970's.

<sup>b</sup> These factors are for non-methane organic compound emission rates.

<sup>c</sup> The light liquid pump seal factor can be used to estimate the leak rate from agitator seals.

<sup>d</sup> The American Petroleum Institute is conducting a program to develop revised emission factors for components in heavy liquid service. Contact state or local agencies to determine the appropriate application of heavy liquid emission factors.

Although the average emission factors are in units of kilogram per hour per individual source, it is important to note that these factors are most valid for estimating emissions from a population of equipment. However, the average emission factor approach may present the largest potential error, among the other approaches, when applied to estimate emissions from equipment populations. The average factors are not intended to be used for estimating emissions from an individual piece of equipment over a short time period (i.e., 1 hour).

When the average emission factors are used to estimate TOC mass emissions from refineries, it is necessary to adjust the refinery emission factors because they represent only non-methane emissions. To estimate TOC emissions, methane and non-methane organic compounds must be included. Two guidelines for adjusting the refinery emission factors are as follows:

- The adjustment should be applied only to equipment containing a mixture of organic and methane, and
- The maximum adjustment for the methane weight fraction should not exceed 0.10, even if the equipment contains greater than 10 weight percent methane. (This reflects that equipment in the Refinery Assessment Study (EPA, April and July 1980) typically contained 10 weight percent or less methane).

Because the average emission factors for refineries must be adjusted when estimating TOC emissions, there is one equation (Equation 4.5-1) for using the average emission factors to estimate emissions from SOCFI marketing terminals, and oil and gas production operations and a second equation (Equation 4.5-2) for using the emission factors to estimate emissions from refinery operations.

These equations can be used to estimate TOC emission from all of the equipment of a given equipment type in a stream:

$$E_{\text{TOC}} = F_A \times \text{WF}_{\text{TOC}} \times N \quad (4.5-1)$$

$$E_{\text{TOC}} = F_A \times \frac{\text{WF}_{\text{TOC}}}{\text{WF}_{\text{TOC}} - \text{WF}_{\text{methane}}} \times \text{WF}_{\text{TOC}} \times N \quad (4.5-2)$$

where:

$E_{\text{TOC}}$  = Emission rate of TOC from all equipment in the stream of a given equipment type (kg/hr);



$F_A$	=	Applicable average emission factor <sup>1</sup> for the equipment type (kg/hr per source);
$WF_{TOC}$	=	Average weight fraction of TOC in the stream;
$WF_{methane}$	=	Average weight fraction of methane in the stream;
$WF_{TOC}$	=	Average weight fraction of TOC in the stream; and
$N$	=	Number of pieces of the applicable equipment type in the stream.

If there are several streams at a process unit, the total VOC emission rate for an equipment type is the sum of VOC emissions from each of the streams. The total emission rates for all of the equipment types are summed to generate the process unit total VOC emission rate from leaking equipment.

An example of the average emission factor approach is demonstrated for Streams A and B included in Table 4.4-1. Note that Stream A contains water, which is not a TOC. Therefore, this is accounted for when total TOC emissions are estimated from Stream A. Table 4.5-3 summarizes the average emission factor approach calculations.

**TABLE 4.5-3**  
**AVERAGE EMISSION FACTOR METHOD**

Stream ID	Equipment Count	TOC Emission Factor (kg/hr per source)	Weight Fraction of TOC	Hours of Operation (hr/yr)	VOC Emissions <sup>a</sup> (kg/yr)
A	15	0.0199	0.80	8,760	2,092
B	12	0.0199	1.00	4,380	1,046
<b>Total Emissions</b>					3,138

<sup>a</sup> VOC Emissions = (no. of components) × (emission factor) × (wt. fraction TOC) × (WP<sub>VOC</sub>/WP<sub>TOC</sub>) × (hours of operation).

<sup>1</sup> Emission factors presented in the *1995 Protocol for Equipment Leak Emission Estimates* (EPA, November 1995) are for TOC emission rates, except for refineries that are for non-methane organic compound emission rates.

## 5.2 EMISSION CALCULATIONS USING THE SCREENING RANGES APPROACH

The screening ranges approach requires screening data to be collected for the equipment in the process unit. This approach is applied in a similar manner as the average emission factor approach in that equipment counts are multiplied by the applicable emission factor. However, because the screening value on which emissions are based is a measurement of only organic compound leakage, no adjustment is made for inorganic compounds.

This approach may be applied when screening data are available as either "greater than or equal to 10,000 ppmv" or as "less than 10,000 ppmv." As with the average factors, the SOCMI, marketing terminal, and oil and gas production operations screening range factors predict TOC emissions, whereas the refinery screening range factors predict non-methane organic compound emissions. Thus, when using the average refinery screening range factors to estimate TOC emissions from refineries, an adjustment must be made to the factors to include methane emissions. The maximum adjustment for the methane weight factors should not exceed 0.10, even if the equipment contains greater than 10 weight percent methane.

Because the average screening range factors for refineries must be adjusted when estimating TOC emissions, there is one equation (Equation 4.5-3) for using the average screening range factors to estimate emissions from SOCMI, marketing terminals, and oil and gas production operations and a second equation (Equation 4.5-4) for using the screening range factors to estimate emissions from refinery operations. These equations are described below:

$$E_{\text{TOC}} = (F_G \times N_G) + (F_L \times N_L) \quad (4.5-3)$$

$$E_{\text{TOC}} = \frac{WF_{\text{TOC}}}{WF_{\text{TOC}} - WF_{\text{methane}}} [(F_G \times N_G) + (f_L \times N_L)] \quad (4.5-4)$$

where:

$E_{\text{TOC}}$	=	TOC emission rate for an equipment type (kg/hr);
$F_G$	=	Applicable emission factor <sup>1</sup> for sources with screening values greater than or equal to 10,000 ppmv (kg/hr per source);

<sup>1</sup> Emission factors presented in the *1995 Protocol for Equipment Leak Emission Estimates* (EPA, November 1995) are for TOC emission rates, except for refineries that are for non-methane organic compound emission rates.

$WP_{TOC}$	=	Average weight percent of TOC in the stream;
$WP_{methane}$	=	Average weight percent of methane in the stream;
$N_G$	=	Equipment count (specific equipment type) for sources with screening values greater than or equal to 10,000 ppmv;
$F_L$	=	Applicable emission factor for sources with screening values less than 10,000 ppmv (kg/hr per source); and
$N_L$	=	Equipment count (specific equipment type) for sources with screening values less than 10,000 ppmv.

Assuming all of the organic compounds in the stream are classified as VOCs, the total VOC emission for each stream is calculated as the sum of TOC emissions associated with each specific equipment type in the stream.

The screening range emission factors are a better indication of the actual leak rate from individual equipment than the average emission factors. Nevertheless, available data indicate that measured mass emission rates can vary considerably from the rates predicted by use of these factors.

An example of the screening value ranges approach is demonstrated in Table 4.5-4 using the example of a hypothetical chemical processing facility presented in Section 4 for Streams A and B (Table 4.4-1). The calculations are similar to those used for the average emission factor approach, except that a TOC emission factor for each screening value range is used. Emissions from equipment that could not be screened are calculated using average emission factors. VOC emissions using the screening value range approach are 1,480 kg/yr. In comparison, VOC emissions using the average emission factor approach for the same Streams A and B are 3,138 kg/yr, as shown in Table 4.5-3.

### 5.3 EMISSION CALCULATIONS USING UNIT-SPECIFIC CORRELATION APPROACH

Correlation equations may be developed for specific units rather than using correlation equations developed by the EPA. Once the correlations are developed, they are applied in the same way as described for the EPA correlations.

Before developing unit-specific correlations it is recommended that the validity of the EPA correlations to a particular process unit be evaluated because of the high cost of bagging. This can be done measuring as few as four leak rates of a particular equipment type in a particular service. The measured emission rate can be compared with the predicted rates obtained using the EPA correlations. If there is a consistent trend (i.e., all measured values are less than values predicted by the EPA correlation equation or all measured values are larger) the EPA correlation equation may not provide reasonable emission estimates for the

**TABLE 4.5-4**  
**SCREENING VALUE RANGES METHOD<sup>a</sup>**

Stream ID	Equipment Count <sup>b</sup>	Emission Factor (kg/hr per source)	Hours of Operation (hr/yr)	VOC Emissions (kg/yr)
Components screening $\geq 10,000$ ppmv <sup>c</sup>				
B	1	0.243	4,380	1,060
Components screening $< 10,000$ ppmv <sup>c</sup>				
A	15	0.00187	8,760	246
B	10	0.00187	4,380	82
Components not screened <sup>d</sup>				
B (TOC wt. fraction equal to 1.0)	1	0.0199	4,380	87
Total emissions				1,480

<sup>a</sup> Source: EPA, November, 1995, Table A-3.

<sup>b</sup> It was assumed that none of the light liquid pumps in Stream A have a screening value greater than or equal to 10,000 ppmv, one of the light liquid pumps in Stream B screens greater than 10,000 ppmv, and one of the pumps in Stream B could not be screened.

<sup>c</sup> VOC emissions = (no. of components)  $\times$  (TOC emission factor)  $\times$  (WP<sub>VOC</sub>/WP<sub>TOC</sub>)  $\times$  (hours of operation).

<sup>d</sup> VOC emissions = (no. of components)  $\times$  (average TOC emission factor)  $\times$  (WP<sub>VOC</sub>)  $\times$  (hours of operation).

process unit. There is a more formal comparison, the Wilcoxon signed-rank test, which can be performed by comparing the logarithm of the measured mass emission rates to the logarithm of the corresponding rates predicted by the EPA correlation.

In developing new unit-specific correlations, a minimum number of leak rate measurements and screening value pairs must be obtained. The *Protocol for Equipment Leak Emission Estimates* (EPA, November 1995) provides detailed information on the methodology to be followed. In general, the following consideration should be observed:

- Process unit equipment should be screened to know the distribution of screening values at the unit;
- Mass emission data must be collected from individual sources with screening values distributed over the entire range; and
- A random sample of a minimum of six components from each of the following screening value ranges (in ppmv) should be selected for bagging: 1-100; 101-1,000; 1,001-10,000; 10,001-100,000; and >100,000. Therefore, a minimum of 30 emissions rate/screening value pairs should be obtained to estimate emissions across the entire range of screening values.

The *Protocol* document (EPA, November 1995) provides some alternatives to developing a correlation equation with fewer than 30 bags. These alternatives are based on experience in measuring leak rates and developing leak rate/screening value correlations. However, other source selection strategies can be used if an appropriate rationale is given.

Methodologies for generating leak rate/screening value correlations with mass emissions data and screening values are presented in Appendix B of the *1995 Protocol* document. Once correlations are developed using the methodologies outlined in Appendix B, they are applied in the same manner as described in the example for the EPA correlations.

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# 6

## QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

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The consistent use of standardized methods and procedures is essential in the compilation of reliable emission inventories. Quality assurance (QA) and quality control (QC) of an inventory are accomplished through a set of procedures that ensure the quality and reliability of data collection and analysis. These procedures include the use of appropriate emission estimation techniques, applicable and reasonable assumptions, accuracy/logic checks of computer models, checks of calculations, and data reliability checks. Chapter 4 of Volume VI (the *QA Source Document*) of this series describes some QA/QC methods for performing these procedures.

Volume II, Chapter 1, *Introduction to Stationary Point Source Emission Inventory Development*, presents recommended standard procedures to follow that ensure the reported inventory data are complete and accurate. Chapter 1, should be consulted for current EIIP guidance for QA/QC checks for general procedures, recommended components of a QA plan, and recommended components for point source inventories. The QA plan discussion includes recommendations for data collection, analysis, handling, and reporting. The recommended QC procedures include checks for completeness, consistency, accuracy, and the use of approved standardized methods for emission calculations, where applicable.

### 6.1 SCREENING AND BAGGING DATA COLLECTION

To ensure that data quality is maintained while screening and data collection take place, it is recommended that data be recorded on prepared data sheets. Figures 4.6-1 provides an example data sheet that may be used to log measurements taken during a screening program.

To ensure highest quality of the data collected during the bagging program, QA/QC procedures must be followed. Quality assurance requirements include accuracy checks of the instrumentation used to perform mass emission sampling. Quality control requirements include procedures to be followed when performing equipment leak mass emissions sampling.

Figures 4.6-2 and 4.6-3 present examples of data collection forms to be used when collecting data in the field. Accuracy checks on the instrumentation and monitoring devices used to perform mass emission sampling include a leak rate check performed in the laboratory, blind standards to be analyzed by the laboratory instrumentation, and drift checks on the portable monitoring device.

## CHAPTER 4 - EQUIPMENT LEAKS

Date: \_\_\_\_\_

11/29/96

**FIGURE 4.6-1. EXAMPLE FIELD SHEET FOR EQUIPMENT SCREENING DATA**



### EXAMPLE DATA COLLECTION FORM FOR FUGITIVE EMISSIONS BAGGING TEST (VACUUM METHOD)

Equipment Type _____ Equipment Category _____ Line Size _____ Stream Phase (G/V, LL, HL) _____ Barometric Pressure _____ Ambient Temperature _____ Stream Temperature _____ Stream Composition (Wt. %) _____ _____ _____	Component ID _____ Plant ID _____ Date _____ Analysis Team _____ _____ Instrument ID _____ Stream Pressure _____ _____ _____
---	--

<u>Time</u>	<u>Bagging Test Measurement Data</u>
_____	Initial Screening (ppmv) Equipment Piece <sup>a</sup> _____ Bkgd. _____
_____	Background Bag Organic Compound Conc. (ppmv) <sup>b</sup> _____
_____	Sample Bag 1 Organic Compound Conc. (ppmv) _____
_____	Dry Gas Meter Reading (L/min) _____
_____	Vacuum Check in Bag (Y/N) (Must be YES to collect sample.) _____
_____	Dry Gas Meter Temperature <sup>c</sup> (°C) _____
_____	Dry Gas Meter Pressure <sup>c</sup> (mmHg) _____
_____	Sample Bag 2 Organic Compound Conc. (ppmv) _____
_____	Dry Gas Meter Reading (L/min) _____
_____	Vacuum Check in Bag (Y/N) (Must be YES to collect sample.) _____
_____	Dry Gas Meter Temperature <sup>c</sup> (°C) _____
_____	Dry Gas Meter Pressure <sup>c</sup> (mmHg) _____
Condensate Accumulation: Starting Time _____ Final Time _____	
Organic Condensate Collected (mL) _____	
Density of Organic Condensate (g/mL) _____	
_____	Final Screening (ppmv) Equip. Piece <sup>a</sup> _____ Bkgd. _____

<sup>a</sup> The vacuum method is not recommended if the screening value is approximately 10 ppmv or less.

<sup>b</sup> Collection of a background bag is optional.

<sup>c</sup> Pressure and temperature are measured at the dry gas meter.

**FIGURE 4.6-2. EXAMPLE DATA COLLECTION FORM FOR FUGITIVE EMISSIONS  
BAGGING TEST (VACUUM METHOD)**

### EXAMPLE DATA COLLECTION FORM FOR FUGITIVE EMISSIONS BAGGING TEST (BLOW-THROUGH METHOD)

Equipment Type _____ Equipment Category _____ Line Size _____ Stream Phase (G/V, LL, HL) _____ Barometric Pressure _____ Ambient Temperature _____ Stream Temperature _____ Stream Composition (Wt. %) _____ _____ _____	Component ID _____ Plant ID _____ Date _____ Analysis Team _____ _____ Instrument ID _____ Stream Pressure _____ _____ _____
---	--

<u>Time</u>	<u>Bagging Test Measurement Data</u>
_____	Initial Screening (ppmv) Equipment Piece ____ Bkgd. _____
_____	Background Bag Organic Compound Conc. (ppmv) <sup>a</sup> _____
_____	Sample Bag 1 Organic Compound Conc. (ppmv) _____
_____	Dilution Gas Flow Rate (L/min) _____
_____	O <sub>2</sub> Concentration (volume %) _____
_____	Bag Temperature (°C) _____
_____	Sample Bag 2 Organic Compound Conc. (ppmv) _____
_____	Dilution Gas Flow Rate (L/min) _____
_____	O <sub>2</sub> Concentration (volume %) _____
_____	Bag Temperature (°C) _____
Condensate Accumulation: Starting Time ____ Final Time _____	
Organic Condensate Collected (mL) _____	
Density of Organic Condensate (g/mL) _____	
_____	Final Screening (ppmv) Equipment Piece ____ Bkgd. _____

<sup>a</sup> Collection of a background bag is optional. However, it is recommended in cases where the screening value is less than 10 ppmv and there is a detectable oxygen level in the bag.

**FIGURE 4.6-3. EXAMPLE DATA COLLECTION FORM FOR FUGITIVE EMISSIONS  
BAGGING TEST (BLOW-THROUGH METHOD)**

## 6.2 OTHER QA/QC ISSUES

At a minimum, the approach and data used to estimate emissions should be peer reviewed to assure correctness. In addition, some sample calculations should be performed to verify that calculations were done correctly.

If any of the methods that require screening or bagging data were used, the sample design should be reviewed to assure that all relevant equipment types were sampled. Furthermore, the adequacy of sample sizes should be verified.

## 6.3 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

One measure of emission inventory data quality is the DARS score. Three examples are given here to illustrate DARS scoring using the preferred and alternative methods. The DARS provides a numerical ranking on a scale of 1 to 10 for individual attributes of the emission factor and the activity data. Each score is based on what is known about the factor and activity data, such as the specificity to the source category and the measurement technique employed. The composite attribute score for the emissions estimate can be viewed as a statement of the confidence that can be placed in the data. For a complete discussion of DARS and other rating systems, see the *QA Source Document* (Volume VI, Chapter 4), and Volume II, Chapter 1, *Introduction to Stationary Point Sources Emission Inventory Development*.

For each example, assume emissions are being estimated for a petroleum marketing terminal. Table 4.6-1 gives a set of scores for the preferred method, the EPA correlation approach. Note that a perfect score (1.0) is not possible with any of the methods described in this chapter because all are based on the use of surrogates rather than direct measurement of emissions. The spatial congruity attribute is not particularly relevant for this category, and thus is given a score of 1.0. Both measurement and specificity scores are relatively high (0.8) because the correlation equation is based on a representative sample from the specific category. The measurement attribute score assumes that the pollutants of interest were measured directly. The temporal attribute scores are 0.7 because the data (for the correlation equation and for the screening values) are presumed to be one time samples, but the throughputs are assumed not to vary much over time.

Tables 4.6-2 and 4.6-3 give DARS scores for the average emission factor approach and the unit-specific correlation approach respectively. Not surprisingly, the first approach gets lower DARS scores, while the second gets higher scores.

**TABLE 4.6-1****DARS SCORES: EPA CORRELATION APPROACH**

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.8	0.8	0.64
Specificity	0.8	1.0	0.80
Spatial	1.0	1.0	1.0
Temporal	0.7 <sup>a</sup>	0.7 <sup>a</sup>	0.49
Composite Scores	0.83	0.88	0.73

<sup>a</sup> Assumes a one-time sampling of equipment and little variation in throughput.

**TABLE 4.6-2****DARS SCORES: AVERAGE EMISSION FACTOR APPROACH**

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.6	0.5	0.3
Specificity	0.5	1.0	0.5
Spatial	1.0	1.0	1.0
Temporal	0.7	0.7	0.49
Composite Scores	0.7	0.8	0.57

**TABLE 4.6-3****DARS SCORES: UNIT-SPECIFIC CORRELATION APPROACH**

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.9	0.9	0.81
Specificity	1.0	1.0	1.0
Spatial	1.0	1.0	1.0
Temporal	0.7	0.7	0.49
Composite Scores	0.90	0.90	0.83

These examples are given as an illustration of the relative quality of each method. If the same analysis were done for an actual real site, the scores could be different but the relative ranking of methods should stay the same. Note, however, that if the source is not truly a member of the population used to develop the EPA correlation equations or the emission factors, these approaches are less appropriate and the DARS scores will probably drop.

If sufficient data are available, the uncertainty in the estimate should be evaluated. Qualitative and quantitative methods for conducting uncertainty analyses are described in the *QA Source Document* (Volume VI, Chapter 4).

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# 7

## DATA CODING PROCEDURES

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This section describes the methods and codes available for characterizing fugitive emissions from equipment leaks using Source Classification Codes (SCCs) and Aerometric Information Retrieval System (AIRS) control device codes. Consistent categorization and coding will result in greater uniformity among inventories. The SCCs are the building blocks on which point source emissions data are structured. Each SCC represents a unique process or function within a source category that is logically associated with an emission point. Without an appropriate SCC, a process cannot be accurately identified for retrieval purposes. In addition, the procedures described here will assist the reader preparing data for input into a database management system. For example, the SCCs provided in Table 4.7-1 are typical of the valid codes recommended for describing equipment leaks. This table does not include all fugitive source SCCs, but does include those commonly used to identify equipment leaks. Refer to CHIEF for a complete listing of SCCs.

While the codes presented here are currently in use, they may change based on further refinement by the emission inventory community. As part of the EIIP, a common data exchange format is being developed to facilitate data transfer between industry, states, and EPA.

For equipment leaks, be careful to use only one SCC for each process or source category. Many of these are designated for the entire process unit on an annual basis. In some cases, the user may need to calculate emissions for multiple pieces of equipment and then sum up to the unit total. The process-specific codes should be used as often as possible.

TABLE 4.7-1

**SOURCE CLASSIFICATION CODES AND DESCRIPTIONS FOR FUGITIVE EMISSIONS  
FROM EQUIPMENT LEAKS**

Source Description	Process Description	SCC	Units
Industrial Processes			
Chemical Manufacturing	Adipic Acid - Fugitive Emissions: General	3-01-001-80	Process Unit-Year
	Carbon Black Production; Furnace Process: Fugitive Emissions	3-01-005-09	Tons Produced
	Chlorine: Carbon Reactivation/Fugitives	3-01-007-05	Tons Produced
	Sulfuric Acid (Contact Process): Process Equipment Leaks	3-01-023-22	Tons 100% H <sub>2</sub> SO <sub>4</sub>
	Terephthalic Acid/ Dimethyl Terephthalate: Fugitive Emissions	3-01-031-80	Process Unit-Year
	Aniline/Ethanolamines: Fugitive Emissions	3-01-034-06	Process Unit-Year
	Aniline/Ethanolamines: Fugitive Emissions	3-01-034-14	Process Unit-Year
	Pharmaceutical Preparations: Miscellaneous Fugitives	3-01-060-22	Tons Processed
	Pharmaceutical Preparations: Miscellaneous Fugitives	3-01-060-23	Tons Processed
	Inorganic Chemical Manufacturing (General): Fugitive Leaks	3-01-070-01	Tons Product
	Acetone/Ketone Production: Fugitive Emissions (Acetone)	3-01-091-80	Process Unit-Year
	Maleic Anhydride: Fugitive Emissions	3-01-100-80	Process Unit-Year
	Fugitive Emissions (Formaldehyde)	3-01-120-07	Process Unit-Year



TABLE 4.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
Industrial Processes			
Chemical Manufacturing	Fugitive Emissions (Acetaldehyde)	3-01-120-17	Process Unit-Year
	Fugitive Emissions (Acrolein)	3-01-120-37	Process Unit-Year
	Chloroprene: Fugitive Emissions	3-01-124-80	Process Unit-Year
	Chlorine Derivatives: Fugitive Emissions (Ethylene Dichloride)	3-01-125-09	Process Unit-Year
	Chlorine Derivatives: Fugitive Emissions (Chloromethanes)	3-01-125-14	Process Unit-Year
	Chlorine Derivatives: Fugitive Emissions (Perchloroethylene)	3-01-125-24	Process Unit-Year
	Chlorine Derivatives: Fugitive Emissions (Trichloroethane)	3-01-125-29	Process Unit-Year
	Chlorine Derivatives: Fugitive Emissions (Trichloroethylene)	3-01-125-34	Process Unit-Year
	Chlorine Derivatives: Fugitive Emissions (Vinyl Chloride)	3-01-125-50	Process Unit-Year
	Chlorine Derivatives: Fugitive Emissions (Vinylidene Chloride)	3-01-125-55	Process Unit-Year
	Fluorocarbons/Chlorofluorocarbons: Fugitive Emissions	3-01-127-80	Process Unit-Year
	Organic Acid Manufacturing: Fugitive Emissions	3-01-132-27	Process Unit-Year

TABLE 4.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
Industrial Processes			
Chemical Manufacturing	Acetic Anhydride: Fugitive Emissions	3-01-133-80	Process Unit-Year
	Butadiene: Fugitive Emissions	3-01-153-80	Process Unit-Year
	Cumene: Fugitive Emissions	3-01-156-80	Process Unit-Year
	Cyclohexane: Fugitive Emissions	3-01-157-80	Process Unit-Year
	Cyclohexanone/ Cyclohexanol: Fugitive Emissions	3-01-158-80	Process Unit-Year
	Vinyl Acetate: Fugitive Emissions	3-01-167-80	Process Unit-Year
	Ethyl Benzene: Fugitive Emissions	3-01-169-80	Process Unit-Year
	Ethylene Oxide: Fugitive Emissions	3-01-174-80	Process Unit-Year
	Glycerin (Glycerol): Fugitive Emissions	3-01-176-80	Process Unit-Year
	Toluene Diisocyanate: Fugitive Emissions	3-01-181-80	Process Unit-Year
	Methyl Methacrylate: Fugitive Emissions	3-01-190-80	Process Unit-Year
	Nitrobenzene: Fugitive Emissions	3-01-195-80	Process Unit-Year
	Olefin Prod.: Fugitive Emissions (Propylene)	3-01-197-09	Process Unit-Year
	Olefin Prod.: Fugitive Emissions (Ethylene)	3-01-197-49	Process Unit-Year
	Phenol: Fugitive Emissions	3-01-202-80	Process Unit-Year
	Propylene Oxide: Fugitive Emissions	3-01-205-80	Process Unit-Year
	Styrene: Fugitive Emissions	3-01-206-80	Process Unit-Year

TABLE 4.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
Industrial Processes			
Chemical Manufacturing	Caprolactam: Fugitive Emissions	3-01-210-80	Process Unit-Year
	Linear Alkylbenzene: Fugitive Emissions	3-01-211-80	Process Unit-Year
	Methanol/Alcohol Production: Fugitive Emissions (Methanol)	3-01-250-04	Process Unit-Year
	Ethylene Glycol: Fugitive Emissions	3-01-251-80	Process Unit-Year
	Glycol Ethers: Fugitive Emissions	3-01-253-80	Process Unit-Year
	Nitriles, Acrylonitrile, Adiponitrile Prod.: Fugitive Emissions	3-01-254-09	Process Unit-Year
	Nitriles, Acrylonitrile, Adiponitrile Prod.: Fugitive Emissions	3-01-254-20	Process Unit-Year
	Benzene/Toluene/Aromatics/Xylenes: Fugitive Emissions (Aromatics)	3-01-258-80	Process Unit-Year
	Chlorobenzene: Fugitive Emissions	3-01-301-80	Process Unit-Year
	Carbon Tetrachloride: Fugitive Emissions	3-01-302-80	Tons Product
	Allyl Chloride: Fugitive Emissions	3-01-303-80	Process Unit-Year
	Allyl Alcohol: Fugitive Emissions	3-01-304-80	Process Unit-Year
	Epichlorohydrin: Fugitive Emissions	3-01-305-80	Process Unit-Year
	General Processes: Fugitive Leaks	3-01-800-01	Process Unit-Year

TABLE 4.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
Industrial Processes			
Chemical Manufacturing	Fugitive Emissions: Specify In Comments Field	3-01-888-02	Tons Product
	Fugitive Emissions: Specify In Comments Field	3-01-888-01	Tons Product
	Fugitive Emissions: Specify In Comments Field	3-01-888-03	Tons Product
	Fugitive Emissions: Specify In Comments Field	3-01-888-04	Tons Product
	Fugitive Emissions: Specify In Comments Field	3-01-888-05	Process Unit-Year
Primary Metal Production	By-Product Coke Manufacturing-Equipment Leaks	3-03-003-61	Process Unit-Year
	Primary Metal Production - Equipment Leaks	3-03-800-01	Facility-Annual
Secondary Metal Production	Secondary Metal Production-Equipment Leaks	3-04-800-01	Facility-Annual
Petroleum Industry	Pipeline Valves And Flanges	3-06-008-01	1000 Barrels Refined
	Vessel Relief Valves	3-06-008-02	1000 Barrels Refined
	Pump Seals Without Controls	3-06-008-03	1000 Barrels Refined
	Compressor Seals	3-06-008-04	1000 Barrels Refined
	Misc: Sampling/Non-Asphalt Blowing/Purging/Etc.	3-06-008-05	1000 Barrels Refined
	Pump Seals With Controls	3-06-008-06	1000 Barrels Refined

TABLE 4.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
Industrial Processes			
Petroleum Industry	Blind Changing	3-06-008-07	1000 Barrels Refined
	Pipeline Valves: Gas Streams	3-06-008-11	Valves In Operation
	Pipeline Valves: Light Liquid/Gas Stream	3-06-008-12	Valves In Operation
	Pipeline Valves: Heavy Liquid Stream	3-06-008-13	Valves In Operation
	Pipeline Valves: Hydrogen Streams	3-06-008-14	Valves In Operation
	Open-Ended Valves: All Streams	3-06-008-15	Valves In Operation
	Flanges: All Streams	3-06-008-16	Flanges In Operation
	Pump Seals: Light Liquid/Gas Streams	3-06-008-17	Seals In Operation
	Pump Seals: Heavy Liquid Streams	3-06-008-18	Seals In Operation
	Compressor Seals: Gas Streams	3-06-008-19	Seals In Operation
	Compressor Seals: Heavy Liquid Streams	3-06-008-20	Seals In Operation
	Drains: All Streams	3-06-008-21	Drains In Operation
	Vessel Relief Valves: All Streams	3-06-008-22	Valves In Operation
	Fugitive Emissions - Specify In Comments Field	3-06-888-01	1000 Barrels Refined
	Fugitive Emissions - Specify In Comments Field	3-06-888-02	1000 Barrels Refined
	Fugitive Emissions - Specify In Comments Field	3-06-888-03	1000 Barrels Refined

TABLE 4.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
Industrial Processes			
Petroleum Industry	Fugitive Emissions - Specify In Comments Field	3-06-888-04	1000 Barrels Refined
	Fugitive Emissions - Specify In Comments Field	3-06-888-05	1000 Barrels Refined
Rubber And Miscellaneous Plastics Products	Rubber And Miscellaneous Plastic Parts - Equipment Leaks	3-08-800-01	Facility-Annual
Oil And Gas Production	Crude Oil Production - Complete Well	3-10-001-01	Wells/Year In Operation
	Crude Oil Production - Oil Well Cellars	3-10-001-08	Sq Ft Of Surface Area
	Crude Oil Production - Compressor Seals	3-10-001-30	Number Of Seals
	Crude Oil Production - Drains	3-10-001-31	Number Of Drains
	Natural Gas Production - Valves	3-10-002-07	Million Cubic Feet
	Natural Gas Production - Drains	3-10-002-31	Number Of Drains
	Fugitive Emissions - Specify In Comments Field	3-10-888-01	Process-Unit/Year
	Fugitive Emissions - Specify In Comments Field	3-10-888-02	Process-Unit/Year
	Fugitive Emissions - Specify In Comments Field	3-10-888-03	Process-Unit/Year
	Fugitive Emissions - Specify In Comments Field	3-10-888-04	Process-Unit/Year
	Fugitive Emissions - Specify In Comments Field	3-10-888-05	100 Barrel Feed Prod.
	Fugitive Emissions - Specify In Comments Field	3-10-888-11	Million Cubic Feet

TABLE 4.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
Industrial Processes			
Transportation Equipment	Transportation Equipment - Equipment Leaks	3-14-800-01	Facility-Annual
Petroleum & Solvent Evaporation			
Organic Solvent Evaporation	Dry Cleaning - Misc. Trichloroethylene Fugitives	4-01-001-63	Tons Clothes Cleaned
	Fugitive Emissions - Specify In Comments Field	4-01-888-01	Tons Product
	Fugitive Emissions - Specify In Comments Field	4-01-888-02	Tons Product
	Fugitive Emissions - Specify In Comments Field	4-01-888-03	Tons Product
	Fugitive Emissions - Specify In Comments Field	4-01-888-04	Tons Product
	Fugitive Emissions - Specify In Comments Field	4-01-888-05	Tons Product
	Fugitive Emissions - Specify In Comments Field	4-01-888-98	Gallons
Surface Coating Operations	Surface Coating Operations - Equipment Leaks	4-02-800-01	Facility-Annual
Organic Chemical Transportation	Organic Chemical Transportation - Equipment Leaks	4-08-800-01	Facility-Annual
Organic Solvent Evaporation	Waste Solvent Recovery Operations - Fugitive Leaks	4-90-002-06	Process-Unit/Year
Waste Disposal			
Solid Waste Disposal - Government	Solid Waste Disposal: Govt. - Equipment Leaks	5-01-800-01	Facility-Annual
Solid Waste Disposal - Commercial/ Institutional	Solid Waste Disposal: Comm./Inst. - Equipment Leaks	5-02-800-01	Facility-Annual
Solid Waste Disposal - Industrial	Solid Waste Disposal: Indus. - Equipment Leaks	5-03-800-01	Facility-Annual

TABLE 4.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
Waste Disposal			
Site Remediation	Site Remediation - Equipment Leaks	5-04-800-01	Facility-Annual
MACT Source Categories			
Styrene Or Methacrylate-based Resins	Styrene Or Methacrylate-based Resins - Equipment Leaks	6-41-800-01	Facility-Annual
Cellulose-based Resins	Cellulose-based Resins - Equipment Leaks	6-44-800-01	Facility-Annual
Miscellaneous Resins	Miscellaneous Resins - Equipment Leaks	6-45-800-01	Facility-Annual
Vinyl-based Resins	Vinyl-based Resins - Equipment Leaks	6-46-800-01	Facility-Annual
Miscellaneous Polymers	Miscellaneous Polymers - Equipment Leaks	6-48-800-01	Facility-Annual
MACT Miscellaneous Processes (Chemicals)	MACT Misc. Processes (Chemicals) - Equipment Leaks	6-84-800-01	Facility-Annual
MACT Miscellaneous Processes (Chemicals)	MACT Misc. Processes (Chemicals) - Equipment Leaks	6-85-800-01	Facility-Annual



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# **APPENDIX A**

## **ESTIMATING LEAK DETECTION AND REPAIR (LDAR) CONTROL EFFECTIVENESS**

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## ESTIMATING LDAR CONTROL EFFECTIVENESS

Some process units/facilities may want to develop control efficiencies specific to their process/facility if they have different leak definitions than what is in the federal programs. The LDAR monitoring frequency and leak definitions at some state equipment leak control programs may also be significantly different from federal programs. Table 4.A-1 presents a summary of controls required by federal requirement leak control programs.

The control efficiency of monitoring equipment at various leak definitions and monitoring frequencies may be estimated from the leak frequency before and after an LDAR program is implemented. Tables 4.A-2, and 4.A-3 present equations relating average leak rate to fraction leaking at SOCFI facilities and petroleum refineries. Once the initial and final leak frequencies are determined, they can be entered into the applicable equation to calculate the corresponding average leak rates at these leak frequencies. The control effectiveness for an LDAR program can be calculated from the initial leak rate and the final leak rate.

$$\text{Eff} = (\text{ILR} - \text{FLR})/\text{ILR} \times 100 \quad (4.A-1)$$

where:

Eff = Control effectiveness (percent)  
ILR = Initial leak rate (kg/hr per source)  
FLR = Final leak rate (kg/hr per source)

The methodology for estimating leak frequencies is discussed in detail in Chapter 5 of the *Equipment Leaks Enabling Document* (EPA, July 1992). The methodology requires knowledge of screening data and equipment repair times.

## REFERENCE

EPA. July 1992. *Equipment Leaks Enabling Document*. Final Report. Internal Instruction Manual for ESD Regulation Development. U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

TABLE 4.A-1

## CONTROLS REQUIRED BY EQUIPMENT LEAK CONTROL PROGRAMS

Equipment Type	Service	Petroleum Refinery CTG <sup>a</sup>	SOCMI CTG	Petroleum Refinery NSPS <sup>b</sup>	HON
Valves	Gas	Quarterly LDAR at 10,000 ppm	Quarterly LDAR at 10,000 ppm	Monthly LDAR at 10,000 ppm; decreasing frequency with good performance	Monthly LDAR with >2% leakers; quarterly LDAR with <2% leakers; decreasing frequency with good performance. Initially at 10,000 ppm, annually at 500 ppm
	Light liquid	Annual LDAR at 10,000 ppm	Quarterly LDAR at 10,000 ppm	Monthly LDAR at 10,000 ppm; decreasing frequency with good performance	Monthly LDAR with >2% leakers; quarterly LDAR with <2% leakers; decreasing frequency with good performance. Initially at 10,000 ppm, annually at 500 ppm
Pumps	Light liquid	Annual LDAR at 10,000 ppm; weekly visual inspection	Quarterly LDAR at 10,000 ppm; weekly visual inspection	Monthly LDAR at 10,000 ppm; weekly visual inspection; or dual mechanical seals with controlled degassing vents	Monthly LDAR; weekly visual inspection. Leak definition decreases from 10,000 ppm; or dual mechanical seals or closed-vent system
Compressors	Gas	Quarterly LDAR at 10,000 ppm	Quarterly LDAR at 10,000 ppm	Daily visual inspection; dual mechanical seal with barrier fluid and closed-vent system or maintained at a higher pressure than the compressed gas	Daily visual inspection. Dual mechanical seal with barrier fluid and closed-vent system or maintained at a higher pressure than the compressed gas
Connectors	Gas and light liquid	None	None	None	Annual LDAR at 500 ppm with >0.5% leakers; decreasing frequency with good performance

TABLE 4.A-1

(CONTINUED)

Equipment Type	Service	Petroleum Refinery CTG <sup>a</sup>	SOCMI CTG	Petroleum Refinery NSPS <sup>b</sup>	HON
Pressure relief devices	Gas	Quarterly LDAR at 10,000 ppm	Quarterly LDAR at 10,000 ppm	No detectable emissions	No detectable emissions or closed-vent system
Sampling connections	All	None	None	Closed-loop or in situ sampling	Closed-loop, closed-purge, closed vent or in situ sampling
Open-ended lines	All	Cap, blind flange, plug, or second valve	Cap, blind flange, plug, or second valve	Cap, blind flange, plug, or second valve	Cap, blind flange, plug, or second valve

<sup>a</sup> CTG = Control Techniques Guidelines.<sup>b</sup> NSPS = New Source Performance Standard.

**TABLE 4.A-2**  
**EQUATIONS RELATING AVERAGE LEAK RATE TO FRACTION**  
**LEAKING AT SOCMI UNITS**

Equipment Type	Leak Definition (ppmv)	Equations <sup>a,b</sup>
Gas valve	500	$ALR = (0.04372) \times (Lk \text{ Frac.}) + 0.000017$
	1000	$ALR = (0.04982) \times (Lk \text{ Frac.}) + 0.000028$
	2000	$ALR = (0.05662) \times (Lk \text{ Frac.}) + 0.000043$
	5000	$ALR = (0.06793) \times (Lk \text{ Frac.}) + 0.000081$
	10000	$ALR = (0.07810) \times (Lk \text{ Frac.}) + 0.000131$
Light liquid valve	500	$ALR = (0.04721) \times (Lk \text{ Frac.}) + 0.000027$
	1000	$ALR = (0.05325) \times (Lk \text{ Frac.}) + 0.000039$
	2000	$ALR = (0.06125) \times (Lk \text{ Frac.}) + 0.000059$
	5000	$ALR = (0.07707) \times (Lk \text{ Frac.}) + 0.000111$
	10000	$ALR = (0.08901) \times (Lk \text{ Frac.}) + 0.000165$
Light liquid pump	500	$ALR = (0.09498) \times (Lk \text{ Frac.}) + 0.000306$
	1000	$ALR = (0.11321) \times (Lk \text{ Frac.}) + 0.000458$
	2000	$ALR = (0.13371) \times (Lk \text{ Frac.}) + 0.000666$
	5000	$ALR = (0.19745) \times (Lk \text{ Frac.}) + 0.001403$
	10000	$ALR = (0.24132) \times (Lk \text{ Frac.}) + 0.001868$
Connector	500	$ALR = (0.04684) \times (Lk \text{ Frac.}) + 0.000017$
	2000	$ALR = (0.07307) \times (Lk \text{ Frac.}) + 0.000035$
	5000	$ALR = (0.09179) \times (Lk \text{ Frac.}) + 0.000054$
	10000	$ALR = (0.11260) \times (Lk \text{ Frac.}) + 0.000081$

<sup>a</sup> ALR = Average TOC leak rate (kg/hr per source).

<sup>b</sup> Lk Frac. = Fraction leaking.



**TABLE 4.A-3**  
**EQUATIONS RELATING AVERAGE LEAK RATE TO FRACTION LEAKING**  
**AT REFINERY PROCESS UNITS**

Equipment Type	Leak Definition (ppmv)	Equation <sup>a,b</sup>
Gas valve	500	$ALR = (0.11140) \times (Lk \text{ Frac.}) + 0.000088$
	1000	$ALR = (0.12695) \times (Lk \text{ Frac.}) + 0.000140$
	10000	$ALR = (0.26200) \times (Lk \text{ Frac.}) + 0.000600$
Light liquid valve	500	$ALR = (0.03767) \times (Lk \text{ Frac.}) + 0.000195$
	1000	$ALR = (0.04248) \times (Lk \text{ Frac.}) + 0.000280$
	10000	$ALR = (0.08350) \times (Lk \text{ Frac.}) + 0.001700$
Light liquid pump	500	$ALR = (0.19579) \times (Lk \text{ Frac.}) + 0.001320$
	1000	$ALR = (0.23337) \times (Lk \text{ Frac.}) + 0.001980$
	10000	$ALR = (0.42500) \times (Lk \text{ Frac.}) + 0.012000$
Connector	500	$ALR = (0.01355) \times (Lk \text{ Frac.}) + 0.000013$
	1000	$ALR = (0.01723) \times (Lk \text{ Frac.}) + 0.000018$
	10000	$ALR = (0.03744) \times (Lk \text{ Frac.}) + 0.000060$

<sup>a</sup> ALR = Average non-methane organic compound leak rate (kg/hr per source).

<sup>b</sup> Lk Frac. = Fraction leaking.

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# **APPENDIX B**

## **SOURCE SCREENING — RESPONSE FACTORS**

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## SOURCE SCREENING — RESPONSE FACTORS

This appendix presents additional information on response factors and includes some guidelines on how to evaluate whether a RF correction to a screening value should be made. An RF is a correction factor that can be applied to a screening value to relate the actual concentration to the measured concentration of a given compound. The RF is calculated using the equation:

$$RF = AC/SV \quad (4.B-1)$$

where:

RF	=	Response factor
AC	=	Actual concentration of the organic compound (ppmv)
SV	=	Screening value (ppmv)

The value of the RF is a function of several parameters. These parameters include the monitoring instrument, the calibration gas used to calibrate the instrument, the compound(s) being screened, and the screening value.

The EPA recommends that if a compound (or mixture) has an RF greater than 3, then the RF should be used to adjust the screening value before it is used in estimating emissions. When a compound has an RF greater than three for the recalibrated instrument, the emissions estimated using the unadjusted screening value will, generally, underestimate the actual emissions.

A detailed list of published RFs is presented in Appendix C of the *Protocol* document (EPA, November 1995). These RFs, developed for pure compounds, can be used to estimate the RF for a mixture by using the equation:

$$RF_m = \frac{1}{\sum_{i=1}^n (x_i/RF_i)} \quad (4.B-2)$$

where:

$RF_m$	=	Response factor of the mixture
$n$	=	Number of components in the mixture
$x_i$	=	Mole fraction of constituent "i" in the mixture
$RF_i$	=	Response factor of constituent i in the mixture

For more detail on the derivation of this equation, please refer to Appendix A of the *Protocol* document (EPA, November 1995).

In general, RFs can be used to correct all screening values, if so desired. The following steps can be carried out to evaluate whether an RF correction to a screening value should be made.

1. For the combination of monitoring instrument and calibration gas used, determine the RFs of a given material at an actual concentration of 500 ppmv and 10,000 ppmv. When it may not be possible to achieve an actual concentration of 10,000 ppmv for a given material, the RF at the highest concentration that can be safely achieved should be determined.
2. If the RFs at both actual concentrations are below 3, it is not necessary to adjust the screening values.
3. If either of the RFs are greater than 3, then the EPA recommends an RF be applied for those screening values for which the RF exceeds 3.

One of the following two approaches can be applied to correct screening values:

1. Use the higher of either the 500 ppmv RF or the 10,000 ppmv RF to adjust all screening values; or
2. Generate a response factor curve to adjust the screening values.

When it is necessary to apply RFs, site personnel should use engineering judgement to group process equipment into streams containing similar compounds. All components associated with a given stream can then be assigned the same RF, as opposed to calculating an RF for each individual equipment piece. Appendix A of the *Protocol* document (EPA, November 1995) presents an example about the application of response factors.

## REFERENCE

EPA. November 1995. *Protocol for Equipment Leak Emission Estimates*. U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, 453/R-95-017. Research Triangle Park, North Carolina.

# **APPENDIX C**

## **MASS EMISSIONS SAMPLING — METHODS AND CALCULATION PROCEDURES**

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## MASS EMISSIONS SAMPLING (BAGGING)

When bagging an equipment piece, two methods are generally employed in sampling source enclosures: the vacuum method (Figure 4.C-1) and the blow-through method (Figure 4.C-2). These two methods differ in the ways that the carrier gas is conveyed through the bag. In the vacuum method, a vacuum pump is used to pull air through the bag. In the blow-through method, a carrier gas such as nitrogen is blown into the bag. In general, the blow-through method has advantages over the vacuum method. These advantages are as follows:

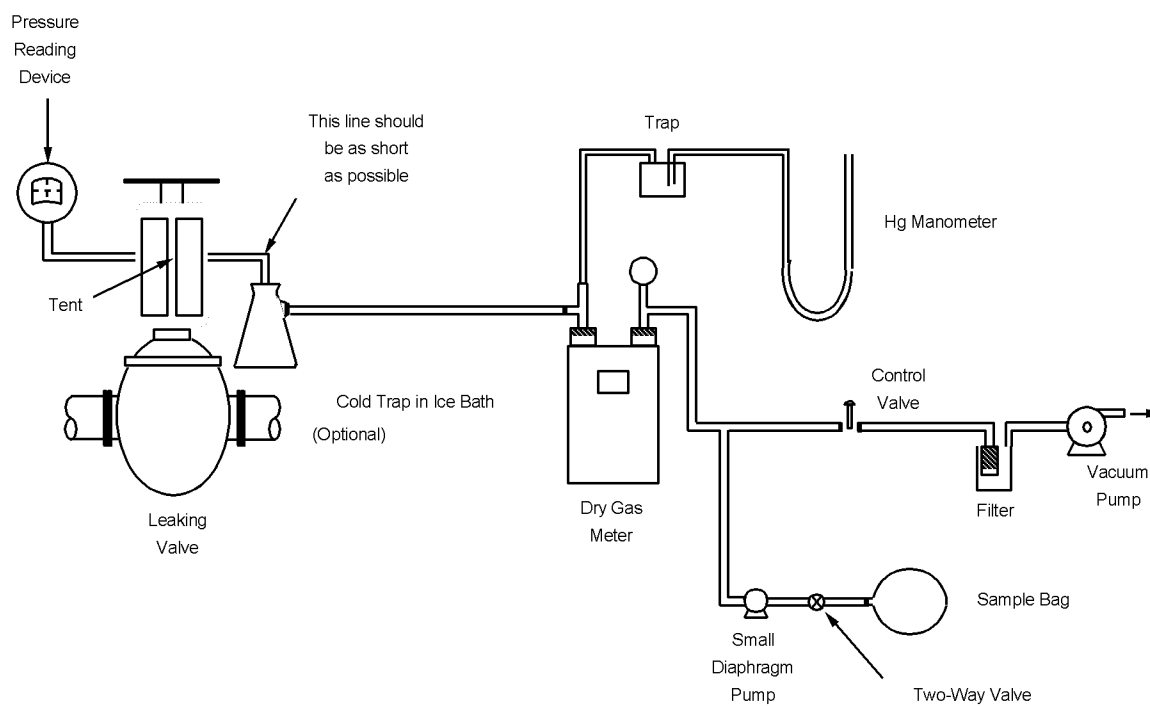
- The blow-through method is more conducive to better mixing in the bag.
- The blow-through method minimizes ambient air in the bag and thus reduces potential error associated with background organic compound concentrations. (For this reason the blow-through method is especially preferable when measuring the leak rate from components with zero or very low screening values.)
- The blow-through method minimizes oxygen concentration in the bag (assuming air is not used as the carrier gas) and the risk of creating an explosive environment.
- In general, less equipment is required to set up the blow-through method sampling train.

However, the blow-through method does require a carrier gas source, and preferably the carrier gas should be inert and free of any organic compounds and moisture. The vacuum method does not require a special carrier gas.

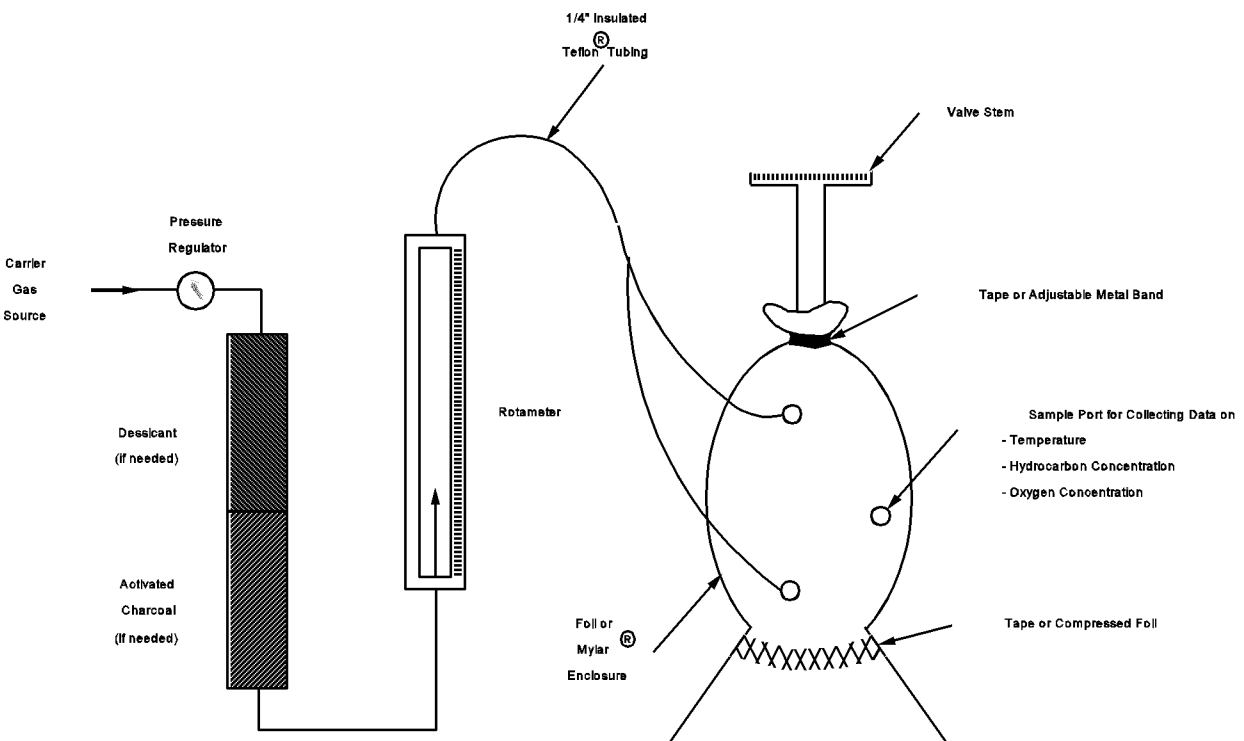
Figures 4.C-3 and 4.C-4 present the calculation procedures for leak rates when using the vacuum and blow-through methods, respectively.

When choosing the bagging material, an important criteria is that it is impermeable to the specific compounds being emitted from the equipment piece.

Example 4.C-1, for the vacuum method, and Example 4.C-2, for the blow-through method, are presented in two parts. Part 1 shows the data sheets that were presented in Section 6 (Figures 4.6-2 and 4.6-3) filled out with the appropriate information, and Part 2 shows how that information is used to calculate the mass emission rates, using the equations shown in Figures 4.C-3 and 4.C-4.



**FIGURE 4.C-1. SAMPLING TRAIN FOR BAGGING A SOURCE USING THE VACUUM METHOD**



**FIGURE 4.C-2. EQUIPMENT REQUIRED FOR THE BLOW-THROUGH SAMPLING TECHNIQUE**

### CALCULATION PROCEDURES FOR LEAK RATE WHEN USING THE VACUUM METHOD

$$\text{Leak Rate (kg/hr)} = \frac{9.63 \times 10^{-10}(Q)(MW)(GC)(P)}{T + 273.15} + \frac{(\rho)(V_L)}{16.67(t)}$$

where:

$9.63 \times 10^{-10}$  = A conversion factor using the gas constant:

$$\frac{^{\circ}\text{K} \times 10^6 \times \text{kg-mol} \times \text{min}}{\text{L} \times \text{hour} \times \text{mmHg}}$$

Q	=	Flow rate out of bag (L/min)
MW <sup>a</sup>	=	Molecular weight of organic compound(s) in the sample bag or alternatively in the process stream contained within the equipment piece being bagged (kg/kg-mol)
GC <sup>b</sup>	=	Sample bag organic compound concentration (ppmv) minus background bag organic compound concentration <sup>c</sup> (ppmv)
P	=	Absolute pressure at the dry gas meter (mmHg)
T	=	Temperature at the dry gas meter (°C)
ρ	=	Density of organic liquid collected (g/mL)
V <sub>L</sub>	=	Volume of liquid collected (mL)
16.67	=	A conversion factor to adjust term to units of kilograms per hour (g × hr)/(kg × min)
t	=	Time in which liquid is collected (min)

<sup>a</sup> For mixtures, calculate MW as:

$$\frac{\sum_{i=1}^n MW_i X_i}{\sum_{i=1}^n X_i}$$

where:

MW <sub>i</sub>	=	Molecular weight of organic compound "i"
X <sub>i</sub>	=	Mole fraction of organic compound i
n	=	Number of organic compounds in mixture.

<sup>b</sup> For mixtures, the value of GC is the total concentration of all the organic compounds in the mixture.

<sup>c</sup> Collection of a background bag is optional. If a bag of background air is not collected, assume the background concentration is zero.

**FIGURE 4.C-3. CALCULATION PROCEDURES FOR LEAK RATE WHEN USING THE VACUUM METHOD**

### CALCULATION PROCEDURES FOR LEAK RATE WHEN USING THE BLOW-THROUGH METHOD

$$\text{Leak Rate (kg/hr)} = \left( \frac{1.219 \times 10^{-5}(Q)(MW)(GC)}{T + 273.15} + \frac{(\rho)(V_L)}{16.67(t)} \right) \times \left( \frac{10^6 \text{ ppmv}}{10^6 \text{ ppmv} - GC} \right)$$

where:

$1.219 \times 10^{-5}$  = A conversion factor taking into account the gas constant and assuming a pressure in the bag of 1 atmosphere:

$$\frac{^{\circ}\text{K} \times 10^6 \times \text{kg-mol}}{\text{m}^3}$$

Q = flow rate out of bag ( $\text{m}^3/\text{hr}$ );

$$= \frac{N_2 \text{ Flow Rate (L/min)}}{1 - [\text{Bag Oxygen Conc. (volume \%)/21]} \times \frac{[0.06 \text{ (m}^3/\text{min)}]}{(\text{L/hr})}$$

MW<sup>a</sup> = Molecular weight of organic compounds in the sample bag or alternatively in the process stream contained within the equipment piece being bagged (kg/kg-mol)

GC<sup>b</sup> = Sample bag organic compound concentration (ppmv), corrected for background bag organic compound concentration (ppmv)<sup>c</sup>

T = Temperature in bag ( $^{\circ}\text{C}$ )

$\rho$  = Density of organic liquid collected (g/mL)

$V_L$  = Volume of liquid collected (mL)

16.67 = A conversion factor to adjust term to units of kilograms per hour ( $\text{g} \times \text{hr})/(\text{kg} \times \text{min})$

t = Time in which liquid is collected (min)

**FIGURE 4.C-4. CALCULATION PROCEDURES FOR LEAK RATE WHEN USING THE  
BLOW-THROUGH METHOD**

### CALCULATION PROCEDURES FOR LEAK RATE WHEN USING THE BLOW-THROUGH METHOD (CONTINUED)

<sup>a</sup> For mixtures, calculate MW as:

$$\frac{\sum_{i=1}^n MW_i X_i}{\sum_{i=1}^n X_i}$$

where:

MW <sub>i</sub>	=	Molecular weight of organic compound "i"
X <sub>i</sub>	=	Mole fraction of organic compound i
n	=	Number of organic compounds in mixture

<sup>b</sup> For mixtures, the value of GC is the total concentration of all the organic compounds in the mixture.

<sup>c</sup> Collection of a background bag is optional. If a bag of background air is not collected, assume the background concentration is zero. To correct for background concentration, use the following equation:

$$GC \text{ (ppmv)} = SB - \left( \frac{BAG}{21} \times BG \right)$$

where:

SB	=	Sample bag concentration (ppmv);
BAG	=	Tent oxygen concentration (volume %); and
BG	=	Background bag concentration (ppmv)

**FIGURE 4.C-4. (CONTINUED)**

## EXAMPLE 4.C-1: PART 1

EXAMPLE DATA COLLECTION FORM FOR FUGITIVE EMISSIONS  
BAGGING TEST (VACUUM METHOD)

Equipment Type <u>Valve</u>	Component ID <u>V0101</u>
Equipment Category _____	Plant ID <u>P012</u>
Line Size _____	Date <u>10-15-95</u>
Stream Phase (G/V, LL, HL) <u>LL</u>	Analysis Team _____
Barometric Pressure _____	Instrument ID <u>I01</u>
Ambient Temperature _____	Stream Pressure _____
Stream Temperature _____	
Stream Composition (Wt. %) <u>100% TOC MW = 25.4735 kg/kg-mol</u>	

<u>Time</u>	<u>Bagging Test Measurement Data</u>
_____	Initial Screening (ppmv) Equipment Piece <sup>a</sup> <u>450</u> Bkgd. <u>9</u>
_____	Background Bag Organic Compound Conc. (ppmv) <sup>b</sup> _____
_____	Sample Bag 1 Organic Compound Conc. (ppmv) <u>268</u>
_____	Dry Gas Meter Reading (L/min) <u>2.806</u>
_____	Vacuum Check in Bag (Y/N) (Must be YES to collect sample.) _____
_____	Dry Gas Meter Temperature <sup>c</sup> (°C) <u>17</u>
_____	Dry Gas Meter Pressure <sup>c</sup> (mmHg) <u>668</u>
_____	Sample Bag 2 Organic Compound Conc. (ppmv) _____
_____	Dry Gas Meter Reading (L/min) _____
_____	Vacuum Check in Bag (Y/N) (Must be YES to collect sample.) _____
_____	Dry Gas Meter Temperature <sup>c</sup> (°C) _____
_____	Dry Gas Meter Pressure <sup>c</sup> (mmHg) _____
Condensate Accumulation: Starting Time _____ Final Time _____	
Organic Condensate Collected (mL) _____	
Density of Organic Condensate (g/mL) _____	
_____	Final Screening (ppmv) Equip. Piece <sup>a</sup> <u>450</u> Bkgd. <u>9</u>

<sup>a</sup> The vacuum method is not recommended if the screening value is approximately 10 ppmv or less.

<sup>b</sup> Collection of a background bag is optional.

<sup>c</sup> Pressure and temperature are measured at the dry gas meter.

**EXAMPLE 4.C-1: PART 2****EQUATION FOR CALCULATING THE LEAK RATE USING THE DATA FROM PART 1**

$$\begin{aligned}
 \text{Leak Rate} &= \left( \frac{9.63\text{E-}10 (Q)(MW)(GC)(P)}{T + 273.15} \right) \\
 &= \left( 9.63\text{E-}10 \frac{^{\circ}\text{K} \times 10^6 \times \text{kg-mol} \times \text{min}}{\text{L} \times \text{hr} \times \text{mmHg}} \right) \left( 2.806 \frac{\text{L}}{\text{min}} \right) \left( 25.4735 \frac{\text{kg}}{\text{kg-mol}} \right) \\
 &\quad \left( \frac{(268 \text{ ppmv})(668 \text{ mmHg})}{(17 + 273.15)^{\circ}\text{K}} \right) \\
 &= 4.25\text{E-}05 \text{ kg/hr}
 \end{aligned}$$



## EXAMPLE 4.C-2: PART 1

EXAMPLE DATA COLLECTION FORM FOR FUGITIVE EMISSIONS BAGGING TEST  
(BLOW-THROUGH METHOD)

Equipment Type <u>Valve</u>	Component ID <u>V0102</u>
Equipment Category _____	Plant ID <u>P012</u>
Line Size _____	Date <u>10-15-95</u>
Stream Phase (G/V, LL, HL) <u>LL</u>	Analysis Team _____
Barometric Pressure _____	_____
Ambient Temperature _____	Instrument ID <u>I01</u>
Stream Temperature _____	Stream Pressure _____
Stream Composition (Wt. %) <u>100% TOC MW=28.12 kg/kg-mol</u>	
_____	
_____	

<u>Time</u>	<u>Bagging Test Measurement Data</u>	
_____	Initial Screening (ppmv) Equipment Piece <u>8</u>	Bkgd. <u>4</u>
_____	Background Bag Organic Compound Conc. (ppmv) <sup>a</sup> _____	
_____	Sample Bag 1 Organic Compound Conc. (ppmv)	<u>29.3</u>
_____	Dilution Gas Flow Rate (L/min)	<u>5.21</u>
_____	O <sub>2</sub> Concentration (volume %)	<u>2.55</u>
_____	Bag Temperature (°C)	<u>23.89</u>
_____	Sample Bag 2 Organic Compound Conc. (ppmv)	_____
_____	Dilution Gas Flow Rate (L/min)	_____
_____	O <sub>2</sub> Concentration (volume %)	_____
_____	Bag Temperature (°C)	_____
Condensate Accumulation: Starting Time _____ Final Time _____		
Organic Condensate Collected (mL) _____		
Density of Organic Condensate (g/mL) _____		
_____	Final Screening (ppmv) Equipment Piece <u>8</u>	Bkgd. <u>4</u>

<sup>a</sup> Collection of a background bag is optional. However, it is recommended in cases where the screening value is less than 10 ppmv and there is a detectable oxygen level in the bag.

**EXAMPLE 4.C-2: PART 2****EQUATION FOR CALCULATING THE LEAK RATE USING THE DATA FROM PART 1**

$$\begin{aligned}
 Q &= \frac{\text{Dilution Gas Flow Rate}}{\left(1 - \frac{\text{Bag O}_2 \text{ conc (vol\%)}}{21\%}\right)} \times \frac{[0.06 \text{ m}^3/\text{min}]}{\text{L/hr}} \\
 &= \frac{5.21 \frac{\text{L}}{\text{min}}}{1 - \left(\frac{2.55\%}{21\%}\right)} \times \frac{[0.06 \text{ m}^3/\text{min}]}{\text{L/hr}} \\
 &= 0.36 \text{ m}^3/\text{hr}
 \end{aligned}$$

$$\begin{aligned}
 \text{Leak Rate} &= \left( \frac{1.219\text{E-}05 (Q) (MW) (GC)}{T + 273.15} \right) \times \left( \frac{10^6}{10^6 - GC} \right) \\
 &= \frac{\left( 1.219\text{E-}05 \frac{^\circ\text{K} \times 10^6 \times \text{kg-mol} \times \text{min}}{\text{m}^3} \right) \left( 0.36 \frac{\text{m}^3}{\text{hr}} \right) \left( 28.12 \frac{\text{kg}}{\text{kg-mol}} \right) (29.3\text{ppmv})}{(23.89+273.15)^\circ\text{K}} \times \left( \frac{10^6}{10^6 - 29.3} \right) \\
 &= 1.22\text{E-}05 \text{ kg/hr}
 \end{aligned}$$

# **APPENDIX D**

## **EXAMPLE DATA COLLECTION FORM FOR FUGITIVE EMISSIONS FROM EQUIPMENT LEAKS**

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## EXAMPLE DATA COLLECTION FORM INSTRUCTIONS

### GENERAL

- This form may be used as a worksheet to aid in collecting the information/data necessary to estimate HAP and VOC emissions from equipment leaks.
- The form is divided into five sections: General Information; Stream Composition Data; Equipment Counts; Screening Data; and Equipment Leaks Controls.
- Some of the sections require entry on a stream basis; for these, a separate copy of the section will need to be made for each stream in the process unit.
- If you want to modify the form to better serve your needs, an electronic copy of the form may be obtained through the EIIP on the CHIEF system of the OAQPS TTN.

### STREAM COMPOSITION DATA SECTION

- Weight percents may not need to be provided for constituents present in concentrations less than 1.0 weight percent.
- In the row labelled "OTHER," identify total weight percent of all constituents not previously listed. The total weight percent of constituents labelled as "OTHER" must not exceed 10 percent. Total weight percent of all constituents in the stream must equal 100 percent.

### SCREENING DATA SECTION

- Complete the information/data for each screened stream.

## EQUIPMENT COUNT SECTION

- Complete each blank form for each stream in the facility.
- The LDAR trigger concentration refers to the concentration level that the component is considered to be leaking.
- Enter the control parameters for each component type in the stream. Provide the percent of the total equipment type in the stream that has the controls listed in the attached table.
- If other controls are used, specify what they are in the space left of the slash. Specify the percent of each component type in the stream that use the other control in the space to the right of the slash.
- Indicate any secondary control devices to which the closed vent system transports the process fluid.

Example 4.D-1 shows how all of the sections of this form would be filled out for the example presented in Section 4 (Tables 4.4-1 and 4.4-2) for a hypothetical chemical processing facility, which is subject to an LDAR program.

**Note:** Complete this form for each type of fuel used and for each unit.

### EXAMPLE DATA COLLECTION FORM - FUGITIVE EMISSIONS FROM EQUIPMENT LEAKS

GENERAL INFORMATION						
Process Unit Capacity (lb/yr)						
Portable VOC Monitoring Instrument Used <sup>a</sup>						
Calibration Gas of Monitoring Instrument <sup>a</sup>						
STREAM COMPOSITION DATA						
CAS Number	Chemical Name	Concentration (wt.%)				
		Stream 1	Stream 2	Stream 3	Stream 4	Stream 5
--	OTHER					
--	Total HAPs					
--	Total VOCs					
--	Source <sup>c</sup>					
Amount of Time Fluid in Stream (hr/yr)						

<sup>a</sup> Collect information if screening data have been gathered at the process unit.

<sup>b</sup> CAS = Chemical Abstract Service.

<sup>c</sup> EJ = Engineering judgement; TD = Test data; LV = Literature values.

## EXAMPLE DATA COLLECTION FORM - FUGITIVE EMISSIONS FROM EQUIPMENT LEAKS

EQUIPMENT COUNTS					
Component	Service	Count Source <sup>b</sup>	Stream 1 (A)	Stream 2 (B)	Stream 3 (C)
Valves	gas/vapor				
	light liquid				
	heavy liquid				
Connectors	all				
Pumps	light liquid				
	heavy liquid				
Compressor	gas/vapor				
Open Lines	all				
Sample Connections	all				
Pressure Relief Valve	gas/vapor				

<sup>a</sup> Do not include equipment in vacuum service.

<sup>b</sup> D = Design specifications; I = Inspection and maintenance tags; C = Actual count; and R = Ratio; if ratio, specify (i.e., 25 valves per pump).



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## EXAMPLE DATA COLLECTION FORM - FUGITIVE EMISSIONS FROM EQUIPMENT LEAKS

EQUIPMENT LEAKS CONTROLS									
Stream ID:									
Is the equipment in this stream subject to a LDAR program? (Yes/No)									
Type of Monitoring System <sup>a</sup> :									
Leak Detection and Repair Parameters					Control Parameters				
Equipment	Quantity in Program	LDAR Trigger Conc.	Monitoring Frequency	Response Time <sup>b</sup>	Percent with Control A <sup>c</sup>	Percent with Control B <sup>c</sup>	Percent with Control C <sup>c</sup>	Other	Closed Vent Secondary Control
Valves							NA <sup>d</sup>	/	
Pumps								/	
Compressors							NA	/	
Connectors						NA	NA	/	
Open-ended lines							NA	/	
Sampling Connections	NA	NA	NA	NA				/	
Pressure Relief Valves							NA	/	

<sup>a</sup> V = Visual; P = Portable; F = Fixed point; If other, please specify.

<sup>b</sup> IM = Immediately; D = 1 day; D3 = 3 days; W = 1 week; W2 = 2 weeks; and M = 1 month.

<sup>c</sup> See attached table, Controls by Equipment Type.

<sup>d</sup> NA = Not applicable.

# EXAMPLE DATA COLLECTION FORM - FUGITIVE EMISSIONS FROM EQUIPMENT LEAKS

## TABLE OF CONTROLS BY EQUIPMENT TYPE

Control Option	Equipment	Controls
A	All	Closed vent system
B	Valves Pumps Compressors Open-ended lines Sampling Connections PRVs	Sealless Dual mechanical seal with barrier fluid Mechanical seals with barrier fluid Capped, plugged, blind-flagged <i>In-situ</i> sampling Rupture disk
C	Pumps Sampling connections	Sealless Closed loop sampling

## EXAMPLE 4.D-1

**EXAMPLE DATA COLLECTION FORM -  
FUGITIVE EMISSIONS FROM EQUIPMENT FROM EQUIPMENT LEAKS**

GENERAL INFORMATION						
Process Unit Capacity (lb/yr) <b>800,000</b>						
Portable VOC Monitoring Instrument Used <sup>a</sup> Foxboro OVA Model <b>108</b>						
Calibration Gas of Monitoring Instrument <sup>a</sup> <b>Methane</b>						
STREAM COMPOSITION DATA						
CAS Number	Chemical Name	Concentration (wt%)				
		Stream 1 (A)	Stream 2 (B)	Stream 3 (C)	Stream 4	Stream 5
<b>140885</b>	<b>ETHYL ACRYLATE</b>	<b>80</b>	<b>10</b>	<b>65</b>		
<b>100425</b>	<b>STYRENE</b>		<b>90</b>			
<b>74840</b>	<b>ETHANE</b>			<b>25</b>		
<b>7732185</b>	<b>WATER</b>	<b>20</b>		<b>10</b>		
--	OTHER					
--	Total HAPs	<b>80</b>	<b>100</b>	<b>65</b>		
--	Total VOCs	<b>80</b>	<b>100</b>	<b>90</b>		
--	Source <sup>b</sup>	<b>TD</b>	<b>TD</b>	<b>TD</b>		
Amount of Time Fluid in Stream (hr/yr)		<b>8760</b>	<b>4380</b>	<b>8760</b>		

<sup>a</sup> Collect information if screening data have been gathered at the process unit.

<sup>b</sup> EJ = Engineering judgement; TD = Test data; LV = Literature values.

**EXAMPLE 4.D-1****(CONTINUED)**

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EQUIPMENT COUNTS					
Component	Service	Count Source <sup>b</sup>	Stream 1 (A)	Stream 2 (B)	Stream 3 (C)
Valves	gas/vapor	<i>C</i>			<b>40</b>
	light liquid				
	heavy liquid				
Connectors	all				
Pumps	light liquid	<i>C</i>	<b>15</b>	<b>12</b>	
	heavy liquid				
Compressor	gas/vapor				
Open Lines	all				
Sample Connections	all				
Pressure Relief Valve	gas/vapor				

<sup>a</sup> Do not include equipment in vacuum service.<sup>b</sup> D = Design specifications; I = Inspection and maintenance tags; C = Actual count; and R = Ratio; if ratio, specify (i.e., 25 valves per pump).

**EXAMPLE 4.D-1****(CONTINUED)**

SCREENING DATA	
Stream ID: <i>A</i>	Component Type: <i>Light Liquid Pump</i>
Date Components Screened: <i>7-15-95</i>	Total Number of Components Screened: <i>15</i>
Component ID	Screening Value (ppmv)
<i>A-1</i>	<i>0</i>
<i>A-2</i>	<i>0</i>
<i>A-3</i>	<i>0</i>
<i>A-4</i>	<i>0</i>
<i>A-5</i>	<i>0</i>
<i>A-6</i>	<i>20</i>
<i>A-7</i>	<i>50</i>
<i>A-8</i>	<i>50</i>
<i>A-9</i>	<i>100</i>
<i>A-10</i>	<i>100</i>
<i>A-11</i>	<i>200</i>
<i>A-12</i>	<i>400</i>
<i>A-13</i>	<i>1000</i>
<i>A-14</i>	<i>2000</i>
<i>A-15</i>	<i>5000</i>

**EXAMPLE 4.D-1****(CONTINUED)**

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SCREENING DATA	
Stream ID: <i>B</i>	Component Type: <i>Light Liquid Pump</i>
Date Components Screened: <i>7-15-95</i>	Total Number of Components Screened: <i>11</i>
Component ID	Screening Value (ppmv)
<i>B-1</i>	<i>0</i>
<i>B-2</i>	<i>0</i>
<i>B-3</i>	<i>0</i>
<i>B-4</i>	<i>10</i>
<i>B-5</i>	<i>30</i>
<i>B-6</i>	<i>250</i>
<i>B-7</i>	<i>500</i>
<i>B-8</i>	<i>2000</i>
<i>B-9</i>	<i>5000</i>
<i>B-10</i>	<i>8000</i>
<i>B-11</i>	<i>25,000</i>

## EXAMPLE 4.D-1

(CONTINUED)

SCREENING DATA	
Stream ID: <i>C</i>	Component Type: <i>Gas/Vapor Valve</i>
Date Components Screened: <i>7-15-95</i>	Total Number of Components Screened: <i>40</i>
Component ID	Screening Value (ppmv)
<i>C-1</i>	<i>0</i>
<i>C-2</i>	<i>0</i>
<i>C-3</i>	<i>0</i>
<i>C-4</i>	<i>0</i>
<i>C-5</i>	<i>0</i>
<i>C-6</i>	<i>0</i>
<i>C-7</i>	<i>15</i>
<i>C-8</i>	<i>20</i>
<i>C-9</i>	<i>20</i>
<i>C-10</i>	<i>35</i>
<i>C-11</i>	<i>50</i>
<i>C-12</i>	<i>50</i>
<i>C-13</i>	<i>120</i>
<i>C-14</i>	<i>150</i>
<i>C-15</i>	<i>200</i>



**EXAMPLE 4.D-1****(CONTINUED)**

SCREENING DATA	
Stream ID: <i>C</i>	Component Type: <i>Gas/Vapor Valve</i>
Date Components Screened: <i>7-15-95</i>	Total Number of Components Screened: <i>40</i>
Component ID	Screening Value (ppmv)
<i>C-16</i>	<i>500</i>
<i>C-17</i>	<i>550</i>
<i>C-18</i>	<i>575</i>
<i>C-19</i>	<i>600</i>
<i>C-20</i>	<i>610</i>
<i>C-21</i>	<i>700</i>
<i>C-22</i>	<i>800</i>
<i>C-23</i>	<i>1010</i>
<i>C-24</i>	<i>1200</i>
<i>C-25</i>	<i>1500</i>
<i>C-26</i>	<i>1550</i>
<i>C-27</i>	<i>1700</i>
<i>C-28</i>	<i>2000</i>
<i>C-29</i>	<i>5000</i>
<i>C-30</i>	<i>5100</i>

## EXAMPLE 4.D-1

(CONTINUED)

SCREENING DATA	
Stream ID: <i>C</i>	Component Type: <i>Gas/Vapor Valve</i>
Date Components Screened: <i>7-15-95</i>	Total Number of Components Screened: <i>40</i>
Component ID	Screening Value (ppmv)
<i>C-31</i>	<i>6100</i>
<i>C-32</i>	<i>7000</i>
<i>C-33</i>	<i>8000</i>
<i>C-34</i>	<i>8100</i>
<i>C-35</i>	<i>8150</i>
<i>C-36</i>	<i>8300</i>
<i>C-37</i>	<i>9000</i>
<i>C-38</i>	<i>10,000</i>
<i>C-39</i>	<i>15,000</i>
<i>C-40</i>	<i>50,000</i>

## EXAMPLE 4.D-1

(CONTINUED)

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EQUIPMENT LEAKS CONTROLS									
Stream ID: <i>A</i>									
Is the equipment in this stream subject to a LDAR program? (Yes/No) <i>Yes</i>									
Type of Monitoring System <sup>a</sup> : <i>P</i>									
Leak Detection and Repair Parameters					Control Parameters				
Equipment	Quantity in Program	LDAR Trigger Conc.	Monitoring Frequency	Response Time <sup>b</sup>	Percent with Control A <sup>c</sup>	Percent with Control B <sup>c</sup>	Percent with Control C <sup>c</sup>	Other	Closed Vent Secondary Control
Valves							NA <sup>d</sup>	/	
Pumps	<i>15</i>	<i>10,000 ppm</i>	<i>monthly</i>	<i>W</i>	<i>53%</i>	<i>7%</i>	<i>40%</i>	/	
Compressors							NA	/	
Connectors						NA	NA	/	
Open-ended lines							NA	/	
Sampling Connections	NA	NA	NA	NA				/	
Pressure Relief Valves							NA	/	

<sup>a</sup> V = Visual; P = Portable; F = Fixed point; If other, please specify.<sup>b</sup> IM = Immediately; D = 1 day; D3 = 3 days; W = 1 week; W2 = 2 weeks; and M = 1 month.<sup>c</sup> See attached table, Controls by Equipment Type.<sup>d</sup> NA = Not applicable.

## EXAMPLE 4.D-1

(CONTINUED)

EQUIPMENT LEAKS CONTROLS									
Stream ID: <i>B</i>									
Is the equipment in this stream subject to a LDAR program? (Yes/No) <i>Yes</i>									
Type of Monitoring System <sup>a</sup> : <i>P</i>									
Leak Detection and Repair Parameters					Control Parameters				
Equipment	Quantity in Program	LDAR Trigger Conc.	Monitoring Frequency	Response Time <sup>b</sup>	Percent with Control A <sup>c</sup>	Percent with Control B <sup>c</sup>	Percent with Control C <sup>c</sup>	Other	Closed Vent Secondary Control
Valves							NA <sup>d</sup>	/	
Pumps	<i>12</i>	<i>10,000 ppm</i>	<i>monthly</i>	<i>W</i>	<i>67%</i>	<i>33%</i>	<i>0%</i>	/	
Compressors							NA	/	
Connectors						NA	NA	/	
Open-ended lines							NA	/	
Sampling Connections	NA	NA	NA	NA				/	
Pressure Relief Valves							NA	/	

<sup>a</sup> V = Visual; P = Portable; F = Fixed point; If other, please specify.<sup>b</sup> IM = Immediately; D = 1 day; D3 = 3 days; W = 1 week; W2 = 2 weeks; and M = 1 month.<sup>c</sup> See attached table, Controls by Equipment Type.<sup>d</sup> NA = Not applicable.

## EXAMPLE 4.D-1

(CONTINUED)

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CHAPTER 4 - EQUIPMENT LEAKS

EQUIPMENT LEAKS CONTROLS									
Stream ID: <i>C</i>									
Is the equipment in this stream subject to a LDAR program? (Yes/No) <i>Yes</i>									
Type of Monitoring System <sup>a</sup> : <i>P</i>									
Leak Detection and Repair Parameters					Control Parameters				
Equipment	Quantity in Program	LDAR Trigger Conc.	Monitoring Frequency	Response Time <sup>b</sup>	Percent with Control A <sup>c</sup>	Percent with Control B <sup>c</sup>	Percent with Control C <sup>c</sup>	Other	Closed Vent Secondary Control
Valves	<i>40</i>	<i>10,000 ppm</i>	<i>monthly</i>	<i>W</i>	<i>50%</i>	<i>50%</i>	NA <sup>d</sup>	/	
Pumps								/	
Compressors							NA	/	
Connectors						NA	NA	/	
Open-ended lines							NA	/	
Sampling Connections	NA	NA	NA	NA				/	
Pressure Relief Valves							NA	/	

<sup>a</sup> V = Visual; P = Portable; F = Fixed point; If other, please specify.<sup>b</sup> IM = Immediately; D = 1 day; D3 = 3 days; W = 1 week; W2 = 2 weeks; and M = 1 month.<sup>c</sup> See attached table, Controls by Equipment Type.<sup>d</sup> NA = Not applicable.

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# **PREFERRED AND ALTERNATIVE METHODS FOR ESTIMATING AIR EMISSIONS FROM WASTEWATER COLLECTION AND TREATMENT**

**Final Report**

**March 1997**



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## **DISCLAIMER**

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.



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# 1

## INTRODUCTION

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The purposes of the preferred methods guidelines are to describe emissions estimation techniques for stationary point sources in a clear and unambiguous manner and to provide concise example calculations to aid in the preparation of emission inventories. This chapter describes the procedures and recommended approaches of estimating volatile organic compound (VOC) emissions from wastewater collection and treatment (WWCT).

Section 2 of this chapter contains a general description of the WWCT source category, a listing of common emission sources associated with WWCT, and an overview of the available air pollution control technologies for WWCT. Section 3 of this chapter provides an overview of available emission estimation methods. It should be noted that the use of site-specific emissions data is always preferred over the use of industry-averaged data such as default data, available in several of the current WWCT air emissions models. However, depending upon available resources, obtaining site-specific data may not be cost effective. Section 4 presents the preferred emission estimation methods for WWCT, while Section 5 presents alternative emission estimation techniques. Quality assurance and quality control procedures are described in Section 6, and Section 7 lists references. Appendix A contains an example data collection form for WWCT sources, and Appendix B contains the *AP-42* WWCT equations and example calculations (Environmental Protection Agency [EPA], 1995). Appendix C contains a list of references that may be consulted for more detailed, technical evaluations and comparisons of the emission estimation techniques and emissions software models discussed in this chapter.

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# 2

## GENERAL SOURCE CATEGORY DESCRIPTION

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### 2.1 SOURCE CATEGORY DESCRIPTION

This section provides a brief overview discussion of the WWCT category. In addition to wastewater generated at the municipal level, many industries generate large quantities of contaminated water as a byproduct of production processes. These wastewaters typically pass through a series of on-site collection and treatment units before discharge to a receiving water body or publicly owned treatment works (POTW). Many of these collection and treatment units are open to the atmosphere and allow for volatilization of VOCs from the wastewater.

The information presented in this document is applicable to any source, municipality, or industry treating wastewater on-site.

The following sections describe the various types of wastewater collection and treatment devices. The type of unit (collection or treatment) is provided, as is a brief description of each. Table A-1, Appendix A lists approximate physical dimensions of several units.

### 2.2 WWCT DEVICES

#### 2.2.1 DRAINS (COLLECTION UNIT)

Wastewater streams from various sources throughout a given process are normally introduced into the collection system through process drains. Drains may be of a trapped or untrapped design. Individual drains are usually connected directly to the main process sewer line. However, they may also drain to trenches, sumps, or ditches. Some drains are dedicated to a single piece of equipment such as a scrubber, decanter, or stripper. Others serve several sources. These types of drains are located centrally between the pieces of equipment they serve and are referred to as area drains (EPA, 1990).

#### 2.2.2 MANHOLES (COLLECTION UNIT)

Manholes are service entrances into sewer lines that permit inspection and cleaning of the sewer line. They are normally placed at periodic lengths along the sewer line. They may also be located where sewers intersect or where there is a significant change in direction,

grade, or sewer line diameter. The lower portion of the manhole is usually cylindrical, with a typical inside diameter of 4 feet to allow adequate space for workers. The upper portion tapers to the diameter of the opening at ground level. The opening is normally about 2 feet in diameter and covered with a heavy cast-iron plate with two to four holes for ventilation and for cover removal.

### **2.2.3 REACHES (COLLECTION UNIT)**

A reach is a segment of sewer channel that conveys wastewater between two manholes or other sewer components such as lift stations or junction boxes. Sanitary sewers are naturally ventilated through holes in manhole covers, gooseneck vents (which are sometimes included to enhance ventilation), and vent risers on buildings that are connected to sewers. (Sanitary sewers are sometimes mechanically ventilated; i.e., fans or blowers are used to remove hydrogen sulfide.) Combined sanitary/storm sewers are generally well-ventilated, and include openings associated with street-level storm drains.

### **2.2.4 JUNCTION BOXES (COLLECTION UNIT)**

A junction box normally serves several process sewer lines. Process lines meet at the junction box to combine the multiple wastewater streams into one stream that flows downstream from the junction box. Liquid level in the junction box depends on the flow rate of the wastewater. Junction boxes are either square or rectangular and are sized based on the flow rate of the entering streams. They may also be water-sealed or covered and vented.

### **2.2.5 LIFT STATIONS (COLLECTION UNIT)**

Lift stations are usually the last collection unit prior to the treatment system, accepting wastewater from one or several sewer lines. The main function of the lift station is to provide sufficient head pressure to transport the collected wastewater to the treatment system. A pump is used to provide the head pressure and is generally designed to operate or cut off based on preset high and low liquid levels.

### **2.2.6 TRENCHES (COLLECTION UNIT)**

Trenches are used to transport wastewater from the point of process equipment discharge to subsequent wastewater collection units such as junction boxes and lift stations. This mode of transport replaces the drain scenario as a method for introducing process wastewater into the downstream collection system. In older plants, trenches are often the primary mode of wastewater transportation in the collection system. Trenches are often interconnected throughout the process area to accommodate pad water runoff, water from equipment washes and spill cleanups, as well as process wastewater discharges. Normally, the length of the

trench is determined by the general locations of the process equipment and the downstream collection system units. This length typically ranges from 50 to 500 feet. Trench depth and width are dictated by the wastewater flow rate discharged from process equipment. The depth and width of the trench must be sufficient to accommodate expected as well as emergency wastewater flows from the process equipment.

### **2.2.7 SUMPS (COLLECTION UNIT)**

Sumps are typically used for collection and equalization of wastewater flow from trenches prior to treatment. They are usually quiescent and open to the atmosphere. Typical diameters and depths are approximately 1.5 meters.

### **2.2.8 WEIRS (COLLECTION UNIT)**

Weirs act as dams in open channels in order to maintain constant water level upstream. The weir face is normally aligned perpendicular to the bed and walls of the channel. Water from the channel normally overflows the weir but may pass through a notch, or opening, in the weir face. Because of this configuration, weirs provide some control of the level and flow rate through the channel. This control, however, may be insignificant compared to upstream factors that influence the supply of water to the channel.

### **2.2.9 OIL/WATER SEPARATORS (TREATMENT UNIT)**

Oil/water separators are often the first step in the wastewater treatment plant but may also be found in the process area. The purpose of these units is to separate liquid phases of different specific gravities; they also serve to remove free oil and suspended solids contained in the wastewater. Most of the separation occurs as the wastewater stream passes through a quiescent zone in the unit. Oils and scum with specific gravities less than water float to the top of the aqueous phase. Heavier solids sink to the bottom. Most of the organics contained in the wastewater tend to partition to the oil phase. For this reason, most of these organic compounds are removed with the skimmed oil leaving the separator. The wastewater stream leaving the separator, therefore, is reduced in organic loading.

### **2.2.10 EQUALIZATION BASINS (TREATMENT UNIT)**

Equalization basins are used to reduce fluctuations in the wastewater flow rate and organic content to the downstream treatment processes and may be covered, stirred, or aerated. Equalization of wastewater flow rate results in more uniform effluent quality from downstream settling units such as clarifiers. Biological treatment performance can also benefit significantly from the damping of concentration and flow fluctuations. This damping

protects biological processes from upset or failure due to shock loadings of toxic or treatment-inhibiting compounds.

### **2.2.11 CLARIFIERS (TREATMENT UNIT)**

The primary purpose of a clarifier is to separate any oils, grease, scum, and solids contained in the wastewater. Most clarifiers are equipped with surface skimmers to clear the water of floating oil deposits and scum. Clarifiers also have sludge raking arms that prevent accumulation of organic solids collected at the bottom of the tank.

### **2.2.12 BIOLOGICAL TREATMENT BASINS (TREATMENT UNIT)**

Biological waste treatment is normally accomplished through the use of aeration basins. Microorganisms that metabolize aerobically require oxygen to carry out the biodegradation of organic compounds that results in energy and biomass production. The aerobic environment in the basin is normally achieved by the use of diffused or mechanical aeration. This aeration also serves to maintain the biomass in a well-mixed regime. The goal is to maintain the biomass concentration at a level where the treatment is efficiently optimized and proper growth kinetics are induced.

### **2.2.13 SLUDGE DIGESTERS (TREATMENT UNIT)**

Sludge digesters are used to treat organic sludges produced from various treatment operations. Two types of digesters are used: anaerobic digesters and aerobic digesters.

In the anaerobic digestion process, the organic material in mixtures of primary settled and biological sludges is converted biologically, under anaerobic conditions, to a variety of byproducts including methane ( $\text{CH}_4$ ), carbon dioxide ( $\text{CO}_2$ ), and hydrogen sulfide ( $\text{H}_2\text{S}$ ). The process is carried out in an airtight reactor. Sludge, introduced continuously or intermittently, is retained in the reactor for varying periods of time. The stabilized sludge, withdrawn continuously or intermittently from the reactor, is reduced in organic and pathogen content and is nonputrescible.

In aerobic digestion, the sludge is aerated for an extended period of time in an open, unheated tank using conventional air diffusers or surface aeration equipment. The process may be operated in a continuous or batch mode. Smaller plants use the batch system in which sludge is aerated and completely mixed for an extended period of time, followed by quiescent settling and decantation. In continuous systems, a separate tank is used for decantation and concentration. High-purity oxygen aerobic digestion is a modification of the aerobic digestion process in which high-purity oxygen is used in lieu of air. The resultant sludge is similar to conventional aerobically digested sludge (Burton and Tchobanoglous, 1991).

### **2.2.14 TREATMENT TANKS (TREATMENT UNIT)**

Flocculation tanks and pH adjustment tanks may be used for treatment of wastewater after and before biological treatment, respectively. In flocculation tanks, flocculating agents are added to the wastewater to promote formation of large-particle masses from the fine solids formed during biological treatment. These large particles will then precipitate out of the wastewater in the clarifier that typically follows. Tanks designed for pH adjustment typically precede the biological treatment step. In these tanks, the wastewater pH is adjusted, using acidic or alkaline additives, to prevent shocking of the biological system downstream.

### **2.2.15 SURFACE IMPOUNDMENTS (TREATMENT UNIT)**

Surface impoundments are typically used for evaporation, polishing, equalization, storage prior to further treatment or disposal, leachate collection, and as emergency surge basins. They may be either quiescent or mechanically agitated.

### **2.2.16 AIR AND STEAM STRIPPING (TREATMENT UNIT)**

Air stripping and steam stripping may be used to remove organic constituents in industrial wastewater streams prior to secondary and tertiary treatment devices.

Air stripping involves the contact of wastewater and air to strip out volatile organic constituents. As the volume of air contacting the contaminated water increases, an increase in the transfer rate of the organic compounds into the vapor phase is achieved. Removal efficiencies vary with volatility and solubility of organic impurities. For highly volatile compounds, average removal ranges from 90 to 99 percent, for medium- to low-volatility compounds, removal ranges from less than 50 to 90 percent, though a higher air flow rate may be needed (EPA, 1995).

Steam stripping is the distillation of wastewater to remove volatile organic constituents, with the basic operating principle being the direct contact of steam with wastewater. The steam provides the heat of vaporization for the more volatile organic constituents. Removal efficiencies vary with the amount of steam applied for a given wastewater flow rate and the volatility and solubility of the organic impurities. For highly volatile compounds (Henry's Law constant [HLC] greater than  $10^{-3}$  atm-m<sup>3</sup>/gmol), VOC removal ranges from 95 to 99 percent and can easily be achieved with a sufficient amount of steam. For medium-volatility compounds (HLC between  $10^{-5}$  and  $10^{-3}$  atm-m<sup>3</sup>/gmol), average VOC removal ranges from 90 to 95 percent and would require more steam than needed for more volatile compounds. For low-volatility compounds (HLC less than  $10^{-5}$  atm-m<sup>3</sup>/gmol), average removal ranges from less than 50 to 90 percent (EPA, 1995).

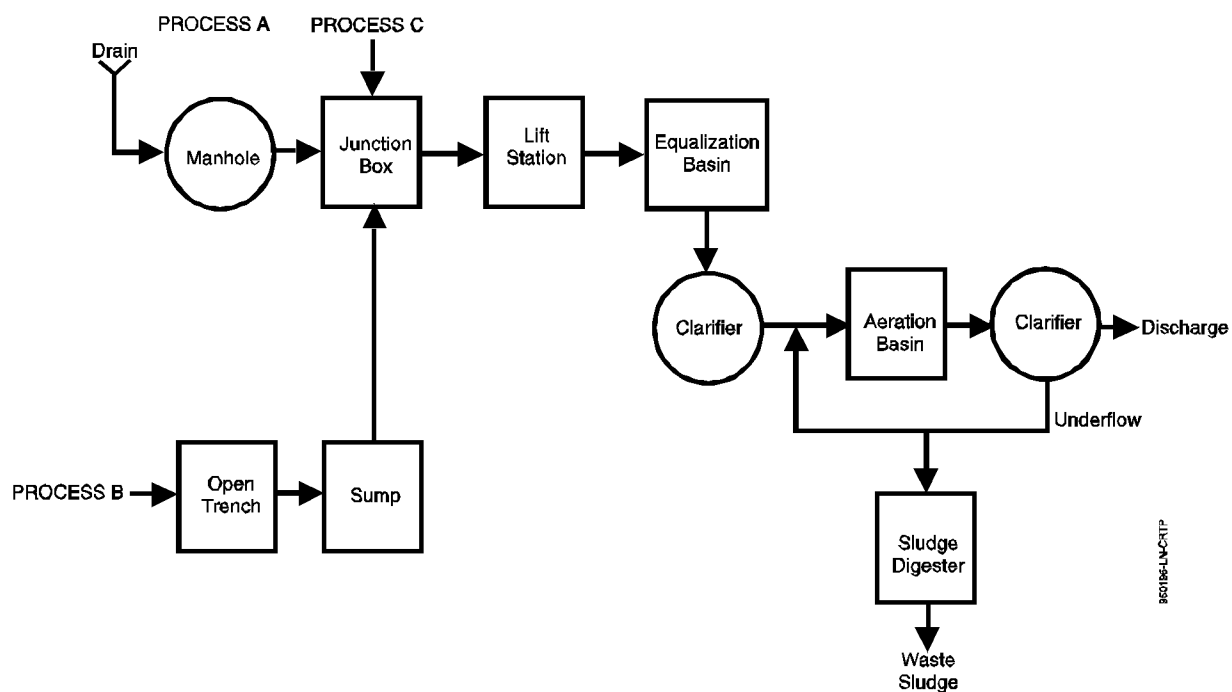
## **2.3 EMISSION SOURCES**

Wastewater streams are collected and treated in a variety of ways. Many of these collection and treatment system units are open to the atmosphere and allow organic-containing wastewaters to contact ambient air. Whenever this happens, there is a potential for VOC emissions. The organic pollutants volatilize in an attempt to exert their equilibrium partial pressure above the wastewater. In doing so, the organics are emitted to the ambient air surrounding the collection and treatment units. The magnitude of VOC emissions depends greatly on many factors such as the physical properties of the pollutants, pollutant concentration, flow rate, the temperature of the wastewater, and the design of the individual collection and treatment units. All of these factors, as well as the general scheme used to collect and treat facility wastewater, have a major effect on VOC emissions.

Collection and treatment schemes are facility specific. The flow rate and organic composition of wastewater streams at a particular facility are functions of the processes used. The wastewater flow rate and composition, in turn, influence the sizes and types of collection and treatment units that must be employed at a given facility.

Figure 5.2-1 illustrates a typical scheme for collecting and treating process wastewater generated at a facility and the opportunity for volatilization of organics.

Drains are often open to the atmosphere and provide an opportunity for volatilization of organics in the wastewater. The drain is normally connected to the process sewer line that carries the wastewater to the downstream collection and treatment units. Figure 5.2-1 illustrates the wastewater being carried past a manhole and on to a junction box where two process wastewater streams are joined. The manhole provides an escape route for organics volatilized in the sewer line. In addition, the junction box may also be open to the atmosphere, allowing organics to volatilize. Wastewater is discharged from



**FIGURE 5.2-1. TYPICAL WASTEWATER COLLECTION AND TREATMENT SYSTEM**

the junction box to a lift station where it is pumped to the treatment system. The lift station is also likely to be open to the atmosphere, allowing volatilization of organics.

The equalization basin, the first treatment unit shown in Figure 5.2-1, regulates the wastewater flow and pollutant compositions to the remaining treatment units. The equalization basin also typically provides a large area for wastewater contact with ambient air. For this reason, emissions may be relatively high from this unit. Suspended solids are removed in the clarifier, and the wastewater then flows to the aeration basin where microorganisms act on the organic constituents. Both the clarifier and the aeration basin may be open to the atmosphere. In addition, the aeration basin is normally aerated either mechanically or with diffused air. Wastewater leaving the aeration basin normally flows through a secondary clarifier for solids removal before it is discharged from the facility. The secondary clarifier is also likely to be open to the atmosphere. The solids that settle in the clarifier are discharged partly to a sludge digester and partly recycled to the aeration basin. Finally, waste sludge from the sludge digester is generally hauled off for land treatment or to a landfill.

In addition to VOC emissions from volatilization, sulfur oxides ( $\text{SO}_x$ ) emissions from the thermal destruction of hydrogen sulfide can occur if methane gas from digesters is used in on-site combustion equipment. Chlorine and chlorinated compounds may be released if the wastewater stream is disinfected using chlorine prior to discharge.

## **2.4 FACTORS AND DESIGN CONSIDERATIONS INFLUENCING EMISSIONS**

### **2.4.1 PROCESS OPERATING FACTORS**

During wastewater treatment, the fate mechanisms of volatilization/stripping, sorption, and biotransformation primarily determine the fate of VOCs (Mihelcic et al., 1993). Of these, it is volatilization and stripping that result in air emissions. Biodegradation and sorption onto sludge serve to suppress air emissions.

Stripping may be defined as pollutant loss from the wastewater due to water movement caused by mechanical agitation, head loss, or air bubbles, while volatilization may be defined as quiescent or wind-driven loss (Mihelcic et al., 1993). The magnitude of emissions from volatilization/stripping depends on factors such as the physical properties of the pollutants (vapor pressure, Henry's Law constants, solubility in water, etc.), the temperature of the wastewater, and the design of the individual collection and treatment units. WWCT unit design is important in determining the surface area of the air-water interface and the degree of mixing occurring in the wastewater.



Biodegradation by microorganisms occurs in biological treatment devices such as aeration basins. Due to the high level of biomass present in aeration basins, organic compounds may also be removed via sorption mechanisms. Parameters important in determining the rate of biodegradation and sorption occurring in aeration basins include the degree of biodegradability of the compound, the affinity of the compound for the organic or aqueous phase, and the biomass concentration in the basin (EPA, 1990). EPA has developed several methods for determining site-specific biodegradation rates for regulatory purposes. These include batch tests (aerated reactor and sealed reactor), as well as EPA Test Methods 304A and 304B. However, if site-specific rate constants are not available, default biodegradation rates are available for many pollutants in several of the emissions models used to estimate emissions. The use of site-specific biodegradation rates will result in a more accurate emission estimate.

Detailed information on the rates of organic removal through biodegradation, sorption, and volatilization are required for accurate emission estimates.

## **2.4.2 CONTROL TECHNIQUES**

The types of control technologies generally used in reducing VOC emissions from wastewater include: steam stripping or air stripping (when followed by a collection device such as a carbon adsorber or a control device such as a flare), carbon adsorption (vapor or liquid phase), chemical oxidation, biotreatment (aerobic or anaerobic), and process modifications. Several of the control techniques (steam/air stripping and carbon adsorption) do not destroy the VOCs, they capture them. VOCs captured by these methods should be recovered or destroyed to prevent air emission releases to the environment.

For efficient control, all control elements should be placed as close as possible to the point of wastewater generation, with all collection, treatment, and storage systems ahead of the control technology being covered to suppress emissions. Tightly covered, well-maintained collection systems can suppress emissions by 95 to 99 percent. However, if there is explosion potential, it can be reduced by a low-volume flow of inert gas into the collection component, followed by venting to a device such as an incinerator or carbon adsorber.

The following are brief descriptions of the control technologies listed above and of any secondary controls that may need to be considered for fugitive air emissions.

### ***Air and Steam Stripping***

Steam stripping and air stripping off gases most often are vented to a secondary control or collection device, such as a combustion device or gas-phase carbon adsorber, in order to prevent air emissions. Combustion devices may include incinerators, boilers, and flares. Vent gases of high fuel value can be used as an alternative fuel and may be combined with

other fuels such as natural gas and fuel oil. If the fuel value of the vent gas stream is very low, vent gases may be preheated and combined with combustion air.

### ***Liquid-phase Carbon Adsorption***

Liquid-phase carbon adsorption takes advantage of compound affinities for activated carbon. Activated carbon is an excellent adsorbent because of its large surface area and because it is usually in granular or powdered form for easy handling. Two types of liquid-phase carbon adsorption are the fixed-bed and moving-bed systems. The fixed-bed system is used primarily for low-flow wastewater streams with contact times around 15 minutes, and it is a batch operation (i.e., once the carbon is spent, the system is taken off line). Moving-bed carbon adsorption systems operate continuously with wastewater typically being introduced from the bottom of the column and regenerated carbon from the top (countercurrent flow). Spent carbon is continuously removed from the bottom of the bed. Liquid-phase carbon adsorption is usually used to recover compounds present in low concentrations or for high concentrations of nondegradable compounds. Removal efficiencies depend on the compound's affinity for activated carbon. Average removal efficiency ranges from 90 to 99 percent, but is dependent on compound concentrations (EPA, 1995).

### ***Chemical Oxidation***

Chemical oxidation involves a chemical reaction between the organic compound and an oxidant such as ozone, hydrogen peroxide, permanganate, or chlorine dioxide. Ozone is usually added to the wastewater through an ultraviolet-ozone reactor. Permanganate and chlorine dioxide are added directly into the wastewater. It is important to note that adding chlorine dioxide can form chlorinated hydrocarbons in a side reaction. The applicability of this technique depends on the reactivity of the individual organic compound.

### ***Biotreatment***

Biotreatment is the aerobic or anaerobic chemical breakdown of organic chemicals by microorganisms. Removal of organics by biodegradation is highly dependent on the compound's biodegradability, volatility, and ability to be adsorbed onto solids. Removal efficiencies range from almost 0 to 100 percent. In an acclimated biotreatment system, the microorganisms easily convert available organics into biological cells or biomass, or CO<sub>2</sub>. This often requires a mixed culture of organisms, where each organism utilizes the food source most suitable to its metabolism. The organisms will starve and the organics will not be biodegraded if a system is not acclimated (i.e., the organisms cannot metabolize the available food source).

### ***Process Modifications***

Emissions from wastewater collection or treatment units may also be reduced by process modifications such as the use of level control gates, closed piping, or covered process units. These techniques reduce emissions by minimizing weir drops, turbulence, and contact with air.

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# 3

## OVERVIEW OF AVAILABLE METHODS

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### 3.1 EMISSION ESTIMATION METHODOLOGIES

Several methodologies are available for calculating fugitive emissions from industrial and municipal wastewater treatment systems. The method used is dependent upon available data, available resources, and the degree of accuracy required in the estimate.

This section discusses the methods available for calculating emissions from WWCT and identifies the preferred method of calculation. The discussion focuses on estimating emissions that occur from stripping mechanisms and the volatilization of pollutants present in wastewater streams.

#### 3.1.1 MANUAL CALCULATIONS

Several EPA documents are available that provide theoretical equations that may be used to calculate emissions from WWCT. These include *Industrial Wastewater Volatile Organic Compound Emissions - Background Information for BACT/LAER Determinations* (EPA-450/3-90-004), *AP-42*, and *Air Emissions Models for Waste and Wastewater* (EPA-453/R-94-080A). The equations are based on mass transfer and liquid-gas equilibrium theory and use individual gas-phase and liquid-phase mass transfer coefficients to estimate overall mass transfer coefficients. Calculating air emissions using these equations is a complex procedure, especially if several systems are present, because the physical properties of the numerous contaminants must be individually determined. Because of the great deal of complexity involved, computer programs are available that incorporate these equations to estimate emissions from WWCT.

#### 3.1.2 EMISSION MODELS

Some emission models currently available are based on measured or empirical values. The computer model may be based on theoretical equations that have been calibrated using actual data. Or, the models may be purely empirical, in which case the equations are usually based on statistical correlations with independent variables. Emissions estimated using models are a function of the WWCT system configuration, the properties of the specific compounds present in the wastewater streams, and the emission estimation approaches used in the model algorithms.

### **3.1.3 GAS-PHASE MEASUREMENT**

Measuring air emissions from large open surfaces common at industrial and municipal wastewater treatment facilities is extremely difficult and perhaps one of the most challenging air quantification problems. Several techniques have been developed for this purpose, including surface emission isolation flux chambers, and transect and fenceline methods. If the industrial process is enclosed and vented, it is possible to directly measure emissions using standard measurement techniques. (Refer to Chapter 1 of this volume for a discussion of available methods.) In particular, POTWs may be covered or enclosed to reduce odor and/or prevent freezing in which case gas-phase measurement may be appropriate.

### **3.1.4 EMISSION FACTORS**

Emission factors have been or are being developed for WWCT for several source categories. These factors have been developed as part of regulatory development projects such as the National Emissions Standards for Hazardous Air Pollutants (NESHAP) for the pulp and paper industry and for petroleum refineries. In some cases, emission factors are based on emissions estimates obtained using models, but have been reduced to a more simplistic form (mass of pollutant per process rate).

In addition, emission factors were developed by a consortium of California POTW operators as part of the Pooled Emissions Estimation Program (PEEP). These factors are not publicly available but may be obtained through Jim Bewley of the South Bayside System Authority at (415) 594-8411.

The PEEP emission factors were developed from field samples at 20 POTWs and cover 18 compounds and 18 processes. Liquid- and gas-phase samples were collected to complete mass balances at plants with similar processes. The emission factors are medians of the measured offgas mass emissions divided by the influent mass. When no data were available, because of "nondetects" or other causes, emission factors were extrapolated by averaging the known emission factors of either chlorinated or nonchlorinated compounds. PEEP factors usually predict significantly lower emissions than BAAT or fate models.

### **3.1.5 MATERIAL BALANCE**

The simplest estimation method, material balance, relies on wastewater flow rate and influent and effluent liquid-phase pollutant concentrations. Compound mass that cannot be accounted for in the effluent is assumed to be volatilized. However, it needs to be noted that this method does not account for biodegradation or sorption onto solids or other removal mechanisms.

## **3.2 COMPARISON OF AVAILABLE EMISSION ESTIMATION METHODOLOGIES**

### **3.2.1 MANUAL CALCULATIONS**

Estimating emissions from WWCT by hand (or by spreadsheets) using the equations presented in the various literature is a very labor-intensive process and increases the potential for manual calculation error. For this reason, the use of manual calculations is not a preferred method, and should only be used in cases where access to models is prohibitive. It should be noted that the equations presented in the EPA document *Air Emissions Model for Waste and Wastewater* (EPA, 1994) have been incorporated into EPA's WATER8 model (discussed in Section 4) to alleviate the burden of performing the calculations by hand.

### **3.2.2 EMISSIONS MODELS**

The use of emissions software models to calculate emissions from WWCT provides a widely accepted method of calculation. Most models are based on the theoretical equations presented in various literature and provide an automated means of performing the calculations. It should be noted that models estimate average emissions over a period of time. Peak or maximum emission rates over a short term may be more accurately assessed using gas-phase measurement or material balance approaches. Also, an in-depth knowledge of the WWCT schemes including pollutant concentrations and flow rate information are needed in order to obtain an accurate emission estimate.

### **3.2.3 GAS-PHASE MEASUREMENT**

Direct and indirect gas-phase measurements are alternative methods of calculating emissions from WWCT. Once pollutant concentrations are known at a specific point, atmospheric dispersion modeling equations may be used to estimate an emission rate. Two potential sources of uncertainty, pollutant measurement error and the representativeness of the statistical dispersion equations for this type of application, are present in this method. In addition, the monitoring equipment needed to perform this method may be cost-prohibitive unless already in place.

If the treatment plant is enclosed and vented through a limited number of vents, traditional stack testing may be used to estimate emissions and would be considered a preferred method.

### **3.2.4 EMISSION FACTORS**

Emission factors may be used to calculate emissions where approximate figures are acceptable. However, due to the variability of emissions based on site-specific operational, physical, and chemical parameters, emission factors should be carefully chosen that are based on similar-type sources.

### **3.2.5 MATERIAL BALANCE**

Material balance calculations are a simple method of estimating emissions where inlet and outlet pollutant concentrations are known.

Other variables also may affect an estimate. Effluent data can be used to account for compounds passing through the plant, but if chlorine is added during treatment, chlorinated compounds that form can result in higher emissions than predicted by a material balance approach. To compensate, intermediate samples must be taken to quantify chlorinated compound emissions.

As mentioned before, material balance does not account for fate mechanisms other than volatilization. For example, it can overestimate emissions if the compound is biodegradable or adsorbs onto sludge.



# 4

## PREFERRED METHOD FOR ESTIMATING EMISSIONS

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The preferred method for estimating emissions from WWCT is the use of computer-based emissions models. There are numerous emissions estimation models available to calculate emissions from WWCT. These include publicly available models as well as proprietary models. Differences in the models include applicability to the types of collection and treatment systems, the level of site-specific data accepted, the level of default data provided, and whether or not the models account for the full spectrum of pollutant pathways (volatilization, biodegradation, and sorption). Models may also contain different default data (e.g., Henry's Law constants, biodegradation rate constants).

Many of these models allow for user input of data. The use of site-specific data is always preferred over the use of default data. Typically, the types of data needed are the chemical and physical properties of the wastewater stream, as well as collection and treatment device parameters. At a minimum, wastewater stream characteristics are needed at the inlet to the treatment plant or collection device. However, if data are available for various points within the treatment plant, a more accurate emissions estimate may be obtained.

In order to obtain a reliable emissions estimate using a software model, the modeler needs to understand both the configuration and wastewater stream characteristics of the collection and/or treatment units, as well as the emissions estimation algorithm used by the model. Not all models can handle all collection/treatment devices and results are likely to vary between models. A more accurate emissions estimate will result if the user has confidence in the input data and understands the emission estimation approach used by the model.

**NOTE:** A brief summary of some currently available models is provided below. Work is ongoing to improve some of the current models and to develop new ones. The discussion presented in this document is not to be interpreted as an endorsement of one model over another, but is provided for informational purposes only. The reader should consult with their state regulatory agency for guidance on the selection and use of an appropriate model. Also, Appendix C contains a reference list of technical articles providing qualitative as well as quantitative comparisons between models and emission estimation techniques.

### 4.1 WATER8/CHEMDAT8 (TREATMENT AND COLLECTION)

WATER8 is a publicly available computer program model developed by EPA that models the

fate of organic compounds in various wastewater treatment units, including collection systems, aerated basins, and other units. WATER8 contains useful features such as the ability to link treatment units to form a treatment system, the ability for recycle among units, and the ability to generate and save site-specific compound properties. WATER8 has a database with compound-specific data for over 950 chemicals. The mathematical equations used to calculate emissions in this model are based on the approaches described in *Air Emissions Models for Waste and Wastewater* (EPA, 1994). The WATER8 model is publicly available on the Clearinghouse for Inventories and Emission Factors (CHIEF) system. Many of the emissions models contained in WATER8 are also presented in spreadsheet form in CHEMDAT8.

## 4.2 BASTE (TREATMENT ONLY)

This model was developed to estimate sewage treatment emissions from treatment plants in the Bay Area of California. BASTE is a computer-based model with menu-driven input and is structured to allow significant flexibility in simulating a wide range of treatment processes. It can simulate the fate of organic compounds in well-mixed to plug-flow reactors, diffused bubble and surface aeration, and emissions from weirs and drops. BASTE is available through the CH<sub>2</sub>M Hill Company.

## 4.3 CORAL+ (COLLECTION ONLY)

CORAL+ is a model that predicts emissions from sewer reaches based on actual data from field experiments. CORAL+ allows for continuous or slug discharges to sewers, variations in depth of flow and temperature, sewer physical conditions, and retardation of mass transfer by gas accumulation in the sewer headspace. Emissions are based on inputs of ventilation rates and patterns. CORAL+ also estimates losses at sewer drop structures and is available through the Enviromega Ltd. Company.

## 4.4 PAVE (TREATMENT ONLY)

This model was developed for the Chemical Manufacturers Association. It simulates the fate of contaminants in both surface-aerated and diffused-air activated sludge systems. The PAVE model offers a selection of different biological kinetic models. It is based on traditional kinetic process modelling for biological reactors and performs the traditional calculations of dissolved oxygen concentration and waste-activated sludge flow. The PAVE model works with compounds that have low volatilities and, therefore, may be gas-phase mass transfer limited. Most other models use oxygen as a mass transfer surrogate so that only liquid-phase mass transfer resistance is considered. PAVE is available through the Chemical Manufacturers Association.

#### **4.5 CINCI (EPA - CINCINNATI MODEL) - INTEGRATED MODEL FOR PREDICTING THE FATE OF ORGANICS IN WASTEWATER TREATMENT PLANTS (TREATMENT ONLY)**

This model was developed with support from the EPA Risk Reduction Engineering Laboratory. The physical properties database of the model includes 196 chemicals and metals, Henry's Law constants, sorption coefficients, biodegradation rate constants, and diffusivities. Removal mechanisms included are stripping/volatilization, stripping, surface volatilization, sorption, and biodegradation. Unit operations included are primary treatment followed by secondary treatment with sludge recycle, secondary treatment with sludge recycle, and secondary treatment without sludge recycle. The model is written in FORTRAN and has three built-in default cases. CINCI is available at no charge through the U.S. EPA Risk Reduction Engineering Laboratory.

#### **4.6 NOCEPM - NCASI ORGANIC COMPOUND ELIMINATION PATHWAY MODEL (TREATMENT ONLY)**

This model was developed by the National Council of the Paper Industry for Air and Stream Improvement, Inc. (NCASI); components were chosen from published literature. This model is also in the public domain. The physical properties database includes 11 chemicals, Henry's Law constants, sorption coefficients, biodegradation rate constants, and diffusion coefficients for 9 chemicals. Conceptual removal mechanisms are stripping, surface aeration, subsurface aeration, surface volatilization, sorption, and biodegradation. NOCEPM simulates only the secondary treatment step, but can represent activated sludge or aerated stabilization. It is written in QuickBasic™ and has no built-in default cases. The model was validated with chloroform for activated sludge and aerated stabilization processes and is available through NCASI.

#### **4.7 TORONTO - A MODEL OF ORGANIC CHEMICAL FATE IN A BIOLOGICAL WASTEWATER TREATMENT PLANT (TREATMENT ONLY)**

This model was developed with the support of the Ontario Ministry of the Environment, from which copies are available. There are 18 chemicals, Henry's Law constants, sorption coefficients, and biodegradation rate constants in the physical properties database. Removal mechanisms include stripping, surface volatilization, sorption, and biodegradation. TORONTO simulates primary sedimentation and secondary (biological) treatment. According to the report, this is a relatively simple model that uses a "fugacity" approach that "takes advantage of the linear relationship of fugacity to concentration to derive a relatively simple

set of linear material balance expressions." Fugacity capacities and rate parameters are calculated for the air, water, and biomass phases. TORONTO is available through the Ontario Ministry of the Environment.

#### **4.8 TOXCHEM+ - TOXIC CHEMICAL MODELING PROGRAM FOR WATER POLLUTION CONTROL PLANTS (TREATMENT AND COLLECTION)**

This model was developed by Enviromega Ltd. Company (Campbellville, Ontario), in cooperation with the Environment Canada Wastewater Technology Centre. The database includes 204 chemicals (including metals) and detailed information on physical properties. The model also includes Henry's Law constants, sorption coefficients, and biodegradation rate constants. The model simulates volatilization, stripping, sorption, and biodegradation removal mechanisms from weirs, surface volatilization, surface aeration, and subsurface aeration. A wide variety of wastewater unit operations can be represented including grit chambers, primary clarifiers, collection reaches, sludge digestion, aeration basins, and secondary clarifiers. Both steady-state and dynamic results can be obtained. TOXCHEM+ is available through the Enviromega Ltd. Company.

# 5

## ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

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### 5.1 EMISSION FACTORS

Emission factors for WWCT are presented in the literature in two forms: traditional emission factors that relate emissions of a particular pollutant to a process rate, and fraction emitted (Fe) emission factors that relate emissions of a particular pollutant to the total amount of that pollutant present in the wastewater stream.

Examples 5.5-1 and 5.5-2 show how process rate emission factors and Fe emission factors may be used to calculate emissions from WWCT.

#### Example 5.5-1

This example shows how toluene emissions can be calculated using Fe and the wastewater stream characteristics provided:

Wastewater flow into collection system	=	4,575,000 gal/day
Toluene concentration	=	4 µg/L
Fe	=	0.35 (for the collection system)
Toluene mass flow rate	=	$4,575,000 \text{ gal/day} * 3.785 \text{ L/gal} * 4 \text{ µg/L} * 10^{-6} \text{ g/µg} * \text{lb}/453.6 \text{ g}$
	=	0.153 lb/day
Toluene emissions	=	$0.35 * 0.153 \text{ lb/day}$
	=	0.054 lb/day

**Example 5.5-2**

This example shows how VOC emissions can be calculated using process rate-based emission factors (EFs) and the process parameters provided:

$$EF_{\text{VOC}} = 0.17 \text{ kg VOC/Mg pulp}$$

$$\text{Process rate} = 27 \text{ Mg pulp/hr}$$

$$\begin{aligned} \text{VOC emissions} &= 27 \text{ Mg pulp/hr} * 0.17 \text{ kg VOC/Mg pulp} * 1,000 \text{ g/1 kg} * \\ &\quad \text{lb/453.6 g} \\ &= 10.1 \text{ lb VOC/hr} \end{aligned}$$

## 5.2 MATERIAL BALANCE

Using a material balance approach to calculate emissions from WWCT is straightforward if the data are available and if the emissions estimate does not require extreme accuracy. In most cases, a material balance calculation will provide an emission estimate that is biased toward overestimating emissions due to the fact that the other (nonair) pollutant removal mechanisms (sorption and biodegradation) are not considered. This approach may be a viable option for collection systems and nonbiologically activated treatment where inlet and outlet pollutant concentrations are known. Example 5.5-3 shows how a material balance approach may be used to calculate emissions from WWCT.

## 5.3 MANUAL CALCULATIONS

Appendix B provides example calculations using the mass transfer equations presented in *AP-42*. The equations, along with guidance on how to use them, are included. (Please note that while the *AP-42* section still refers to the SIMS model, this has been superseded by the WATER8 model, which is available on the CHIEF BBS. Therefore, as of the writing of this document, *AP-42* is not consistent with EPA's method of choice for estimating emissions from wastewater treatment.)

**Example 5.5-3**

This example shows how toluene emissions can be calculated using a material balance approach. The wastewater stream is the same as that considered in Example 5.5-1. However, in this example, it is known that the wastewater stream exiting the collection system has a toluene concentration of 2 µg/L:

Wastewater flow	=	4,575,000 gal/day
Toluene concentration at inlet	=	4 µg/L
Toluene concentration at outlet	=	2 µg/L
Toluene lost through system =	4 µg/L - 2 µg/L = 2 µg/L	
Toluene emissions	=	4,575,000 gal/day * 3.785 L/gal * 2 µg/L * 10 <sup>-6</sup> g/µg * lb/453.6 g
	=	0.0764 lb/day

## 5.4 GAS-PHASE MEASUREMENT

### 5.4.1 DIRECT MEASUREMENT

The surface isolation flux chamber is the only commonly accepted direct measurement technique available for open wastewater surfaces. When properly placed and operated, the flux chamber accurately measures surface emissions. Total surface emissions are calculated by multiplying the values from the individual flux chamber measurements by the surface area each measurement represents. This can be quite challenging for processes that are not completely mixed and may have unique emissions at every point on the surface. For these cases, modeling can be used to interpolate surface emission values between flux chamber measurement points. This method is not suitable for estimating emissions of compounds with low volatility.

Treatment processes that are enclosed or covered may lend themselves to traditional stack testing methods for emission estimation purposes. If a collection system or treatment plant is well covered and vented through a limited number of openings, direct measurement (such as the use of EPA Method 25) may be considered a preferred, rather than an alternative, method of emission estimation.

### **5.4.2 INDIRECT MEASUREMENT**

Indirect measurement techniques, including transect and fenceline sensing, primarily are used for estimating fugitive emissions from area sources.

Transect and fenceline methods are both indirect measurement techniques that rely on dispersion modeling to predict the emission rate based on measurements of the ambient pollutant concentrations in the emission plume.

The transect method typically uses both vertically and horizontally dispersed measurement points positioned close to the source.



# 6

## QUALITY ASSURANCE/QUALITY CONTROL

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The consistent use of standardized methods and procedures is essential in the compilation of reliable emission inventories. Quality assurance (QA) and quality control (QC) of an inventory are accomplished through a set of procedures that ensure the quality and reliability of data collection and analysis. These procedures include the use of appropriate emission estimation techniques, applicable and reasonable assumptions, accuracy/logic checks of computer models, checks of calculations, and data reliability checks. Depending upon the technical approach used to estimate emissions, a checklist with all of the particular data needs should be prepared to verify that each piece of information is used accurately and appropriately.

This section discusses QA/QC procedures for specific emission estimation methods presented in Sections 4 and 5 of this chapter. Volume VI, *Quality Assurance Procedures*, of this series describes additional QA/QC methods and tools for performing these procedures. Also, Volume II, Chapter 1, *Introduction to Stationary Point Source Emission Inventory Development*, presents recommended standard procedures to follow to ensure that the reported inventory data are complete and accurate.

### 6.1 GENERAL FACTORS INVOLVED IN EMISSION ESTIMATION TECHNIQUES

All calculations, whether done manually or electronically, should be verified by repeating at least one complete set of calculations. If a computer model is being used, verification that the calculations are done correctly need only be done once (until the model is updated or modified). The model verification process should be documented carefully (see Volume VI, Chapter 3, Section 4). Although this level of checking for a program can require a significant amount of time, it is necessary. Furthermore, given that these programs are generally used many times over, the effort required to check the algorithms is relatively small.

Manual calculations should be checked even more carefully, although completely replicating the set of equations is overly burdensome. Because manual calculations introduce more possibility for errors, are difficult to quality assure, and are harder to revise or update later, use of a spreadsheet or other electronic tool is strongly advised. Often, emissions inventories are developed and/or compiled in computerized emissions

databases or models. Presumably, the methods, assumptions, and any data included with the software are documented in a user's or a technical manual. If not, the user should conduct extensive and careful QA of the model or find a better documented system.

Even if the validation of the system is well-documented, the user will need to provide information about the input data. Comment fields, if available and sufficiently large, can be used to record assumptions, data references, and any other pertinent information.

Alternatively, this information can be recorded in a separate document, electronically or otherwise. If at all possible, the electronic database should record a cross-reference to the document. This cross-reference could be a file name (and directory or disk number), a notebook identification number, or other document.

### **6.1.1 EMISSIONS MODELS**

Use of emission models and equations generally involves more effort than use of emission factors. The level of effort is related to the complexity of the equation, the types of data that must be collected, and the diversity of products manufactured at a facility. Typically, the use of emission models involves making one or more conservative assumptions if a complete set of site-specific data is unavailable. As a result, the use of models may result in an overestimation of emissions. However, the accuracy and reliability of models can be improved by ensuring that data collected for emission calculations (e.g., material speciation data) are of the highest possible quality.

The EIIP recommends that sensitivity analyses be used as part of the QA program for emissions models. A sensitivity analysis is a process for identifying the magnitude, direction, and form of the effect of an individual parameter on the model's result. It is usually done by repeatedly running the model and changing the value of one variable while holding the others constant. Sensitivity analyses may be used to select the most appropriate model for a given situation. For example, one model may be particularly sensitive to errors in a variable that is not reliably measured. An alternative model may be found that is better suited to the available data. Sensitivity analyses also aid QC by identifying the key variables to be checked.

### **6.1.2 GAS-PHASE MEASUREMENT**

When applying this technique for estimating emissions, sampling and analytical procedures, use of data, preparation and use of a QA plan, and report preparation should be described and understood by the team conducting the test. A systems audit should be conducted on-site as a qualitative review of the various aspects of a total sampling and analytical system to assess its overall effectiveness. For detailed information pertaining to specific test methods, procedures described in the published reference methods should be reviewed, as well as, Chapter 1 of this volume.

### 6.1.3 EMISSION FACTORS

The use of emission factors is straightforward when the relationship between process data and emissions is direct and relatively uncomplicated. When using emission factors, the user should be aware of the quality indicator associated with the value. Emission factors published within EPA documents and electronic tools have a quality rating applied to them. The lower the quality indicator, the more likely that a given emission factor may not be representative of the source type. The reliability and uncertainty of using emission factors as an emission estimation technique are discussed in detail in the QA/QC section of Chapter 1 of this volume.

### 6.1.4 MATERIAL BALANCE

As stated in Section 5, the accuracy and reliability of emission values calculated using the material balance approach are biased toward overestimation. Uncertainty of emissions using the material balance approach is also related to the quality of material speciation data, which is typically extracted from Material Safety Data Sheets (MSDSs). To assess the level of uncertainty of such data, the user should verify if a standard analytical test method (e.g., one using a gas chromatograph) has been used to measure the concentrations of the constituents.

## 6.2 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

One measure of emission inventory data quality is the DARS score. Four examples are given here to illustrate DARS scoring using the preferred and alternative methods presented in this document. The DARS provides a numerical ranking on a scale of 0.1 to 1.0 for individual attributes of the emission factor and the activity data. Each score is based on what is known about the factor and activity data, such as the specificity to the source category and the measurement technique employed. The composite attribute score for the emissions estimate can be viewed as a statement of the confidence that can be placed in the data. For a complete discussion of DARS and other rating systems, see the *Quality Assurance Procedures* (Volume VI, Chapter 4) and *Introduction to Stationary Point Sources Emission Inventory Development* (Volume II, Chapter 1).

Each of the examples below is hypothetical. A range is given where appropriate to cover different situations. Table 5.6-1 shows scores developed from the use of emission models. Table 5.6-2 demonstrates scores determined for gas-phase measurement. Table 5.6-3 gives a set of scores for an estimate made with an emission factor. Table 5.6-4 demonstrates scores developed from a material balance approach. The activity data are assumed to be measured directly or indirectly. These examples are given as an illustration of the relative quality of each method. If the same analysis were done for an actual site, the scores could be different but the relative ranking of methods should stay the same.

**TABLE 5.6-1**  
**DARS SCORES: EMISSION MODELS**

Attribute	Scores		
	Factor <sup>a</sup>	Activity <sup>b</sup>	Emissions
Measurement	0.3 - 0.9	1.0	0.3 - 0.9
Specificity	0.5 - 0.9	0.9	0.45 - 0.81
Spatial	1.0	1.0	1.0
Temporal	1.0	0.5 - 0.9	0.5 - 0.9
Composite Scores	0.75 - 0.95	0.85 - 0.95	0.56 - 0.90

<sup>a</sup> Lower scores apply to purely theoretical models and/or use of defaults rather than site-specific input values.

<sup>b</sup> Scores assume activity is volume of wastewater processed and that it is measured.

**TABLE 5.6-2**  
**DARS SCORES: GAS-PHASE MEASUREMENT**

Attribute	Scores		
	Factor <sup>a</sup>	Activity <sup>b</sup>	Emissions
Measurement	0.5 - 1.0	1.0	0.5 - 1.0
Specificity	0.7 - 1.0	0.9	0.63 - 0.9
Spatial	0.5 - 1.0	1.0	0.5 - 1.0
Temporal	0.5 - 1.0	0.7 - 1.0	0.35 - 1.0
Composite Scores	0.55 - 1.0	0.9 - 0.98	0.50 - 0.98

<sup>a</sup> Exact score will depend on sample size, method used, and whether scales are appropriate to inventory.

<sup>b</sup> Assumes activity is wastewater processed and measured.

**TABLE 5.6-3**  
**DARS SCORES: EMISSION FACTORS**

Attribute	Scores		
	Factor	Activity <sup>a</sup>	Emissions
Measurement	0.3 - 0.5	1.0	0.3 - 0.5
Specificity	0.3 - 0.7	0.9	0.21 - 0.63
Spatial	1.0	1.0	1.0
Temporal	0.8	0.8	0.5 - 0.9
Composite Scores	0.45 - 0.85	0.78 - 0.98	0.40 - 0.76

<sup>a</sup> Scores assume activity is volume of wastewater processed and that it is measured.

**TABLE 5.6-4**  
**DARS SCORES: MATERIAL BALANCE**

Attribute	Scores		
	Factor	Activity	Emissions
Measurement <sup>a</sup>	0.5 - 0.7	1.0	0.5 - 0.7
Specificity	1.0	1.0	1.0
Spatial	1.0	1.0	1.0
Temporal <sup>b</sup>	0.5 - 1.0	0.5 - 1.0	0.25 - 1.0
Composite Scores	0.75 - 0.93	0.88 - 1.0	0.69 - 0.93

<sup>a</sup> Score increases as sample sizes (influent and effluent) increase.

<sup>b</sup> If influent/effluent concentrations are scaled up or down, lower DARS scores.

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# 7

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# **APPENDIX A**

## **EXAMPLE DATA COLLECTION FORMS-WASTEWATER TREATMENT UNITS**

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## **EXAMPLE DATA COLLECTION FORMS INSTRUCTIONS**

1. These forms may be used as work sheets to aid the plant engineer in collecting the information necessary to calculate emissions from wastewater treatment units. The information requested on the forms relates to the methods (described in Sections 3 through 5) for quantifying emissions. These forms may also be used by regulatory agency personnel to assist in area-wide inventory preparation.
2. The completed forms should be maintained in a reference file by the plant engineer with other supporting documentation.
3. If the information requested is unknown, write "unknown" in the blank. If the information requested does not apply to a particular unit, write "NA" in the blank.
4. If you want to modify the form to better serve your needs, an electronic copy of the form may be obtained through the EIIP on the Clearinghouse for Inventories and Emission Factors system (CHIEF ).
5. Table A-1 can be used as a reference for typical dimensions associated with each unit design parameter.
6. Use the comments field on the form to record all useful information that will allow your work to be reviewed and reconstructed.

**TABLE A-1****DIMENSIONS FOR WASTE STREAM COLLECTION AND TREATMENT UNITS<sup>a</sup>**

<b>Component</b>	<b>Design Parameter</b>	<b>Typical Dimensions</b>
Drain	riser height (m)	0.6
	riser diameter (m)	0.2
	process drain pipe diameter (m)	0.1
	effective diameter of riser (m)	0.1
	riser cap thickness (cm)	0.6
	sewer diameter (m)	0.9
Manhole	diameter (m)	1.2
	height (m)	1.2
	cover diameter (m)	0.6
	diameter of holes in cover (cm)	2.5
	cover thickness (cm)	0.6
	sewer diameter (m <sup>2</sup> )	0.9
Junction Box	effective diameter (m)	0.9
	grade height (m)	1.5
	water depth (m)	0.9
	surface area (m <sup>2</sup> )	0.7
Lift Station	effective diameter (m)	1.5
	width (m)	1.8
	grade height (m)	2.1
	water depth (m)	1.5
	surface area (m <sup>2</sup> )	1.8
Trench	length (m)	15.2
	water depth (m)	0.6
	depth (m)	0.8
	width (m)	0.6
Weir	height (m)	1.8
Oil/Water Separator	length (m)	13.7
	width (m)	7.6
	retention time (hr)	0.8

**TABLE A-1**  
**(CONTINUED)**

<b>Component</b>	<b>Design Parameter</b>	<b>Typical Dimensions</b>
Clarifier	diameter (m)	18.3
	depth (m)	3.5
	retention time (hr)	4.0
Sump	effective diameter (m)	1.5
	water depth (m)	1.5
	surface area (m <sup>2</sup> )	1.8
Equalization Basin	effective diameter (m)	109
	water depth (m)	2.9
	surface area (m <sup>2</sup> )	9,290
	retention time (days)	5
Aeration Basin	effective diameter (m)	150
	water depth (m)	2.0
	surface area (m <sup>2</sup> )	17,652
	retention time (days)	6.5
Treatment Tank	effective diameter (m)	11
	water depth (m)	4.9
	surface area (m <sup>2</sup> )	93
	retention time (hr)	2

<sup>a</sup> EPA. 1990. *Industrial Wastewater Volatile Organic Compound Emissions-Background Information for BACT/LAER Determinations*. U.S. Environmental Protection Agency, EPA-450/3-90-004. Research Triangle Park, North Carolina.

**EXAMPLE DATA COLLECTION FORM - WASTEWATER UNITS**

<b>GENERAL INFORMATION</b>		
Facility/Plant Name:		
SIC Code:		
SCC:		
SCC Description:		
Location:		
County:	City:	State:
Plant Geographical Coordinates:		
Latitude:		
Longitude:		
UTM Zone:		
UTM Easting:		
UTM Northing:		
Contact Name:		
Title:		
Telephone Number:	Facsimile Number:	
Source ID Number:	Unit ID Number:	
Permit Number:		
Permitted Hours of Operation (per year):		
Actual Hours of Operation:		
Hours/Day:	Days/Weeks:	Weeks/Year:

**EXAMPLE DATA COLLECTION FORM - WASTEWATER UNITS**

<b>UNIT DESCRIPTION<sup>a</sup></b>
UNIT NUMBER ____ of ____
Junction box:
Reach:
Drain:
Drain type:
Lift station:
Sump:
Weir:
Other:
<b>CONFIGURATION</b>
Flowthrough:
Disposal:
<b>MECHANICAL AERATION</b>
Diffused air:
Biodegradation:
Oil film layer:
<b>DESIGN PARAMETERS</b>
Volume flow rate (units):
Surface area (units):
Liquid depth (units):
Width (units):
Fetch length (units):
Retention time (turnover/yr):
Pollutant of interest:
Concentration before treatment:

<sup>a</sup> Refer to Table A-1 for typical dimensions associated with design parameters.

### INPUT DATA FOR MODELING WASTEWATER TREATMENT SYSTEMS

<b>COLLECTION SYSTEM</b>			
Please fill out the following information for each unit. Attach additional sheets as needed.			
<b>TRUNK/REACH</b>	<b>UNIT NUMBER</b>	<b>UNIT NUMBER</b>	<b>UNIT NUMBER</b>
Wastewater flow:			
Open or closed channel:			
Reach (channel) diameter:			
Reach surface roughness: (e.g., smooth, concrete, tile, pipe)			
Reach slope:			
Reach length:			
Wastewater temperature:			
Water concentration of known organics:			
Manholes and drop structures:			
Manhole gas volume:			
Tailwater depth in manhole:			
Air concentration of VOCs (if available):			
Water drop height in drop structure (height of splashing flow):			
Wind speed or ventilation rate in sewer:			



**INPUT DATA FOR MODELING WASTEWATER TREATMENT SYSTEMS (CONTINUED)**

BASINS & TANKS	COMMENTS
Flow rates and composition:	
Influent flow rate to unit (gal/hr):	
Recycle flow rate from clarifier (gal/hr):	
Feed influent organics:	
Major components (mg/L):	
Total organics (mg/L):	
Microorganism level in recycle (mg/L MLVSS <sup>a</sup> ):	
Microorganism level in basin (mg/L MLVSS):	
Microorganism level in feed (mg/L MLVSS):	
Microorganism level in clarifier effluent (mg/L MLVSS):	
Oxygen concentration in feed (ppm):	
Oxygen concentration in basin (ppm):	
Basin geometry and characteristics:	
Volume (gal):	
Depth (ft):	
Surface area (ft <sup>2</sup> ):	
Temperature of liquid in basin (°C):	
Number of turbines:	
Turbine speed (rpm):	
Delivered power of turbine (hp/turbine):	
Oxygen transfer rating of turbine (lb of O <sub>2</sub> /hp-hr):	
Diameter of turbine blade (ft):	
For subsurface aeration:	
Air flow to basin (ft <sup>3</sup> /min):	
Liquid injection rate (ft <sup>3</sup> /hr):	
Biodegradation rates:	
Overall removal efficiency (%):	
Compound-specific biorates (if known):	

<sup>a</sup> MLVSS = mixed liquor volatile suspended solids.

## EMISSION ESTIMATION RESULTS

Pollutant	Emission Estimation Method <sup>a</sup>	Annual Emissions	Emissions Units	Emission Factor <sup>b</sup>	Emission Factor Units	Comments
VOC						
Hazardous Air Pollutants (list individually)						

<sup>a</sup> Use the following codes to indicate which emission estimation method is used for each pollutant:

Emission Factor = EF; Other (indicate) = O; Model (indicate which model was used) = M.

<sup>b</sup> Where applicable, enter the emission factor and provide the full citation of the reference or source of information from where the emission factor came. Include edition, version, table, and page numbers if *AP-42* is used.

Please copy blank form and attach additional sheets as needed.

# APPENDIX B

## ***AP-42* EMISSION ESTIMATION ALGORITHM AND EXAMPLE CALCULATIONS**

Source: EPA. January 1995. "Waste Water Collection, Treatment and Storage" (Section 4.3.2). In: *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, Fifth Edition, AP-42*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina.

Note: *AP-42* refers to the SIMS model although it has been superseded by the WATER8 model, which is available on the CHIEF BBS.

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## EMISSIONS

Volatile organic compounds (VOCs) are emitted from wastewater collection, treatment, and storage systems through volatilization of organic compounds at the liquid surface. Emissions can occur by diffusive or convective mechanisms, or both. Diffusion occurs when organic concentrations at the water surface are much higher than ambient concentrations. The organics volatilize or diffuse into the air, in an attempt to reach equilibrium between aqueous and vapor phases. Convection occurs when air flows over the water surface, sweeping organic vapors from the water surface into the air. The rate of volatilization relates directly to the speed of the air flow over the water surface.

Other factors that can affect the rate of volatilization include wastewater surface area, temperature, and turbulence; wastewater retention time in the system(s); the depth of the wastewater in the system(s); the concentration of organic compounds in the wastewater and their physical properties, such as volatility and diffusivity in water; the presence of a mechanism that inhibits volatilization, such as an oil film; or a competing mechanism, such as biodegradation.

The rate of volatilization can be determined by using mass transfer theory. Individual gas phase and liquid phase mass transfer coefficients ( $k_g$  and  $k_l$ , respectively) are used to estimate overall mass transfer coefficients ( $K$ ,  $K_{oil}$ , and  $K_D$ ) for each VOC.<sup>1-2</sup> Figure 5.B-1 presents a flow diagram to assist in determining the appropriate emissions model for estimating VOC emissions from various types of wastewater treatment, storage, and collection systems. Tables 5.B-1 and 5.B-2, respectively, present the emission model equations and definitions.

VOCs vary in their degree of volatility. The emission models presented in this section can be used for high-, medium-, and low-volatility organic compounds. The Henry's Law constant (HLC) is often used as a measure of a compound's volatility, or the diffusion of organics into the air relative to diffusion through liquids. High-volatility VOCs are  $HLC > 10^{-3} \text{ atm-m}^3/\text{gmol}$ ; medium-volatility VOCs are  $10^{-3} < HLC < 10^{-5} \text{ atm-m}^3/\text{gmol}$ ; and low-volatility VOCs are  $HLC < 10^{-5} \text{ atm-m}^3/\text{gmol}$ .<sup>1</sup>

The design and arrangement of collection, treatment, and storage systems are facility-specific; therefore the most accurate wastewater emissions estimate will come from actual tests of a facility (i.e., tracer studies or direct measurement of emissions from openings). If actual data are unavailable, the emission models provided in this section can be used.

Emission models should be given site-specific information whenever it is available. The most extensive characterization of an actual system will produce the most accurate

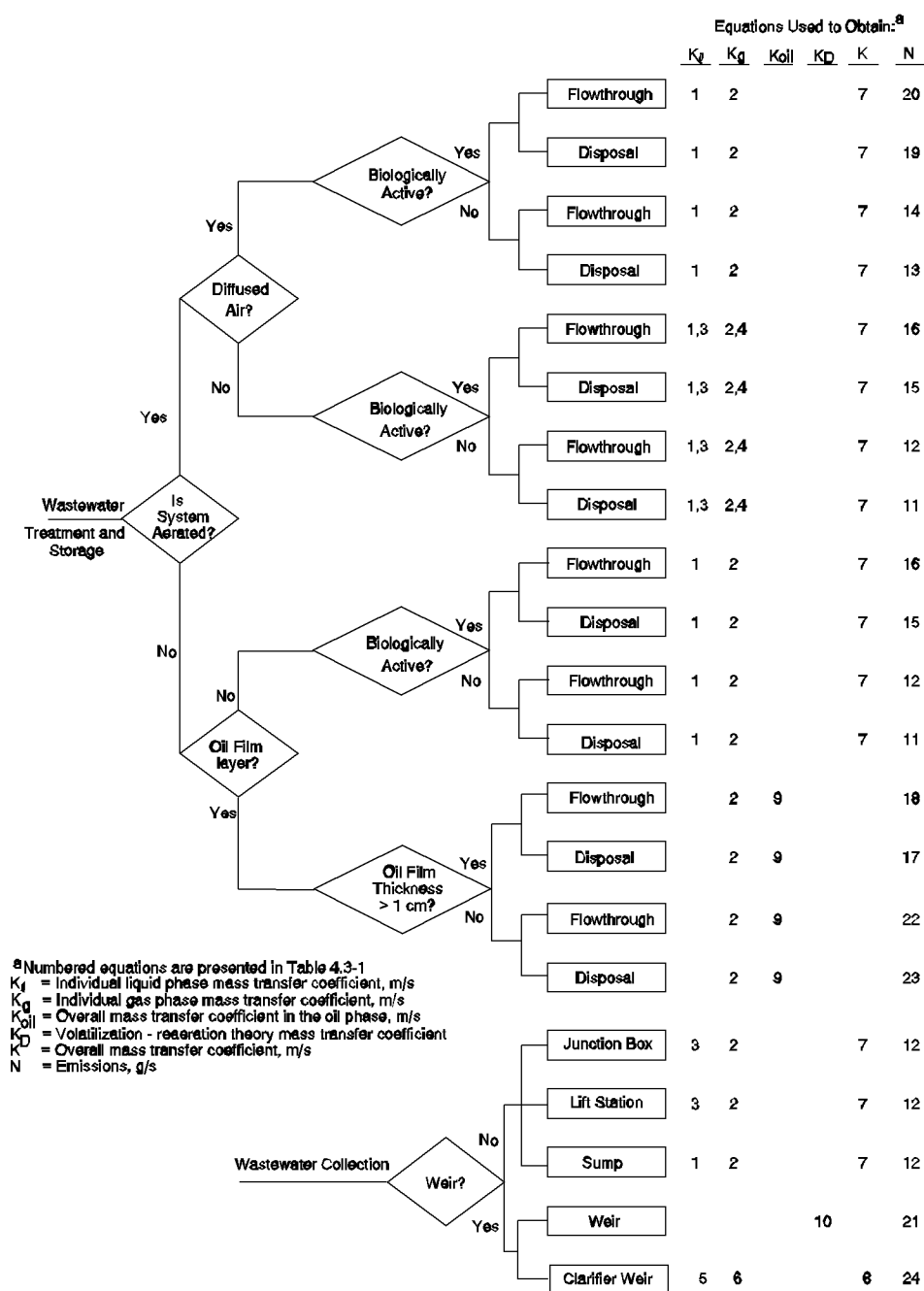


Figure 5.B-1. Flow diagram for estimating VOC emissions from wastewater collection, treatment, and storage systems.

<sup>a</sup> Citation refers to table assignment number in AP-42.

TABLE 5.B-1

MASS TRANSFER CORRELATIONS AND EMISSIONS EQUATIONS<sup>a</sup>

Equation No.	Equation
<u>Individual liquid (<math>k_\ell</math>) and gas (<math>k_g</math>) phase mass transfer coefficients</u>	
1	$k_\ell \text{ (m/s)} = (2.78 \times 10^{-6})(D_w/D_{\text{ether}})^{2/3}$ <p>For: <math>0 &lt; U_{10} &lt; 3.25 \text{ m/s}</math> and all <math>F/D</math> ratios</p> $k_\ell \text{ (m/s)} = [(2.605 \times 10^{-9})(F/D) + (1.277 \times 10^{-7})](U_{10})^2(D_w/D_{\text{ether}})^{2/3}$ <p>For: <math>U_{10} &gt; 3.25 \text{ m/s}</math> and <math>14 &lt; F/D &lt; 51.2</math></p> $k_\ell \text{ (m/s)} = (2.61 \times 10^{-7})(U_{10})^2(D_w/D_{\text{ether}})^{2/3}$ <p>For: <math>U_{10} &gt; 3.25 \text{ m/s}</math> and <math>F/D &gt; 51.2</math></p> $k_\ell \text{ (m/s)} = 1.0 \times 10^{-6} + 144 \times 10^{-4} (U^*)^{2.2} (Sc_L)^{-0.5}; U^* < 0.3$ $k_\ell \text{ (m/s)} = 1.0 \times 10^{-6} + 34.1 \times 10^{-4} U^* (Sc_L)^{-0.5}; U^* > 0.3$ <p>For: <math>U_{10} &gt; 3.25 \text{ m/s}</math> and <math>F/D &lt; 14</math></p> <p>where:</p> $U^* \text{ (m/s)} = (0.01)(U_{10})(6.1 + 0.63(U_{10}))^{0.5}$ $Sc_L = \mu_L/(\rho_L D_w)$ $F/D = 2 (A/\pi)^{0.5}$
2	$k_g \text{ (m/s)} = (4.82 \times 10^{-3})(U_{10})^{0.78} (Sc_G)^{-0.67} (d_e)^{-0.11}$ <p>where:</p> $Sc_G = \mu_a/(\rho_a D_a)$ $d_e \text{ (m)} = 2(A/\pi)^{0.5}$
3	$k_\ell \text{ (m/s)} = [(8.22 \times 10^{-9})(J)(\text{POWR})(1.024)^{(T-20)}(O_t)(10^6) * (MW_L)/(V a_v \rho_L)](D_w/D_{O2,w})^{0.5}$ <p>where:</p> $\text{POWR (hp)} = (\text{total power to aerators})(V)$ $V a_v \text{ (ft}^2\text{)} = (\text{fraction of area agitated})(A)$
4	$k_g \text{ (m/s)} = (1.35 \times 10^{-7})(\text{Re})^{1.42} (P)^{0.4} (Sc_G)^{0.5} (\text{Fr})^{-0.21} (D_a \text{ MW}_a/d)$ <p>where:</p> $\text{Re} = d^2 w \rho_a / \mu_a$ $P = [(0.85)(\text{POWR})(550 \text{ ft-lb}_f/\text{s-hp})/N_I] g_c / (\rho_L (d^*)^5 w^3)$ $Sc_G = \mu_a/(\rho_a D_a)$ $\text{Fr} = (d^*)w^2/g_c$

TABLE 5.B-1

(CONTINUED)

Equation No.	Equation
5	$k_\ell \text{ (m/s)} = (f_{\text{air},\ell})(Q)/[3600 \text{ s/min } (h_c)(\pi d_c)]$ <p>where:</p> $f_{\text{air},\ell} = 1 - 1/r$ $r = \exp [0.77(h_c)^{0.623}(Q/\pi d_c)^{0.66}(D_w/D_{O2,w})^{0.66}]$
6	$k_g \text{ (m/s)} = 0.001 + (0.0462(U^{**})(Sc_G)^{-0.67})$ <p>where:</p> $U^{**} \text{ (m/s)} = [6.1 + (0.63)(U_{10})]^{0.5}(U_{10}/100)$ $Sc_G = \mu_a/(\rho_a D_a)$
<u>Overall mass transfer coefficients for water (K) and oil (K<sub>oil</sub>) phases and for weirs (K<sub>D</sub>)</u>	
7	$K = (k_\ell K_{eq} k_g)/(K_{eq} k_g + k_\ell)$ <p>where:</p> $K_{eq} = H/(RT)$
8	$K \text{ (m/s)} = [[MW_L/(k_{\ell PL}^*(100 \text{ cm/m}))] + [MW_a/(k_g \rho_a H^* 55,555(100 \text{ cm/m}))]]^{-1} MW_L/[(100 \text{ cm/m})\rho_L]$
9	$K_{oil} = k_g K_{eq_{oil}}$ <p>where:</p> $K_{eq_{oil}} = P^* \rho_a MW_{oil}/(\rho_{oil} MW_a P_o)$
10	$K_D = 0.16h (D_w/D_{O2,w})^{0.75}$
<u>Air emissions (N)</u>	
11	$N(\text{g/s}) = (1 - Ct/Co) V Co/t$ <p>where:</p> $Ct/Co = \exp[-K A t/V]$



TABLE 5.B-1

(CONTINUED)

Equation No.	Equation
12	$N(g/s) = K C_L A$ <p>where:</p> $C_L(g/m^3) = Q Co/(KA + Q)$
13	$N(g/s) = (1 - Ct/Co) V Co/t$ <p>where:</p> $Ct/Co = \exp[-(KA + KeqQ_a)t/V]$
14	$N(g/s) = (KA + Q_a Keq)C_L$ <p>where:</p> $C_L(g/m^3) = QCo/(KA + Q + Q_a Keq)$
15	$N(g/s) = (1 - Ct/Co) KA/(KA + K_{max} b_i V/K_s) V Co/t$ <p>where:</p> $Ct/Co = \exp[-K_{max} b_i t/K_s - K A t/V]$
16	$N(g/s) = K C_L A$ <p>where:</p> $C_L(g/m^3) = [-b + (b^2 - 4ac)^{0.5}]/(2a)$ <p>and:</p> $a = KA/Q + 1$ $b = K_s(KA/Q + 1) + K_{max} b_i V/Q - Co$ $c = -K_s Co$
17	$N(g/s) = (1 - Ct_{oil}/Co_{oil})V_{oil}Co_{oil}/t$ <p>where:</p> $Ct_{oil}/Co_{oil} = \exp[-K_{oil} t/D_{oil}]$ <p>and:</p> $Co_{oil} = Kow Co/[1 - FO + FO(Kow)]$ $V_{oil} = (FO)(V)$ $D_{oil} = (FO)(V)/A$

TABLE 5.B-1

(CONTINUED)

Equation No.	Equation
18	$N(g/s) = K_{oil} C_{L,oil} A$ <p>where:</p> $C_{L,oil}(g/m^3) = Q_{oil} Co_{oil} / (K_{oil} A + Q_{oil})$ <p>and:</p> $Co_{oil} = Kow Co / [1 - FO + FO(Kow)]$ $Q_{oil} = (FO)(Q)$
19	$N(g/s) = (1 - Ct/Co)(KA + Q_a K_{eq}) / (KA + Q_a K_{eq} + K_{max} b_i V / K_s) V Co / t$ <p>where:</p> $Ct/Co = \exp[-(KA + K_{eq} Q_a)t/V - K_{max} b_i t/K_s]$
20	$N(g/s) = (KA + Q_a K_{eq}) C_L$ <p>where:</p> $C_L(g/m^3) = [-b + (b^2 - 4ac)^{0.5}] / (2a)$ <p>and:</p> $a = (KA + Q_a K_{eq}) / Q + 1$ $b = K_s [(KA + Q_a K_{eq}) / Q + 1] + K_{max} b_i V / Q - Co$ $c = -K_s Co$
21	$N(g/s) = (1 - \exp[-K_D]) Q Co$
22	$N(g/s) = K_{oil} C_{L,oil} A$ <p>where:</p> $C_{L,oil}(g/m^3) = Q_{oil} (Co_{oil}^*) / (K_{oil} A + Q_{oil})$ <p>and:</p> $Co_{oil}^* = Co / FO$ $Q_{oil} = (FO)(Q)$

TABLE 5.B-1

(CONTINUED)

Equation No.	Equation
23	$N(\text{g/s}) = (1 - C_{t_{oil}}/C_{o_{oil}}^*)(V_{oil})(C_{o_{oil}}^*)/t$ <p>where:</p> $C_{t_{oil}}/C_{o_{oil}}^* = \exp[-K_{oil} t/D_{oil}]$ <p>and:</p> $C_{o_{oil}}^* = C_o/FO$ $V_{oil} = (FO)(V)$ $D_{oil} = (FO)(V)/A$
24	$N(\text{g/s}) = (1 - \exp[-K \pi d_c h_c/Q])Q C_o$

<sup>a</sup> All parameters in numbered equations are defined in Table 5.B-2.

TABLE 5.B-2

**PARAMETER DEFINITIONS FOR MASS TRANSFER CORRELATIONS  
AND EMISSIONS EQUATIONS**

Parameter	Definition	Units	Code <sup>a</sup>
A	Wastewater surface area	m <sup>2</sup> or ft <sup>2</sup>	A
b <sub>i</sub>	Biomass concentration (total biological solids)	g/m <sup>3</sup>	B
C <sub>L</sub>	Concentration of constituent in the liquid phase	g/m <sup>3</sup>	D
C <sub>L,oil</sub>	Concentration of constituent in the oil phase	g/m <sup>3</sup>	D
Co	Initial concentration of constituent in the liquid phase	g/m <sup>3</sup>	A
Co <sub>oil</sub>	Initial concentration of constituent in the oil phase considering mass transfer resistance between water and oil phases	g/m <sup>3</sup>	D
Co <sub>oil</sub> <sup>*</sup>	Initial concentration of constituent in the oil phase considering no mass transfer resistance between water and oil phases	g/m <sup>3</sup>	D
Ct	Concentration of constituent in the liquid phase at time = t	g/m <sup>3</sup>	D
Ct <sub>oil</sub>	Concentration of constituent in the oil phase at time = t	g/m <sup>3</sup>	D
d	Impeller diameter	cm	B
D	Wastewater depth	m or ft	A,B
d <sup>*</sup>	Impeller diameter	ft	B
D <sub>a</sub>	Diffusivity of constituent in air	cm <sup>2</sup> /s	C
d <sub>c</sub>	Clarifier diameter	m	B
d <sub>e</sub>	Effective diameter	m	D
D <sub>ether</sub>	Diffusivity of ether in water	cm <sup>2</sup> /s	(8.5x10 <sup>-6</sup> ) <sup>b</sup>
D <sub>O2,w</sub>	Diffusivity of oxygen in water	cm <sup>2</sup> /s	(2.4x10 <sup>-5</sup> ) <sup>b</sup>
D <sub>oil</sub>	Oil film thickness	m	B

TABLE 5.B-2

(CONTINUED)

Parameter	Definition	Units	Code <sup>a</sup>
$D_w$	Diffusivity of constituent in water	$\text{cm}^2/\text{s}$	C
$f_{\text{air},\ell}$	Fraction of constituent emitted to the air, considering zero gas resistance	dimensionless	D
F/D	Fetch to depth ratio, $d_c/D$	dimensionless	D
FO	Fraction of volume which is oil	dimensionless	B
Fr	Froude number	dimensionless	D
$g_c$	Gravitation constant (a conversion factor)	$\text{lb}_m\text{-ft/s}^2\text{-lb}_f$	32.17
h	Weir height (distance from the wastewater overflow to the receiving body of water)	ft	B
$h_c$	Clarifier weir height	m	B
H	Henry's Law constant of constituent	$\text{atm}\cdot\text{m}^3/\text{gmol}$	C
J	Oxygen transfer rating of surface aerator	$\text{lb O}_2/(\text{hr}\cdot\text{hp})$	B
K	Overall mass transfer coefficient for transfer of constituent from liquid phase to gas phase	m/s	D
$K_D$	Volatilization-re-aeration theory mass transfer coefficient	dimensionless	D
$K_{eq}$	Equilibrium constant or partition coefficient (concentration in gas phase/concentration in liquid phase)	dimensionless	D
$K_{eq_{oil}}$	Equilibrium constant or partition coefficient (concentration in gas phase/concentration in oil phase)	dimensionless	D
$k_g$	Gas phase mass transfer coefficient	m/s	D
$k_\ell$	Liquid phase mass transfer coefficient	m/s	D
Kmax	Maximum biorate constant	$\text{g/s}\cdot\text{g biomass}$	A,C
$K_{oil}$	Overall mass transfer coefficient for transfer of constituent from oil phase to gas phase	m/s	D

TABLE 5.B-2

(CONTINUED)

Parameter	Definition	Units	Code <sup>a</sup>
K <sub>ow</sub>	Octanol-water partition coefficient	dimensionless	C
K <sub>s</sub>	Half saturation biorate constant	g/m <sup>3</sup>	A,C
MW <sub>a</sub>	Molecular weight of air	g/gmol	29
MW <sub>oil</sub>	Molecular weight of oil	g/gmol	B
MW <sub>L</sub>	Molecular weight of water	g/gmol	18
N	Emissions	g/s	D
N <sub>I</sub>	Number of aerators	dimensionless	A,B
O <sub>t</sub>	Oxygen transfer correction factor	dimensionless	B
P	Power number	dimensionless	D
P*	Vapor pressure of the constituent	atm	C
P <sub>o</sub>	Total pressure	atm	A
POWR	Total power to aerators	hp	B
Q	Volumetric flow rate	m <sup>3</sup> /s	A
Q <sub>a</sub>	Diffused air flow rate	m <sup>3</sup> /s	B
Q <sub>oil</sub>	Volumetric flow rate of oil	m <sup>3</sup> /s	B
r	Deficit ratio (ratio of the difference between the constituent concentration at solubility and actual constituent concentration in the upstream and the downstream)	dimensionless	D
R	Universal gas constant	atm-m <sup>3</sup> /gmol-K	8.21x10 <sup>-5</sup>
Re	Reynolds number	dimensionless	D
Sc <sub>G</sub>	Schmidt number on gas side	dimensionless	D
Sc <sub>L</sub>	Schmidt number on liquid side	dimensionless	D

TABLE 5.B-2

(CONTINUED)

Parameter	Definition	Units	Code <sup>a</sup>
T	Temperature of water	°C or Kelvin (K)	A
t	Residence time of disposal	s	A
U*	Friction velocity	m/s	D
U**	Friction velocity	m/s	D
U <sub>10</sub>	Wind speed at 10 m above the liquid surface	m/s	B
V	Wastewater volume	m <sup>3</sup> or ft <sup>3</sup>	A
Va <sub>v</sub>	Turbulent surface area	ft <sup>2</sup>	B
V <sub>oil</sub>	Volume of oil	m <sup>3</sup>	B
w	Rotational speed of impeller	rad/s	B
ρ <sub>a</sub>	Density of air	g/cm <sup>3</sup>	(1.2x10 <sup>-3</sup> ) <sup>b</sup>
ρ <sub>L</sub>	Density of water	g/cm <sup>3</sup> or lb/ft <sup>3</sup>	1 <sup>b</sup> or 62.4 <sup>b</sup>
ρ <sub>oil</sub>	Density of oil	g/m <sup>3</sup>	B
μ <sub>a</sub>	Viscosity of air	g/cm-s	(1.81x10 <sup>-4</sup> ) <sup>b</sup>
μ <sub>L</sub>	Viscosity of water	g/cm-s	(8.93x10 <sup>-3</sup> ) <sup>b</sup>

<sup>a</sup> Code:

A = Site-specific parameter.

B = Site-specific parameter. For default values, see Table 5.B-3.

C = Parameter can be obtained from literature. See Table 5.B-4 for a list of ~150 compound chemical properties at T = 25°C (298°K).

D = Calculated value.

<sup>b</sup> Reported values at 25°C (298°K).

estimates from an emissions model. In addition, when addressing systems involving biodegradation, the accuracy of the predicted rate of biodegradation is improved when site-specific compound biorates are input. Reference 3 contains information on a test method for measuring site-specific biorates, and Table 5.B-4 presents estimated biorates for approximately 150 compounds.

To estimate an emissions rate (N), the first step is to calculate individual gas phase and liquid phase mass transfer coefficients  $k_g$  and  $k_l$ . These individual coefficients are then used to calculate the overall mass transfer coefficient, K. Exceptions to this procedure are the calculation of overall mass transfer coefficients in the oil phase,  $K_{oil}$ , and the overall mass transfer coefficient for a weir,  $K_D$ .  $K_{oil}$  requires only  $k_g$ , and  $K_D$  does not require any individual mass transfer coefficients. The overall mass transfer coefficient is then used to calculate the emissions rates. The following discussion describes how to use Figure 5.B-1 to determine an emission rate. An example calculation is presented in Part B-1 below.

Figure 5.B-1 is divided into two sections: wastewater treatment and storage systems, and wastewater collection systems. Wastewater treatment and storage systems are further segmented into aerated/nonaerated systems, biologically active systems, oil film layer systems, and surface impoundment flowthrough or disposal. In flowthrough systems, wastewater is treated and discharged to a publicly owned treatment works (POTW) or a receiving body of water, such as a river or stream. All wastewater collection systems are by definition flowthrough. Disposal systems, on the other hand, do not discharge any wastewater.

Figure 5.B-1 includes information needed to estimate air emissions from junction boxes, lift stations, sumps, weirs, and clarifier weirs. Sumps are considered quiescent, but junction boxes, lift stations, and weirs are turbulent in nature. Junction boxes and lift stations are turbulent because incoming flow is normally above the water level in the component, which creates some splashing. Wastewater falls or overflows from weirs and creates splashing in the receiving body of water (both weir and clarifier weir models). Wastewater from weirs can be aerated by directing it to fall over steps, usually only the weir model.

Assessing VOC emissions from drains, manholes, and trenches is also important in determining the total wastewater facility emissions. As these sources can be open to the atmosphere and closest to the point of wastewater generation (i.e., where water temperatures and pollutant concentrations are greatest), emissions can be significant. Currently, there are no well-established emission models for these collection system types. However, work is being performed to address this need.



Preliminary models of VOC emissions from waste collection system units have been developed.<sup>4</sup> The emission equations presented in Reference 4 are used with standard collection system parameters to estimate the fraction of the constituents released as the wastewater flows through each unit. The fractions released from several units are estimated for high-, medium-, and low-volatility compounds. The units used in the estimated fractions included open drains, manhole covers, open trench drains, and covered sumps.

The numbers in Figure 5.B-1 under the columns for  $k_l$ ,  $k_g$ ,  $K_{oil}$ ,  $K_D$ ,  $K$ , and  $N$  refer to the appropriate equations in Table 5.B-1.<sup>a</sup> Definitions for all parameters in these equations are given in Table 5.B-2. Table 5.B-2 also supplies the units that must be used for each parameter, with codes to help locate input values. If the parameter is coded with the letter A, a site-specific value is required. Code B also requires a site-specific parameter, but defaults are available. These defaults are typical or average values and are presented by specific system in Table 5.B-3.

Code C means the parameter can be obtained from literature data. Table 5.B-4 contains a list of approximately 150 chemicals and their physical properties needed to calculate emissions from wastewater, using the correlations presented in Table 5.B-1. All properties are at 25°C (77°F). A more extensive chemical properties data base is contained in Appendix C of Reference 1.) Parameters coded D are calculated values.

Calculating air emissions from wastewater collection, treatment, and storage systems is a complex procedure, especially if several systems are present. Performing the calculations by hand may result in errors and will be time consuming. A personal computer program called the Surface Impoundment Modeling System (SIMS) is now available for estimating air emissions. The program is menu driven and can estimate air emissions from all surface impoundment models presented in Figure 5.B-1, individually or in series. The program requires for each collection, treatment, or storage system component, at a minimum, the wastewater flow rate and component surface area. All other inputs are provided as default values. Any available site-specific information should be entered in place of these defaults, as the most fully characterized system will provide the most accurate emissions estimate.

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<sup>a</sup> All emission model systems presented in Figure 5.B-1 imply a completely mixed or uniform waste water concentration system. Emission models for a plug flow system, or system in which there is no axial, or horizontal mixing, are too extensive to be covered in this document. (An example of plug flow might be a high waste water flow in a narrow channel.) For information on emission models of this type, see Reference 1.

**TABLE 5.B-3**  
**SITE-SPECIFIC DEFAULT PARAMETERS<sup>a</sup>**

Default Parameter <sup>b</sup>	Definition	Default Value
<b>General</b>		
T	Temperature of water	298°K
U <sub>10</sub>	Windspeed	4.47 m/s
<b>Biotreatment Systems</b>		
b <sub>i</sub>	Biomass concentration (for biologically active systems)	
	Quiescent treatment systems	50 g/m <sup>3</sup>
	Aerated treatment systems	300 g/m <sup>3</sup>
	Activated sludge units	4000 g/m <sup>3</sup>
POWR	Total power to aerators (for aerated treatment systems) (for activated sludge)	0.75 hp/1000 ft <sup>3</sup> (V) 2 hp/1000 ft <sup>3</sup> (V)
W	Rotational speed of impeller (for aerated treatment systems)	126 rad/s (1200 rpm)
d(d <sup>*</sup> )	Impeller diameter (for aerated treatment systems)	61 cm (2 ft)
Va <sub>v</sub>	Turbulent surface area (for aerated treatment systems) (for activated sludge)	0.24 (A) 0.52 (A)
J	Oxygen transfer rating to surface aerator (for aerated treatment systems)	3 lb O <sub>2</sub> /hp•hr
O <sub>t</sub>	Oxygen transfer correction factor (for aerated treatment systems)	0.83
N <sub>I</sub>	Number of aerators	POWR/75
<b>Diffused Air Systems</b>		
Q <sub>a</sub>	Diffused air volumetric flow rate	0.0004(V) m <sup>3</sup> /s

TABLE 5.B-3

(CONTINUED)

Default Parameter <sup>b</sup>	Definition	Default Value
Oil Film Layers		
MW <sub>oil</sub>	Molecular weight of oil	282 g/gmol
D <sub>oil</sub>	Depth of oil layer	0.001 (V/A) m
V <sub>oil</sub>	Volume of oil	0.001 (V) m <sup>3</sup>
Q <sub>oil</sub>	Volumetric flow rate of oil	0.001 (Q) m <sup>3</sup> /s
ρ <sub>oil</sub>	Density of oil	0.92 g/cm <sup>3</sup>
FO	Fraction of volume which is oil <sup>c</sup>	0.001
Junction Boxes		
D	Depth of Junction Box	0.9 m
N <sub>I</sub>	Number of aerators	1
Lift Station		
D	Depth of Lift Station	1.5 m
N <sub>I</sub>	Number of aerators	1
Sump		
D	Depth of sump	5.9 m
Weirs		
d <sub>c</sub>	Clarifier weir diameter <sup>d</sup>	28.5 m
h	Weir height	1.8 m
h <sub>c</sub>	Clarifier weir height <sup>e</sup>	0.1 m

<sup>a</sup> Reference 1.<sup>b</sup> As defined in Table 5.B-2.<sup>c</sup> Reference 4.<sup>d</sup> Reference 2.<sup>e</sup> Reference 5.

The SIMS program with user's manual and background technical document can be obtained through state air pollution control agencies and through the U.S. Environmental Protection Agency's Control Technology Center in Research Triangle Park, North Carolina, telephone (919) 541-0800. The user's manual and background technical document should be followed to produce meaningful results.

The SIMS program and user's manual also can be downloaded from EPA's Clearinghouse for Inventories and Emission Factors system (CHIEF ). The CHIEF is open to all persons involved in air emission inventories.

First-time users must register before access is allowed.

Emissions estimates from SIMS are based on mass transfer models developed by Emissions Standards Division (ESD) during evaluations of treatment, storage, and disposal facilities (TSDFs) and VOC emissions from industrial wastewater. As a part of the TSDF project, a Lotus<sup>®</sup> spreadsheet program called CHEMDAT7 was developed for estimating VOC emissions from wastewater land treatment systems, open landfills, closed landfills, and waste storage piles, as well as from various types of surface impoundments. For more information about CHEMDAT7, contact the ESD's Chemicals And Petroleum Branch (MD-13), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

## EXAMPLE CALCULATION

An example industrial facility operates a flowthrough, mechanically aerated biological treatment impoundment that receives wastewater contaminated with benzene at a concentration of 10.29 g/m<sup>3</sup>.

The following format is used for calculating benzene emissions from the treatment process:

- I. Determine which emission model to use
- II. User-supplied information
- III. Defaults
- IV. Pollutant physical property data and water, air, and other properties
- V. Calculate individual mass transfer coefficient
- VI. Calculate the overall mass transfer coefficients
- VII. Calculate VOC emissions

I. Determine Which Emission Model To Use — Following the flow diagram in Figure 5.B-1,

the emission model for a treatment system that is aerated, but not by diffused air, is biologically active, and is a flowthrough system, contains the following equations:

Parameter	Definition	Equation Nos. from Table 5.B-1
K	Overall mass transfer coefficient, m/s	7
$k_\ell$	Individual liquid phase mass transfer coefficient, m/s	1, 3
$k_g$	Individual gas phase mass transfer coefficient, m/s	2, 4
N	VOC emissions, g/s	16

- II. User-supplied Information — Once the correct emission model is determined, some site-specific parameters are required. As a minimum for this model, site-specific flow rate, wastewater surface area and depth, and pollutant concentration should be provided. For this example, these parameters have the following values:

$$\begin{aligned} Q &= \text{Volumetric flow rate} = 0.0623 \text{ m}^3/\text{s} \\ D &= \text{Wastewater depth} = 1.97 \text{ m} \\ A &= \text{Wastewater surface area} = 17,652 \text{ m}^2 \\ C_o &= \text{Initial benzene concentration in the liquid phase} = 10.29 \text{ g/m}^3 \end{aligned}$$

- III. Defaults — Defaults for some emission model parameters are presented in Table 5.B-3. Generally, site-specific values should be used when available. For this facility, all available general and biotreatment system defaults from Table 5.B-3 were used:

$$\begin{aligned} U_{10} &= \text{Wind speed at 10 m above the liquid surface} = e = 4.47 \text{ m/s} \\ T &= \text{Temperature of water} = 25^\circ\text{C} (298^\circ\text{K}) \\ b_i &= \text{Biomass concentration for aerated treatment systems} = 300 \text{ g/m}^3 \\ J &= \text{Oxygen transfer rating to surface aerator} = 3 \text{ lb O}_2/\text{hp-hr} \\ \text{POWR} &= \text{Total power to aerators} = 0.75 \text{ hp/1,000 ft}^3 \text{ (V)} \\ O_t &= \text{Oxygen transfer correction factor} = 0.83 \\ V_{a_v} &= \text{Turbulent surface area} = 0.24 \text{ (A)} \\ d &= \text{Impeller diameter} = 61 \text{ cm} \\ d^* &= \text{Impeller diameter} = 2 \text{ ft} \\ w &= \text{Rotational speed of impeller} = 126 \text{ rad/s} \\ N_I &= \text{Number of aerators} = \text{POWR}/75 \text{ hp} \end{aligned}$$

- IV. Pollutant Physical Property Data, And Water, Air and Other Properties — For each pollutant, the specific physical properties needed by this model are listed in Table 5.B-4. Water, air, and other property values are given in Table 5.B-2.

A. Benzene (from Table 5.B-4)

$$\begin{aligned} D_{w,\text{benzene}} &= \text{Diffusivity of benzene in water} = 9.8 \times 10^{-6} \text{ cm}^2/\text{s} \\ D_{a,\text{benzene}} &= \text{Diffusivity of benzene in air} = 0.088 \text{ cm}^2/\text{s} \\ H_{\text{benzene}} &= \text{Henry's Law constant for benzene} = 0.0055 \text{ atm} \cdot \text{m}^3/\text{gmol} \\ K_{\text{max},\text{benzene}} &= \text{Maximum biorate constant for benzene} = 5.28 \times 10^{-6} \text{ g/g-s} \\ K_{s,\text{benzene}} &= \text{Half saturation biorate constant for benzene} = 13.6 \text{ g/m}^3 \end{aligned}$$

B. Water, Air, and Other Properties (from Table 5.B-2)

$$\begin{aligned} \rho_a &= \text{Density of air} = 1.2 \times 10^{-3} \text{ g/cm}^3 \\ \rho_L &= \text{Density of water} = 1 \text{ g/cm}^3 \text{ (62.4 lb}_m/\text{ft}^3\text{)} \\ \mu_a &= \text{Viscosity of air} = 1.81 \times 10^{-4} \text{ g/cm-s} \\ D_{O_2,w} &= \text{Diffusivity of oxygen in water} = 2.4 \times 10^{-5} \text{ cm}^2/\text{s} \\ D_{\text{ether}} &= \text{Diffusivity of ether in water} = 8.5 \times 10^{-6} \text{ cm}^2/\text{s} \\ MW_L &= \text{Molecular weight of water} = 18 \text{ g/gmol} \\ MW_a &= \text{Molecular weight of air} = 29 \text{ g/gmol} \\ g_c &= \text{Gravitation constant} = 32.17 \text{ lb}_m \cdot \text{ft}/\text{lb}_f \cdot \text{s}^2 \\ R &= \text{Universal gas constant} = 8.21 \times 10^{-5} \text{ atm} \cdot \text{m}^3/\text{gmol} \end{aligned}$$

- V. Calculate Individual Mass Transfer Coefficients — Because part of the impoundment is turbulent and part is quiescent, individual mass transfer coefficients are determined for both turbulent and quiescent areas of the surface impoundment.

Turbulent area of impoundment — Equations 3 and 4 from Table 5.B-1.

- A. Calculate the individual liquid mass transfer coefficient,  $k_\ell$ :

$$k_\ell (\text{m/s}) = [(8.22 \times 10^{-9})(J)(\text{POWR})(1.024)^{(T-20)} * (O_t)(10^6)MW_L / (V_a \rho_L)](D_w/D_{O_2,w})^{0.5}$$

The total power to the aerators, POWR, and the turbulent surface area,  $V_a$ , are calculated separately [Note: some conversions are necessary.]:

1. Calculate total power to aerators, POWR (Default presented in III):

$$\begin{aligned} \text{POWR (hp)} &= 0.75 \text{ hp}/1,000 \text{ ft}^3 (V) \\ V &= \text{wastewater volume, m}^3 \\ V (\text{m}^3) &= (A)(D) = (17,652 \text{ m}^2)(1.97 \text{ m}) \\ V &= 34,774 \text{ m}^3 \\ \text{POWR} &= (0.75 \text{ hp}/1,000 \text{ ft}^3)(\text{ft}^3/0.028317 \text{ m}^3)(34,774 \text{ m}^3) \\ &= 921 \text{ hp} \end{aligned}$$

2. Calculate turbulent surface area,  $Va_v$  (default presented in III):

$$\begin{aligned} Va_v \text{ (ft}^2\text{)} &= 0.24 \text{ (A)} \\ &= 0.24(17,652 \text{ m}^2)(10.758 \text{ ft}^2/\text{m}^2) \\ &= 45,576 \text{ ft}^2 \end{aligned}$$

Now, calculate  $k_\ell$ , using the above calculations and information from II, III, and IV:

$$\begin{aligned} k_\ell \text{ (m/s)} &= [(8.22 \times 10^{-9})(3 \text{ lb O}_2/\text{hp-hr})(921 \text{ hp}) * \\ &\quad (1.024)^{(25-20)}(0.83)(10^6)(18 \text{ g/gmol})/ \\ &\quad ((45,576 \text{ ft}^2)(1 \text{ g/cm}^3))] * \\ &\quad [(9.8 \times 10^{-6} \text{ cm}^2/\text{s})/(2.4 \times 10^{-5} \text{ cm}^2/\text{s})]^{0.5} \\ &= (0.00838)(0.639) \\ k_\ell &= 5.35 \times 10^{-3} \text{ m/s} \end{aligned}$$

- B. Calculate the individual gas phase mass transfer coefficient,  $k_g$ :

$$k_g \text{ (m/s)} = (1.35 \times 10^{-7})(\text{Re})^{1.42}(\text{P})^{0.4}(\text{Sc}_G)^{0.5}(\text{Fr})^{-0.21}(\text{D}_a \text{ MW}_a/\text{d})$$

The Reynolds number, Re, power number, P, Schmidt number on the gas side,  $\text{Sc}_G$ , and Froude's number, Fr, are calculated separately:

1. Calculate Reynolds number, Re:

$$\begin{aligned} \text{Re} &= d^2 \omega \rho_a / \mu_a \\ &= (61 \text{ cm})^2 (126 \text{ rad/s})(1.2 \times 10^{-3} \text{ g/cm}^3) / (1.81 \times 10^{-4} \text{ g/cm-s}) \\ &= 3.1 \times 10^6 \end{aligned}$$

2. Calculate power number, P:

$$\begin{aligned} P &= [(0.85)(\text{POWR})(550 \text{ ft-lb}_f/\text{s-hp})/N_I] \text{ g}_c / (\rho_L (d^*)^5 \omega^3) \\ N_I &= \text{POWR}/75 \text{ hp (default presented in III)} \\ P &= (0.85)(75 \text{ hp})(\text{POWR}/\text{POWR})(550 \text{ ft-lb}_f/\text{s-hp}) * \\ &\quad (32.17 \text{ lb}_m\text{-ft/lb}_f\text{-s}^2) / [(62.4 \text{ lb}_m/\text{ft}^3)(2 \text{ ft})^5 (126 \text{ rad/s})^3] \\ &= 2.8 \times 10^{-4} \end{aligned}$$

3. Calculate Schmidt number on the gas side,  $\text{Sc}_G$ :

$$\begin{aligned} \text{Sc}_G &= \mu_a / (\rho_a \text{D}_a) \\ &= (1.81 \times 10^{-4} \text{ g/cm-s}) / [(1.2 \times 10^{-3} \text{ g/cm}^3)(0.088 \text{ cm}^2/\text{s})] \\ &= 1.71 \end{aligned}$$

4. Calculate Froude number, Fr:

$$\begin{aligned} \text{Fr} &= (d^*)w^2/g_c \\ &= (2 \text{ ft})(126 \text{ rad/s})^2/(32.17 \text{ lb}_m\text{-ft/lb}_f\text{-s}^2) \\ &= 990 \end{aligned}$$

Now, calculate  $k_g$  using the above calculations and information from II, III, and IV:

$$\begin{aligned} k_g \text{ (m/s)} &= (1.35 \times 10^{-7})(3.1 \times 10^6)^{1.42}(2.8 \times 10^{-4})^{0.4}(1.71)^{0.5} * \\ &\quad (990)^{-0.21}(0.088 \text{ cm}^2/\text{s})(29 \text{ g/gmol})/(61 \text{ cm}) \\ &= 0.109 \text{ m/s} \end{aligned}$$

Quiescent surface area of impoundment — Equations 1 and 2 from Table 5.B-1.

- A. Calculate the individual liquid phase mass transfer coefficient,  $k_\ell$ :

$$\begin{aligned} F/D &= 2(A/\pi)^{0.5}/D \\ &= 2(17,652 \text{ m}^2/\pi)^{0.5}/(1.97 \text{ m}) \\ &= 76.1 \\ U_{10} &= 4.47 \text{ m/s} \\ \text{For } U_{10} > 3.25 \text{ m/s and } F/D > 51.2 \text{ use the following:} \\ k_\ell \text{ (m/s)} &= (2.61 \times 10^{-7})(U_{10})^2(D_w/D_{\text{ether}})^{2/3} \\ &= (2.61 \times 10^{-7})(4.47 \text{ m/s})^2[(9.8 \times 10^{-6} \text{ cm}^2/\text{s})/ \\ &\quad (8.5 \times 10^{-6} \text{ cm}^2/\text{s})]^{2/3} \\ &= 5.74 \times 10^{-6} \text{ m/s} \end{aligned}$$

- B. Calculate the individual gas phase mass transfer coefficient,  $k_g$ :

$$k_g = (4.82 \times 10^{-3})(U_{10})^{0.78}(\text{Sc}_G)^{-0.67}(d_e)^{-0.11} \text{ g}$$

The Schmidt number on the gas side,  $\text{Sc}_G$ , and the effective diameter,  $d_e$ , are calculated separately:

1. Calculate the Schmidt number on the gas side,  $\text{Sc}_G$ :

$$\text{Sc}_G = \mu_a/(\rho_a D_a) = 1.71 \text{ (same as for turbulent impoundments)}$$

2. Calculate the effective diameter,  $d_e$ :



$$\begin{aligned}
 d_e \text{ (m)} &= 2(A/\pi)^{0.5} \\
 &= 2(17,652 \text{ m}^2/\pi)^{0.5} \\
 &= 149.9 \text{ m} \\
 k_g \text{ (m/s)} &= (4.82 \times 10^{-3})(4.47 \text{ m/s})^{0.78} (1.71)^{-0.67} (149.9 \text{ m})^{-0.11} \\
 &= 6.24 \times 10^{-3} \text{ m/s}
 \end{aligned}$$

VI. Calculate The Overall Mass Transfer Coefficient — Because part of the impoundment is turbulent and part is quiescent, the overall mass transfer coefficient is determined as an area-weighted average of the turbulent and quiescent overall mass transfer coefficients. (Equation 7 from Table 5.B-1).

Overall mass transfer coefficient for the turbulent surface area of impoundment,  $K_T$

$$\begin{aligned}
 K_T \text{ (m/s)} &= (k_\ell K_{eq} k_g) / (K_{eq} k_g + k_\ell) \\
 K_{eq} &= H/RT \\
 &= (0.0055 \text{ atm}\cdot\text{m}^3/\text{gmol}) / [(8.21 \times 10^{-5} \text{ atm}\cdot\text{m}^3/\text{gmol}\cdot^\circ\text{K})(298^\circ\text{K})] \\
 &= 0.225 \\
 K_T \text{ (m/s)} &= (5.35 \times 10^{-3} \text{ m/s})(0.225)(0.109) / [(0.109 \text{ m/s})(0.225) + (5.35 \times 10^{-6} \text{ m/s})] \\
 K_T &= 4.39 \times 10^{-3} \text{ m/s}
 \end{aligned}$$

Overall mass transfer coefficient for the quiescent surface area of impoundment,  $K_Q$

$$\begin{aligned}
 K_Q \text{ (m/s)} &= (k_\ell K_{eq} k_g) / (K_{eq} k_g + k_\ell) \\
 &= (5.74 \times 10^{-6} \text{ m/s})(0.225)(6.24 \times 10^{-3} \text{ m/s}) / [(6.24 \times 10^{-3} \text{ m/s})(0.225) + (5.74 \times 10^{-6} \text{ m/s})] \\
 &= 5.72 \times 10^{-6} \text{ m/s}
 \end{aligned}$$

Overall mass transfer coefficient,  $K$ , weighted by turbulent and quiescent surface areas,  $A_T$  and  $A_Q$

$$\begin{aligned}
 K \text{ (m/s)} &= (K_T A_T + K_Q A_Q) / A \\
 A_T &= 0.24(A) \text{ (Default value presented in III: } A_T = V a_v) \\
 A_Q &= (1 - 0.24)A \\
 K \text{ (m/s)} &= [(4.39 \times 10^{-3} \text{ m/s})(0.24 A) + (5.72 \times 10^{-6} \text{ m/s})(1 - 0.24)A] / A \\
 &= 1.06 \times 10^{-3} \text{ m/s}
 \end{aligned}$$

VII. Calculate VOC Emissions For An Aerated Biological Flowthrough Impoundment —  
Equation 16 from Table 5.B-1:

$$N \text{ (g/s)} = K C_L A$$

where:

$$C_L \text{ (g/m}^3\text{)} = [-b + (b^2 - 4ac)^{0.5}]/(2a)$$

and:

$$a = KA/Q + 1$$

$$b = K_s(KA/Q + 1) + K_{max} b_i V/Q - C_o$$

$$c = -K_s C_o$$

Calculate a, b, c, and the concentration of benzene in the liquid phase,  $C_L$ , separately:

1. Calculate a:

$$\begin{aligned} a &= (KA/Q + 1) = [(1.06 \times 10^{-3} \text{ m/s})(17,652 \text{ m}^2)/(0.0623 \text{ m}^3/\text{s})] + 1 \\ &= 301.3 \end{aligned}$$

2. Calculate b ( $V = 34,774 \text{ m}^3$  from IV):

$$\begin{aligned} b &= K_s (KA/Q + 1) + K_{max} b_i V/Q - C_o \\ &= (13.6 \text{ g/m}^3)[(1.06 \times 10^{-3} \text{ m/s})(17,652 \text{ m}^2)/(0.0623 \text{ m}^3/\text{s})] + \\ &\quad [(5.28 \times 10^{-6} \text{ g/g-s})(300 \text{ g/m}^3)(34,774 \text{ m}^3)/(0.0623 \text{ m}^3/\text{s})] - 10.29 \text{ g/m}^3 \\ &= 4,084.6 + 884.1 - 10.29 \\ &= 4,958.46 \text{ g/m}^3 \end{aligned}$$

3. Calculate c:

$$\begin{aligned} c &= -K_s C_o \\ &= -(13.6 \text{ g/m}^3)(10.29 \text{ g/m}^3) \\ &= -139.94 \end{aligned}$$

4. Calculate the concentration of benzene in the liquid phase,  $C_L$ , from a, b, and c above:

$$\begin{aligned}C_L \text{ (g/m}^3\text{)} &= [-b + (b^2 - 4ac)^{0.5}]/(2a) \\&= [(4,958.46 \text{ g/m}^3) + [(4,958.46 \text{ g/m}^3)^2 - \\&\quad [4(301.3)(-139.94)]]^{0.5}]/(2(301.3)) \\&= 0.0282 \text{ g/m}^3\end{aligned}$$

Now calculate N with the above calculations and information from II and V:

$$\begin{aligned}N \text{ (g/s)} &= K A C_L \\&= (1.06 \times 10^{-3} \text{ m/s})(17,652 \text{ m}^2)(0.0282 \text{ g/m}^3) \\&= 0.52 \text{ g/s}\end{aligned}$$

## GLOSSARY OF TERMS

Basin -	an earthen or concrete-lined depression used to hold liquid.
Completely mixed -	having the same characteristics and quality throughout or at all times.
Disposal -	the act of permanent storage. Flow of liquid into, but not out of a device.
Drain -	a device used for the collection of liquid. It may be open to the atmosphere or be equipped with a seal to prevent emissions of vapors.
Flowthrough -	having a continuous flow into and out of a device.
Plug flow -	having characteristics and quality not uniform throughout. These will change in the direction the fluid flows, but not perpendicular to the direction of flow (i.e., no axial movement).
Storage -	any device to accept and retain a fluid for the purpose of future discharge. Discontinuity of flow of liquid into and out of a device.
Treatment -	the act of improving fluid properties by physical means. The removal of undesirable impurities from a fluid.
VOC -	volatile organic compounds, referring to all organic compounds except

the following, which have been shown not to be photochemically reactive: methane, ethane, trichlorotrifluoroethane, methylene chloride, 1,1,1,-trichloroethane, trichlorofluoromethane, dichlorodifluoromethane, chlorodifluoromethane, trifluoromethane, dichlorotetrafluoroethane, and chloropentafluoroethane.

**TABLE 5.B-4**  
**SIMS CHEMICAL PROPERTY DATA FILE (PART 1)**

Chemical Name	CAS Number	Molecular Weight	Vapor Pressure At 25°C (mm Hg)	Henry's Law Constant At 25°C (atm·m <sup>3</sup> /mol)	Diffusivity Of Chemical In Water At 25°C (cm <sup>2</sup> /s)	Diffusivity Of Chemical In Air At 25°C (cm <sup>2</sup> /s)
ACETALDEHYDE	75-07-0	44.00	760	0.000095	0.0000141	0.124
ACETIC ACID	64-19-7	60.05	15.4	0.0627	0.000012	0.113
ACETIC ANHYDRIDE	108-24-7	102.09	5.29	0.00000591	0.00000933	0.235
ACETONE	67-64-1	58.00	266	0.000025	0.0000114	0.124
ACETONITRILE	75-05-8	41.03	90	0.0000058	0.0000166	0.128
ACROLEIN	107-02-8	56.10	244.2	0.0000566	0.0000122	0.105
ACRYLAMIDE	79-06-1	71.09	0.012	0.00000000052	0.0000106	0.097
ACRYLIC ACID	79-10-7	72.10	5.2	0.0000001	0.0000106	0.098
ACRYLONITRILE	107-13-1	53.10	114	0.000088	0.0000134	0.122
ADIPIC ACID	124-04-9	146.14	0.0000225	0.00000000005	0.00000684	0.0659
ALLYL ALCOHOL	107-18-6	58.10	23.3	0.000018	0.0000114	0.114
AMINOPHENOL(-O)	95-55-6	109.12	0.511	0.00000367	0.00000864	0.0774
AMINOPHENOL(-P)	123-30-8	109.12	0.893	0.0000197	0.00000239	0.0774
AMMONIA	7664-41-7	17.03	7470	0.000328	0.0000693	0.259
AMYL ACETATE(-N)	628-37-8	130.18	5.42	0.000464	0.0000012	0.064
ANILINE	62-53-3	93.10	1	0.0000026	0.0000083	0.07
BENZENE	71-43-2	78.10	95.2	0.0055	0.0000098	0.088
BENZO(A)ANTHRACENE	56-55-3	228.30	0.00000015	0.00000000138	0.000009	0.051
BENZO(A)PYRENE	50-32-8	252.30	0.00568	0.00000000138	0.000009	0.043

**TABLE 5.B-4 (PART 1)**  
**(CONTINUED)**

Chemical Name	CAS Number	Molecular Weight	Vapor Pressure At 25°C (mm Hg)	Henry's Law Constant At 25°C (atm·m <sup>3</sup> /mol)	Diffusivity Of Chemical In Water At 25°C (cm <sup>2</sup> /s)	Diffusivity Of Chemical In Air At 25°C (cm <sup>2</sup> /s)
CRESYLIC ACID	1319-77-3	108.00	0.3	0.0000017	0.0000083	0.074
CROTONALDEHYDE	4170-30-0	70.09	30	0.00000154	0.0000102	0.0903
CUMENE (ISOPROPYLBENZENE)	98-82-8	120.20	4.6	0.0146	0.0000071	0.065
CYCLOHEXANE	110-82-7	84.20	100	0.0137	0.0000091	0.0839
CYCLOHEXANOL	108-93-0	100.20	1.22	0.00000447	0.00000831	0.214
CYCLOHEXANONE	108-94-1	98.20	4.8	0.00000413	0.00000862	0.0784
DI-N-OCTYL PHTHALATE	117-84-0	390.62	0	0.137	0.0000041	0.0409
DIBUTYLPHTHALATE	84-74-2	278.30	0.00001	0.00000028	0.0000079	0.0438
DICHLORO(-2)BUTENE(1,4)	764-41-0	125.00	2.87	0.000259	0.00000812	0.0725
DICHLOROBENZENE(1,2) (-O)	95-50-1	147.00	1.5	0.00194	0.0000079	0.069
DICHLOROBENZENE(1,3) (-M)	541-73-1	147.00	2.28	0.00361	0.0000079	0.069
DICHLOROBENZENE(1,4) (-P)	106-46-7	147.00	1.2	0.0016	0.0000079	0.069
DICHLORODIFLUOROMETHANE	75-71-8	120.92	5000	0.401	0.00001	0.0001
DICHLOROETHANE(1,1)	75-34-3	99.00	234	0.00554	0.0000105	0.0914
DICHLOROETHANE(1,2)	107-06-2	99.00	80	0.0012	0.0000099	0.104
DICHLOROETHYLENE(1,2)	156-54-2	96.94	200	0.0319	0.000011	0.0935
DICHLOROPHENOL(2,4)	120-83-2	163.01	0.1	0.0000048	0.0000076	0.0709
DICHLOROPHENOXYACETIC ACID(2,4)	94-75-7	221.00	290	0.0621	0.00000649	0.0588
DICHLOROPROPANE(1,2)	78-87-5	112.99	40	0.0023	0.0000087	0.0782

**TABLE B-4 (PART 1)  
(CONTINUED)**

Chemical Name	CAS Number	Molecular Weight	Vapor Pressure At 25°C (mm Hg)	Henry's Law Constant At 25°C (atm m <sup>3</sup> /mol)	Diffusivity Of Chemical In Water At 25°C (cm <sup>2</sup> /s)	Diffusivity Of Chemical In Air At 25°C (cm <sup>2</sup> /s)
DIETHYL (N,N) ANILINE	91-66-7	149.23	0.00283	0.0000000574	0.00000587	0.0513
DIETHYL PHTHALATE	84-66-2	222.00	0.003589	0.0111	0.0000058	0.0542
DIMETHYL FORMAMIDE	68-12-2	73.09	4	0.0000192	0.0000103	0.0939
DIMETHYL HYDRAZINE(1,1)	57-14-7	60.10	157	0.000124	0.0000109	0.106
DIMETHYL PHTHALATE	131-11-3	194.20	0.000187	0.00000215	0.0000063	0.0568
DIMETHYLBENZ(A)ANTHRACENE	57-97-6	256.33	0	0.00000000027	0.00000498	0.0461
DIMETHYLPHENOL(2,4)	105-67-9	122.16	0.0573	0.000921	0.0000084	0.0712
DINITROBENZENE (-M)	99-65-0	168.10	0.05	0.000022	0.00000764	0.279
DINITROTOLUENE(2,4)	121-14-2	182.10	0.0051	0.00000407	0.00000706	0.203
DIOXANE(1,4)	123-91-1	88.20	37	0.0000231	0.0000102	0.229
DIOXIN	NOCAS2	322.00	0	0.0000812	0.0000056	0.104
DIPHENYLAMINE	122-39-4	169.20	0.00375	0.00000278	0.00000631	0.058
EPICHLOROHYDRIN	106-89-8	92.50	17	0.0000323	0.0000098	0.086
ETHANOL	64-17-5	46.10	50	0.0000303	0.000013	0.123
ETHANOLAMINE(MONO-)	141-43-5	61.09	0.4	0.000000322	0.0000114	0.107
ETHYL ACRYLATE	140-88-5	100.00	40	0.00035	0.0000086	0.077
ETHYL CHLORIDE	75-00-3	64.52	1200	0.014	0.0000115	0.271
ETHYL-(2)PROPYL-(3) ACROLEIN	645-62-5	92.50	17	0.0000323	0.0000098	0.086
ETHYLACETATE	141-78-6	88.10	100	0.000128	0.00000966	0.0732

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**TABLE 5.B-4 (PART 1)**  
**(CONTINUED)**

Chemical Name	CAS Number	Molecular Weight	Vapor Pressure At 25°C (mm Hg)	Henry's Law Constant At 25°C (atm m <sup>3</sup> /mol)	Diffusivity Of Chemical In Water At 25°C (cm <sup>2</sup> /s)	Diffusivity Of Chemical In Air At 25°C (cm <sup>2</sup> /s)
ETHYLBENZENE	100-41-4	106.20	10	0.00644	0.0000078	0.075
ETHYLENEOXIDE	75-21-8	44.00	1250	0.000142	0.0000145	0.104
ETHYLETHER	60-29-7	74.10	520	0.00068	0.0000093	0.074
FORMALDEHYDE	50-00-0	30.00	3500	0.0000576	0.0000198	0.178
FORMIC ACID	64-18-6	46.00	42	0.0000007	0.00000137	0.079
FREONS	NOCAS3	120.92	5000	0.401	0.00001	0.104
FURAN	110-00-9	68.08	596	0.00534	0.0000122	0.104
FURFURAL	96-01-1	96.09	2	0.0000811	0.0000104	0.0872
HEPTANE (ISO)	142-82-5	100.21	66	1.836	0.00000711	0.187
HEXACHLOROBENZENE	118-74-1	284.80	1	0.00068	0.00000591	0.0542
HEXACHLOROBUTADIENE	87-68-3	260.80	0.15	0.0256	0.0000062	0.0561
HEXACHLOROCYCLOPENTADIENE	77-47-4	272.80	0.081	0.016	0.00000616	0.0561
HEXACHLOROETHANE	67-72-1	237.00	0.65	0.00000249	0.0000068	0.00249
HEXANE(-N)	100-54-3	86.20	150	0.122	0.00000777	0.2
HEXANOL(-1)	111-27-3	102.18	0.812	0.0000182	0.00000753	0.059
HYDROCYANIC ACID	74-90-8	27.00	726	0.000000465	0.0000182	0.197
HYDROFLUORIC ACID	7664-39-3	20.00	900	0.000237	0.000033	0.388
HYDROGEN SULFIDE	7783-06-4	34.10	15200	0.023	0.0000161	0.176
ISOPHORONE	78-59-1	138.21	0.439	0.00000576	0.00000676	0.0623



**TABLE 5.B-4 (PART 1)**  
**(CONTINUED)**

Chemical Name	CAS Number	Molecular Weight	Vapor Pressure At 25°C (mm Hg)	Henry's Law Constant At 25°C (atm·m <sup>3</sup> /mol)	Diffusivity Of Chemical In Water At 25°C (cm <sup>2</sup> /s)	Diffusivity Of Chemical In Air At 25°C (cm <sup>2</sup> /s)
METHANOL	67-56-1	32.00	114	0.0000027	0.0000164	0.15
METHYL ACETATE	79-20-9	74.10	235	0.000102	0.00001	0.104
METHYL CHLORIDE	74-87-3	50.50	3830	0.00814	0.0000065	0.126
METHYL ETHYL KETONE	78-93-3	72.10	100	0.0000435	0.0000098	0.0808
METHYL ISOBUTYL KETONE	108-10-1	100.20	15.7	0.0000495	0.0000078	0.075
METHYL METHACRYLATE	80-62-6	100.10	39	0.000066	0.0000086	0.077
METHYL STYRENE (ALPHA)	98-83-9	118.00	0.076	0.00591	0.0000114	0.264
METHYLENE CHLORIDE	75-09-2	85.00	438	0.00319	0.0000117	0.101
MORPHOLINE	110-91-8	87.12	10	0.0000573	0.0000096	0.091
NAPHTHALENE	91-20-3	128.20	0.23	0.00118	0.0000075	0.059
NITROANILINE(-O)	88-74-4	138.14	0.003	0.0000005	0.000008	0.073
NITROBENZENE	98-95-3	123.10	0.3	0.0000131	0.0000086	0.076
PENTACHLOROBENZENE	608-93-5	250.34	0.0046	0.0073	0.0000063	0.057
PENTACHLOROETHANE	76-01-7	202.30	4.4	0.021	0.0000073	0.066
PENTACHLOROPHENOL	87-86-5	266.40	0.00099	0.0000028	0.0000061	0.056
PHENOL	108-95-2	94.10	0.34	0.000000454	0.0000091	0.082
PHOSGENE	75-44-5	98.92	1390	0.171	0.00000112	0.108
PHTHALIC ACID	100-21-0	166.14	121	0.0132	0.0000068	0.064
PHTHALIC ANHYDRIDE	85-44-9	148.10	0.0015	0.0000009	0.0000086	0.071

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**TABLE 5.B-4 (PART 1)**  
**(CONTINUED)**

Chemical Name	CAS Number	Molecular Weight	Vapor Pressure At 25°C (mm Hg)	Henry's Law Constant At 25°C (atm·m <sup>3</sup> /mol)	Diffusivity Of Chemical In Water At 25°C (cm <sup>2</sup> /s)	Diffusivity Of Chemical In Air At 25°C (cm <sup>2</sup> /s)
PICOLINE(-2)	108-99-6	93.12	10.4	0.000127	0.0000096	0.075
POLYCHLORINATED BIPHENYLS	1336-36-3	290.00	0.00185	0.0004	0.00001	0.104
PROPANOL (ISO)	71-23-8	60.09	42.8	0.00015	0.0000104	0.098
PROPIONALDEHYDE	123-38-6	58.08	300	0.00115	0.0000114	0.102
PROPYLENE GLYCOL	57-55-6	76.11	0.3	0.0000015	0.0000102	0.093
PROPYLENE OXIDE	75-66-9	58.10	525	0.00134	0.00001	0.104
PYRIDINE	110-86-1	79.10	20	0.0000236	0.0000076	0.091
RESORCINOL	108-46-3	110.11	0.00026	0.0000000188	0.0000087	0.078
STYRENE	100-42-5	104.20	7.3	0.00261	0.000008	0.071
TETRACHLOROETHANE(1,1,1,2)	630-20-6	167.85	6.5	0.002	0.0000079	0.071
TETRACHLOROETHANE(1,1,2,2)	79-34-5	167.85	6.5	0.00038	0.0000079	0.071
TETRACHLOROETHYLENE	127-18-4	165.83	19	0.029	0.0000082	0.072
TETRAHYDROFURAN	109-99-9	72.12	72.1	0.000049	0.0000105	0.098
TOLUENE	109-88-3	92.40	30	0.00668	0.0000086	0.087
TOLUENE DIISOCYANATE(2,4)	584-84-9	174.16	0.08	0.0000083	0.0000062	0.061
TRICHLORO(1,1,2)TRIFLUOROETHANE	76-13-1	187.38	300	0.435	0.0000082	0.078
TRICHLOROBENZENE(1,2,4)	120-82-1	181.50	0.18	0.00142	0.0000077	0.0676
TRICHLOROBUTANE(1,2,3)	NOCAS5	161.46	4.39	4.66	0.0000072	0.066
TRICHLOROETHANE(1,1,1)	71-55-6	133.40	123	0.00492	0.0000088	0.078

**TABLE 5.B-4 (PART 1)  
(CONTINUED)**

Chemical Name	CAS Number	Molecular Weight	Vapor Pressure At 25°C (mm Hg)	Henry's Law Constant At 25°C (atm m <sup>3</sup> /mol)	Diffusivity Of Chemical In Water At 25°C (cm <sup>2</sup> /s)	Diffusivity Of Chemical In Air At 25°C (cm <sup>2</sup> /s)
TRICHLOROETHANE(1,1,2)	79-00-5	133.40	25	0.000742	0.0000088	0.078
TRICHLOROETHYLENE	79-01-6	131.40	75	0.0091	0.0000091	0.079
TRICHLOROFLUOROMETHANE	75-69-4	137.40	796	0.0583	0.0000097	0.087
TRICHLOROPHENOL(2,4,6)	88-06-2	197.46	0.0073	0.0000177	0.0000075	0.0661
TRICHLOROPROPANE(1,1,1)	NOCAS6	147.43	3.1	0.029	0.0000079	0.071
TRICHLOROPROPANE(1,2,3)	96-18-4	147.43	3	0.028	0.0000079	0.071
UREA	57-13-6	60.06	6.69	0.000264	0.0000137	0.122
VINYL ACETATE	108-05-4	86.09	115	0.00062	0.0000092	0.085
VINYL CHLORIDE	75-01-4	62.50	2660	0.086	0.0000123	0.106
VINYLDENE CHLORIDE	75-35-4	97.00	591	0.015	0.0000104	0.09
XYLENE(-M)	1330-20-7	106.17	8	0.0052	0.0000078	0.07
XYLENE(-O)	95-47-6	106.17	7	0.00527	0.00001	0.087

**TABLE 5.B-4**  
**SIMS CHEMICAL PROPERTY DATA FILE (PART 2)**

Chemical Name	Antoine's Equation Vapor Pressure Coefficient A	Antoine's Equation Vapor Pressure Coefficient B	Antoine's Equation Vapor Pressure Coefficient C	Maximum Biodegradation Rate Constant (g/g Biomass-s)	Half Saturation Constant (g/m <sup>3</sup> )	Octanol-Water Partition Coefficient At 25°C
ACETALDEHYDE	8.005	1600.017	291.809	0.0000228944	419.0542	2.69153
ACETIC ACID	7.387	1533.313	222.309	0.0000038889	14.2857	0.48978
ACETIC ANHYDRIDE	7.149	1444.718	199.817	0.0000026944	1.9323	1
ACETONE	7.117	1210.595	229.664	0.0000003611	1.1304	0.57544
ACETONITRILE	7.119	1314.4	230	0.00000425	152.6014	0.45709
ACROLEIN	2.39	0	0	0.0000021667	22.9412	0.81283
ACRYLAMIDE	11.2932	3939.877	273.16	0.00000425	56.2388	6.32182
ACRYLIC ACID	5.652	648.629	154.683	0.0000026944	54.7819	2.04174
ACRYLONITRILE	7.038	1232.53	222.47	0.000005	24	0.12023
ADIPIC ACID	0	0	0	0.0000026944	66.9943	1.20226
ALLYL ALCOHOL	0	0	0	0.0000048872	3.9241	1.47911
AMINOPHENOL(-O)	0	0	0	0.00000425	68.1356	3.81533
AMINOPHENOL(-P)	-3.357	699.157	-331.343	0.00000425	68.1356	3.81533
AMMONIA	7.5547	1002.711	247.885	0.00000425	15.3	1
AMYL ACETATE(-N)	0	0	0	0.0000026944	16.1142	51.10801
ANILINE	7.32	1731.515	206.049	0.0000019722	0.3381	7.94328
BENZENE	6.905	1211.033	220.79	0.0000052778	13.5714	141.25375
BENZO(A)ANTHRACENE	6.9824	2426.6	156.6	0.0000086389	1.7006	407380.2778

**TABLE 5.B-4 (PART 2)**  
**(CONTINUED)**

Chemical Name	Antoine's Equation Vapor Pressure Coefficient A	Antoine's Equation Vapor Pressure Coefficient B	Antoine's Equation Vapor Pressure Coefficient C	Maximum Biodegradation Rate Constant (g/g Biomass-s)	Half Saturation Constant (g/m <sup>3</sup> )	Octanol-Water Partition Coefficient At 25°C
BENZO(A)PYRENE	9.2455	3724.363	273.16	0.0000086389	1.2303	954992.58602
BENZYL CHLORIDE	0	0	0	0.0000049306	17.5674	199.52623
BIS(2-CHLOROETHYL)ETHER	0	0	0	0.0000029889	20.0021	38.01894
BIS(2-CHLOROISOPROPYL)ETHER	0	0	0	0.0000029889	8.3382	380.1894
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	0	0.0000002139	2.2	199526.2315
BROMOFORM	0	0	0	0.0000029889	10.653	199.52623
BROMOMETHANE	0	0	0	0.0000029889	30.4422	12.58925
BUTADIENE-(1,3)	6.849	930.546	238.854	0.0000042534	15.3	74.32347
BUTANOL (ISO)	7.4743	1314.19	186.55	0.0000021667	70.9091	5.62341
BUTANOL-(1)	7.4768	1362.39	178.77	0.0000021667	70.9091	5.62341
BUTYL BENZYL PHTHALATE	0	0	0	0.0000086389	14.1364	60255.95861
CARBON DISULFIDE	6.942	1169.11	241.59	0.0000042534	5.8175	1
CARBON TETRACHLORIDE	6.934	1242.43	230	0.0000004167	1	524.80746
CHLORO(-P)CRESOL(-M)	0	0	0	0.0000029889	5.2902	1258.92541
CHLOROACETALDEHYDE	0	0	0	0.0000029889	49.838	3.4405
CHLOROBENZENE	6.978	1431.05	217.55	0.0000001083	.039	316.22777
CHLOROFORM	6.493	929.44	196.03	0.0000008167	3.7215	91.20108
CHLORONAPHTHALENE-(2)	0	0	0	0.0000029889	2.167	13182.56739

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**TABLE 5.B-4 (PART 2)**  
**(CONTINUED)**

Chemical Name	Antoine's Equation Vapor Pressure Coefficient A	Antoine's Equation Vapor Pressure Coefficient B	Antoine's Equation Vapor Pressure Coefficient C	Maximum Biodegradation Rate Constant (g/g Biomass-s)	Half Saturation Constant (g/m <sup>3</sup> )	Octanol-Water Partition Coefficient At 25°C
CHLOROPRENE	6.161	783.45	179.7	0.0000029968	6.3412	1
CRESOL(-M)	7.508	1856.36	199.07	0.0000064472	1.3653	93.32543
CRESOL(-O)	6.911	1435.5	165.16	0.0000063278	1.34	95.49926
CRESOL(-P)	7.035	1511.08	161.85	0.0000064472	1.3653	87.09636
CRESYLIC ACID	0	0	0	0.0000041667	15	1
CROTONALDEHYDE	0	0	0	0.0000026944	27.6285	12.36833
CUMENE (ISOPROPYLBENZENE)	6.963	1460.793	207.78	0.0000086458	16.5426	1
CYCLOHEXANE	6.841	1201.53	222.65	0.0000042534	15.3	338.0687
CYCLOHEXANOL	6.255	912.87	109.13	0.0000026944	18.0816	37.74314
CYCLOHEXANONE	7.8492	2137.192	273.16	0.0000031917	41.8921	6.45654
DI-N-OCTYL PHTHALATE	0	0	0	0.000000083	0.02	141253.7
DIBUTYLPHTHALATE	6.639	1744.2	113.59	0.0000001111	0.4	158489.31925
DICHLORO(-2)BUTENE(1,4)	0	0	0	0.0000029889	9.8973	242.1542
DICHLOROBENZENE(1,2) (-O)	0.176	0	0	0.0000006944	4.3103	2398.83292
DICHLOROBENZENE(1,3) (-M)	0	0	0	0.0000017778	2.7826	2398.83292
DICHLOROBENZENE(1,4) (-P)	0.079	0	0	0.0000017778	2.7826	2454.70892
DICHLORODIFLUOROMETHANE	0	0	0	0.0000029889	12.0413	144.54398
DICHLOROETHANE(1,1)	0	0	0	0.0000029889	4.6783	61.6595
DICHLOROETHANE(1,2)	7.025	1272.3	222.9	0.0000005833	2.1429	61.6595

**TABLE 5.B-4 (PART 2)**  
**(CONTINUED)**

Chemical Name	Antoine's Equation Vapor Pressure Coefficient A	Antoine's Equation Vapor Pressure Coefficient B	Antoine's Equation Vapor Pressure Coefficient C	Maximum Biodegradation Rate Constant (g/g Biomass-s)	Half Saturation Constant (g/m <sup>3</sup> )	Octanol-Water Partition Coefficient At 25°C
DICHLOROETHYLENE(1,2)	6.965	1141.9	231.9	0.0000029889	6.3294	1
DICHLOROPHENOL(2,4)	0	0	0	0.0000069444	7.5758	562.34133
DICHLOROPHENOXYACETIC ACID(2,4)	0	0	0	0.0000029889	14.8934	82.61445
DICHLOROPROPANE(1,2)	6.98	1380.1	22.8	0.0000047222	12.1429	1
DIETHYL (N,N) ANILINE	7.466	1993.57	218.5	0.00000425	27.0047	43.57596
DIETHYL PHTHALATE	0	0	0	0.000000753	1.28	1412.537
DIMETHYL FORMAMIDE	6.928	1400.87	196.43	0.00000425	15.3	1
DIMETHYL HYDRAZINE(1,1)	7.408	1305.91	225.53	0.00000425	15.3	1
DIMETHYL PHTHALATE	4.522	700.31	51.42	0.0000006111	0.7097	74.13102
DIMETHYLBENZ(A)ANTHRACENE	0	0	0	0.0000086389	0.3377	28680056.33087
DIMETHYLPHENOL(2,4)	0	0	0	0.0000029722	2.2766	263.0268
DINITROBENZENE (-M)	4.337	229.2	-137	0.00000425	29.9146	33.28818
DINITROTOLUENE(2,4)	5.798	1118	61.8	0.00000425	19.5233	102.3293
DIOXANE(1,4)	7.431	1554.68	240.34	0.0000026944	24.7001	16.60956
DIOXIN	12.88	6465.5	273	0.0000029968	6.3412	1
DIPHENYLAMINE	0	0	0	0.0000052778	8.4103	1659.58691
EPICHLOROHYDRIN	8.2294	2086.816	273.16	0.0000029968	6.3412	1.07152
ETHANOL	8.321	1718.21	237.52	0.0000024444	9.7778	0.47863
ETHANOLAMINE(MONO-)	7.456	1577.67	173.37	0.00000425	223.0321	0.16865

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**TABLE 5.B-4 (PART 2)**  
**(CONTINUED)**

Chemical Name	Antoine's Equation Vapor Pressure Coefficient A	Antoine's Equation Vapor Pressure Coefficient B	Antoine's Equation Vapor Pressure Coefficient C	Maximum Biodegradation Rate Constant (g/g Biomass-s)	Half Saturation Constant (g/m <sup>3</sup> )	Octanol-Water Partition Coefficient At 25°C
ETHYL ACRYLATE	7.9645	1897.011	273.16	0.0000026944	39.4119	4.85667
ETHYL CHLORIDE	6.986	1030.01	238.61	0.0000029889	22.8074	26.91535
ETHYL-(2)PROPYL-(3) ACROLEIN	0	0	0	0.000004425	15.3	1
ETHYLACETATE	7.101	1244.95	217.88	0.0000048833	17.58	1
ETHYLBENZENE	6.975	1424.255	213.21	0.0000018889	3.2381	1412.53754
ETHYLENEOXIDE	7.128	1054.54	237.76	0.0000011667	4.6154	0.50003
ETHYLETHER	6.92	1064.07	228.8	0.0000026944	17.1206	43.57596
FORMALDEHYDE	7.195	970.6	244.1	0.0000013889	20	87.09636
FORMIC ACID	7.581	1699.2	260.7	0.0000026944	6.3412	0.1191
FREONS	0	0	0	0.0000029968	6.3412	1
FURAN	6.975	1060.87	227.74	0.0000026944	14.1936	71.37186
FURFURAL	6.575	1198.7	162.8	0.0000026944	18.0602	37.86047
HEPTANE (ISO)	6.8994	1331.53	212.41	0.0000042534	15.3	1453.372
HEXACHLOROBENZENE	0	0	0	0.0000029889	0.6651	295120.92267
HEXACHLOROBUTADIENE	- 0.824	0	0	0.000003	6.3412	5495.408
HEXACHLOROCYCLOPENTADIENE	0	0	0	0.0000029968	0.3412	9772.372
HEXACHLOROETHANE	0	0	0	0.0000029889	3.3876	4068.32838
HEXANE(-N)	6.876	1171.17	224.41	0.0000042534	15.3	534.0845
HEXANOL(-1)	7.86	1761.26	196.66	0.0000026944	15.2068	59.52851



**TABLE 5.B-4 (PART 2)**  
**(CONTINUED)**

Chemical Name	Antoine's Equation Vapor Pressure Coefficient A	Antoine's Equation Vapor Pressure Coefficient B	Antoine's Equation Vapor Pressure Coefficient C	Maximum Biodegradation Rate Constant (g/g Biomass-s)	Half Saturation Constant (g/m <sup>3</sup> )	Octanol-Water Partition Coefficient At 25°C
HYDROCYANIC ACID	7.528	1329.5	260.4	0.0000026944	1.9323	1
HYDROFLUORIC ACID	7.217	1268.37	273.87	0.0000026944	1.9323	1
HYDROGEN SULFIDE	7.614	885.319	250.25	0.0000029889	6.3294	1
ISOPHORONE	0	0	0	0.00000425	25.6087	50.11872
METHANOL	7.897	1474.08	229.13	0.000005	90	0.19953
METHYL ACETATE	7.065	1157.63	219.73	0.0000055194	159.2466	0.81285
METHYL CHLORIDE	7.093	948.58	249.34	0.0000029889	14.855	83.17638
METHYL ETHYL KETONE	6.9742	1209.6	216	0.0000005556	10	1.90546
METHYL ISOBUTYL KETONE	6.672	1168.4	191.9	0.0000002056	1.6383	23.98833
METHYL METHACRYLATE	8.409	2050.5	274.4	0.0000026944	109.2342	0.33221
METHYL STYRENE (ALPHA)	6.923	1486.88	202.4	0.0000008639	11.12438	2907.589
METHYLENE CHLORIDE	7.409	1325.9	252.6	0.0000061111	54.5762	17.78279
MORPHOLINE	7.7181	1745.8	235	0.00000425	291.9847	0.08318
NAPHTHALENE	7.01	1733.71	201.86	0.0000117972	42.47	1
NITROANILINE(-O)	8.868	336.5	273.16	0.00000425	22.8535	67.6083
NITROBENZENE	7.115	1746.6	201.8	0.0000030556	4.7826	69.1831
PENTACHLOROBENZENE	0	0	0	0.0000029889	0.4307	925887.02902
PENTACHLOROETHANE	6.74	1378	197	0.0000029889	0.4307	925887.02902
PENTACHLOROPHENOL	0	0	0	0.0000361111	38.2353	102329.29923

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**TABLE 5.B-4 (PART 2)**  
**(CONTINUED)**

Chemical Name	Antoine's Equation Vapor Pressure Coefficient A	Antoine's Equation Vapor Pressure Coefficient B	Antoine's Equation Vapor Pressure Coefficient C	Maximum Biodegradation Rate Constant (g/g Biomass-s)	Half Saturation Constant (g/m <sup>3</sup> )	Octanol-Water Partition Coefficient At 25°C
PHENOL	7.133	1516.79	174.95	0.0000269444	7.4615	28.84032
PHOSGENE	6.842	941.25	230	0.00000425	70.8664	3.4405
PHTHALIC ACID	0	0	0	0.0000026944	34.983	6.64623
PHTHALIC ANHYDRIDE	8.022	2868.5	273.16	0.0000048872	3.9241	0.23988
PICOLINE(-2)	7.032	1415.73	211.63	0.00000425	44.8286	11.48154
POLYCYLORINATED BIPHENYLS	0	0	0	0.000005278	20	1
PROPANOL (ISO)	8.117	1580.92	219.61	0.0000041667	200	0.69183
PROPIONALDEHYDE	16.2315	2659.02	-44.15	0.0000026944	39.2284	4.91668
PROPYLENE GLYCOL	8.2082	2085.9	203.5396	0.0000026944	109.3574	0.33141
PROPYLENE OXIDE	8.2768	1656.884	273.16	0.0000048872	3.9241	1
PYRIDINE	7.041	1374.8	214.98	0.0000097306	146.9139	4.4684
RESORCINOL	6.9243	1884.547	186.0596	0.0000026944	35.6809	6.30957
STYRENE	7.14	1574.51	224.09	0.0000086389	282.7273	1445.43977
TETRACHLOROETHANE(1,1,2)	6.898	1365.88	209.74	0.0000029889	6.3294	1
TETRACHLOROETHANE(1,1,2,2)	6.631	1228.1	179.9	0.0000017222	9.1176	363.07805
TETRACHLOROETHYLENE	6.98	1386.92	217.53	0.0000017222	9.1176	398.10717
TETRAHYDROFURAN	6.995	1202.29	226.25	0.0000026944	20.3702	27.58221
TOLUENE	6.954	1344.8	219.48	0.0000204111	30.6167	489.77882
TOLUENE DIISOCYANATE(2,4)	0	0	0	0.0000425	15.3	1

**TABLE 5.B-4 (PART 2)**  
**(CONTINUED)**

Chemical Name	Antoine's Equation Vapor Pressure Coefficient A	Antoine's Equation Vapor Pressure Coefficient B	Antoine's Equation Vapor Pressure Coefficient C	Maximum Biodegradation Rate Constant (g/g Biomass-s)	Half Saturation Constant (g/m <sup>3</sup> )	Octanol-Water Partition Coefficient At 25°C
TRICHLORO(1,1,2)TRIFLUOROETHANE	6.88	1099.9	227.5	0.0000029889	3.3876	4068.32838
TRICHLOROBENZENE(1,2,4)	0	0	0	0.0000029889	2.4495	9549.92586
TRICHLOROBUTANE(1,2,3)	0	0	0	0.0000029968	6.3412	1450901.06626
TRICHLOROETHANE(1,1,1)	8.643	2136.6	302.8	0.0000009722	4.7297	309.02954
TRICHLOROETHANE(1,1,2)	6.951	1314.41	209.2	0.0000009722	4.7297	1
TRICHLOROETHYLENE	6.518	1018.6	192.7	0.0000010833	4.4318	194.98446
TRICHLOROFLUOROMETHANE	6.884	1043.004	236.88	0.000003	6.3412	338.8441
TRICHLOROPHENOL(2,4,6)	0	0	0	0.0000425	58.8462	4897.78819
TRICHLOROPROPANE(1,1,1)	0	0	0	0.0000029889	10.7719	193.7827
TRICHLOROPROPANE(1,2,3)	6.903	788.2	243.23	0.0000029889	10.7719	193.7827
UREA	0	0	0	0.00000425	4.8169	4068.32838
VINYL ACETATE	7.21	1296.13	226.66	0.0000026944	31.8363	8.51722
VINYL CHLORIDE	3.425	0	0	0.000003	6.3412	1.14815
VINYLDENE CHLORIDE	6.972	1099.4	237.2	0.0000029968	6.3412	1
XYLENE(-M)	7.009	1426.266	215.11	0.0000086389	14.0094	1584.89319
XYLENE(-O)	6.998	1474.679	213.69	0.0000113306	22.8569	891.25094

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**VOLUME II: CHAPTER 6**

# **PREFERRED AND ALTERNATIVE METHODS FOR ESTIMATING AIR EMISSIONS FROM SEMICONDUCTOR MANUFACTURING**

**February 1999**



Prepared by:  
Eastern Research Group, Inc.

Prepared for:  
Point Sources Committee  
Emission Inventory Improvement Program

## DISCLAIMER

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# 1

## INTRODUCTION

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The purposes of the preferred methods guidelines are to describe emissions estimation techniques for stationary point sources in a clear and unambiguous manner and to provide concise example calculations to aid in the preparation of emission inventories. This chapter describes the procedures and recommended approaches for estimating air emissions from semiconductor manufacturing operations.

Section 2 of this chapter contains a general description of the semiconductor manufacturing source category, a listing of common emission sources associated with semiconductor manufacturing, and an overview of the available air pollution control technologies for semiconductor manufacturing. Section 3 of this chapter provides an overview of available emission estimation methods. It should be noted that the use of site-specific emissions data is always preferred over the use of industry-averaged data such as default data. However, depending upon available resources, obtaining site-specific data may not be cost effective. Section 4 presents the preferred emission estimation methods for semiconductor manufacturing, and Section 5 presents alternative emission estimation techniques. Quality assurance and quality control procedures are described in Section 6; Section 7 contains data coding procedures. Section 8 identifies the references used to develop this chapter. Appendix A contains an example data collection form for semiconductor manufacturing sources and may be revised to fit individual user's needs.

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# 2

## SOURCE CATEGORY DESCRIPTION

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### 2.1 PROCESS DESCRIPTION

A semiconductor is a material that has an electrical conductivity between that of a conductor and an insulator; its electrical characteristics can be manipulated to behave like either depending on how it is processed. Silicon has traditionally been the substrate used to manufacture semiconductors. However, the focus in recent years has been on developing valence III-V compounds, such as gallium arsenide (GaAs), as a substrate material. GaAs has several advantages over silicon, such as increased electron mobility and semi-insulating properties (Noyes, 1993).

The semiconductor manufacturing process involves a wide variety of distinct processing steps and is continually evolving. As a result, a range of processes may occur at a single plant and non-uniformity exists for a process design from plant to plant. An average semiconductor manufacturing process consists of hundreds of process steps, a significant percentage of which may be potential air emission sources. Furthermore, many of the manufacturing steps are repeated several times during the production process. This section will discuss general manufacturing steps and does not attempt to describe a specific type of plant.

A clean environment is essential to the manufacture of semiconductors; thus cleaning operations precede and follow many of the manufacturing process steps. Wet processing, during which semiconductor devices are repeatedly immersed in, or sprayed with, solutions, is commonly used to minimize the risk of contamination (EPA, 1995a). These processes also give rise to emissions of a variety of pollutants.

The primary component of a semiconductor is the wafer. The general steps in the semiconductor manufacturing process include wafer preparation, wafer fabrication, and die assembly.

#### 2.1.1 WAFER PREPARATION

Wafers are the starting point for semiconductor production. The wafer is typically made from a single crystal silicon with one of two crystallographic orientations. The substrate is silicon grown from a seed crystal into an “ingot” that is sliced, lapped, etched, and polished to form silicon wafers. Substrate preparation can be accomplished on-site, but is usually completed at other facilities.

In the first step of wafer preparation, ingots are shaped into wafer form through a series of cutting and grinding steps, usually performed using diamond-tipped tools. The ends of the silicon ingots are removed and individual wafers are cut. The wafers may then be polished using an aluminum oxide/glycerin solution to provide uniform flatness in a process called lapping.

This initial shaping of the wafers leaves imperfections in the surface and edge of the wafers that are removed in an etching step. Chemical etching involves the use of hydrofluoric, nitric, or acetic acids as well as alkaline solutions of potassium or sodium hydroxide.

A final polishing step is performed to provide a smooth surface for subsequent processing. In this step, wafers are mounted on a fixture, pressed against a polishing pad under high pressure, and rotated relative to the pad. A polishing slurry, typically containing silicon dioxide particles in sodium hydroxide, is used. This step is both a chemical and mechanical process; the slurry reacts chemically with the wafer surface to form silicon dioxide, and the silica particles in the slurry abrade the oxidized silicon.

In some cases, bare silicon wafers are cleaned using ultrasound techniques, which involve the use of potassium chromate or other mild alkaline solutions (EPA, 1995a).

In the final wafer preparation step, the wafers are usually rinsed in deionized water and dried with compressed air or nitrogen (EPA, 1995a).

### **2.1.2 WAFER FABRICATION**

The basic processes that are utilized in wafer fabrication include photolithography, doping, thin film deposition, etching, metallization, cleaning, and in some cases chemical mechanical planarization. Through the use of physical and chemical processes, hundreds of thousands of miniature transistors are created on the substrate. The result is the formation of integrated circuits on silicon wafers that, when cut into the single “chips,” can be packaged and marketed as separate electronic components to be used in various applications.

The process sequence, equipment, and specific chemicals used in any particular process vary widely. Therefore, the descriptions that follow are for generic types of wafer fabrication processes. The steps outlined below are not meant to represent the order of processing in any wafer fabrication facility. Each of these steps may be used many times in processing a wafer; the number of times each step is repeated is highly dependent on the type of device and its final functional requirements.

## **Photolithography**

Photolithography is used in semiconductor manufacturing to form surface patterns on the wafer through the use of a photoresist. The photoresist is typically a viscous, organic solvent-based material which reacts to the presence of light. This process allows various materials to be deposited at or removed from selected, precise locations. In this process, an adhesion promotor is first applied to the wafer surface to help the photoresist stick to the silicon wafer. A fixed amount of photoresist is then applied to the wafer using a high speed rotating element to uniformly coat the wafer surface. In most cases an edge bead removal (EBR) step is performed to remove any beads of photoresist on the edge of the wafer.

After a “soft bake” to remove most of the carrier solvent, a pattern is introduced into the photoresist by exposing predefined areas of the wafer with specific wavelengths of light, lasers, electron beams, or other means. This may be accomplished through the use of a template mask, which is a glass plate containing an image of the desired circuit.

Finally, a photoresist developer is applied to remove unwanted portions of the photoresist, thereby yielding a stencil for further processing. Depending on the photoresist system, the exposed areas become more or less soluble in the developer solution. If a negative photoresist is used, the exposed areas polymerize (harden), while the photoresist unpolymerizes when positive resists are used.

The “patterned” wafer allows for further processing (etching, ion implant, etc.) to ultimately give a printed circuit. After the subsequent processing steps, residual photoresist is removed by wet stripping (solvent or acid) or plasma gas stripping. The number of photolithography steps performed on an individual wafer varies, depending on the type and complexity of the integrated circuit device being produced.

One of the most common adhesion promoters is hexamethyldisilazane. Typical examples of chemicals used in photoresist coating and EBR processes include propylene glycol monomethyl ether acetate (PGMEA), ethyl lactate, n-butyl acetate, methyl isobutyl ketone, n-hexane, toluene, and xylene(s). Photoresist developers for negative resists are typically solvents such as xylenes or mineral spirits; developers for positive photoresists are typically very dilute solutions of tetramethyl ammonium hydroxide in water. Typical solvent based strippers contain amines. Such as N-methyl 2 pyrrolidone, typical acid based strippers contain sulfuric acid, and plasma stripping usually employs oxygen and simple perfluorocarbons (PFCs).

## **Doping**

Doping is a process whereby atoms of specific impurities are introduced into the silicon substrate to alter the electrical properties of the substrate by acting as charge carriers. The concentration

and type of the dopant atoms dictate the electrical characteristics that define the functionality of the transistor, and ultimately, the device. Doping is typically accomplished through ion implantation or diffusion processes.

Ion implantation is the most common method used to introduce impurity atoms into the substrate and provides a more controlled doping mechanism than diffusion. The dopant atoms are first ionized with a medium- to high-current filament, then accelerated toward the wafer surface with large magnetic and electrical fields. Precise control of the dopant ion momentum in this process allows for precise control of the penetration into the silicon substrate. Because of the high kinetic energy of the ions during bombardment, damage to the crystalline structure of the substrate occurs. To restore the structure of the substrate to a satisfactory level, slow heating or “annealing” of the amorphous material in various gaseous atmospheres is subsequently performed.

Diffusion is a high-temperature process also used to introduce a controlled amount of a dopant gas into the silicon substrate. The process occurs in a specially designed tube furnace where dopants may be introduced in one of two primary ways:

- Gaseous diffusion - dopant gases may be introduced into the furnace that will diffuse into the exposed areas of the substrate; or
- Non-gaseous diffusion - or dopant atoms may diffuse into the substrate from a previously deposited dopant oxide layer in the areas where the two are in contact.

By knowing the amount of dopant atoms and using a carefully controlled constant temperature, a predictable solid-state diffusion may be achieved.

Typical examples of chemicals used in doping processes include compounds of antimony, cobalt, indium or other group IIIa or Va elements, as well as gases such as arsine, phosphine, boron trifluoride and diborane.

### ***Thin Film Deposition***

In thin film deposition, layers of single crystal silicon, polysilicon, silicon nitride, silicon dioxide, or other materials are deposited on the wafer to provide desirable properties on portions of the device or to serve as masks. Each of these films serves a specific purpose in device operation:

- Single crystal silicon films (also called epitaxial silicon) serve as the substrate in which the heart of transistors are constructed;

- Amorphous silicon films (also called polysilicon) serve as gate electrodes in most modern devices; these films are typically heavily doped to make them very conductive;
- Silicon nitride films serve as passivation layers that are used primarily as protective layers after most device processing has occurred, but may also be used as an etch stop; and
- Silicon dioxide films are deposited by oxidation processes and are by far the most frequently deposited films. Silicon dioxide films act primarily as dielectric layers, but may also act as masks for subsequent processing.

Oxidation processes may be dry or wet, and occur in high-temperature furnaces ( $>600^{\circ}\text{C}$ ). In the furnace, the silicon wafer surface oxidizes with steam (i.e., wet oxidation) or a gas such as oxygen (i.e., dry oxidation) to form a silicon dioxide layer. Generally, wet oxidation does not involve the use of regulated pollutants. In the dry oxidation process, however, a chlorine source (chlorine gas, anhydrous hydrochloric acid, or trichloroethylene) may be used to alter oxide characteristics.

Deposition of thin films is also frequently performed in chemical vapor deposition (CVD) reactor chambers or high-temperature tube furnaces. CVD processes use silicon-containing gases as reactants and sometimes employ selected impurity compounds (dopants) to alter the electrical characteristics of the deposited film or layer. Diffusion furnaces are, by design, very high throughput tools, are typically run at very high temperatures ( $1,000^{\circ}\text{C}$ ), and can be run at atmospheric or low pressure. Because of the high temperatures, diffusion processes are normally used most frequently before any metals are deposited on the wafer. Reactor chambers can be batch or single wafer tools, and typically have lower throughput than diffusion furnaces. They are typically run at lower temperatures ( $500^{\circ}\text{C}$ ), and low pressure. Deposition in reactor chambers may be enhanced by striking a plasma in the chamber to overcome kinetic barriers. This allows for rapid deposition without the use of elevated temperatures, which is important for processing steps after metals are deposited on the wafer.

Inorganic acids and organic solvents may be used to clean furnaces between batches or to clean reactor chambers after a prescribed number of wafers are processed. Halogenated gases may be used to clean reactor chambers or furnaces between wafers or between batches.

Silicon-bearing reactants (such as silane, tetraethylorthosilicate [TEOS], dichlorosilane, trichlorosilane, silicon tetrachloride and others) may be used with or without nitrogen- and oxygen-containing gases (such as ammonia or nitrous oxide) in deposition of various film types. Where they are used, the dopant gases are similar to those used in doping processes. For deposition of metal films, the silicon-containing reactant gases are replaced with metal-containing

reactant gases such as tungsten hexafluoride. Gases used to clean reactor chambers between runs include hexafluoroethane and nitrogen trifluoride.

Examples of chemicals used in these deposition processes include ammonia, 1,2-dichloroethylene, cobalt, copper, and hydrochloric acid.

### ***Etching***

Etching of the silicon substrate or deposited film is used to chemically remove specific areas of the substrate or film so that an underlying material is exposed or another material may be deposited in place of the etched material. Etch processes usually occur after a photoresist pattern has been applied, so that the etching is accomplished in specific areas.

Etching may be performed by the following processes:

- Wet etch - using solutions of acids, bases, or oxidizers; or
- Dry etch - uses various gases (usually halogenated) excited by striking a plasma .

Dry etching provides a higher resolution than wet etching, generally produces less undercutting of the wafer substrate, and is more likely to be used as circuit elements become smaller. In either case, the fluoride ion or radical is almost always introduced if the substrate or film to be etched contains silicon.

Examples of chemicals used in wet etch processes are hydrofluoric acid (sometimes buffered with ammonium fluoride), phosphoric acid, nitric acid and acetic acid. Plasma etch gases used for silicon films include PFCs such as hexafluoroethane, tetrafluoromethane, trifluoromethane, nitrogen trifluoride and sulfur hexafluoride. Gases used for plasma etch of metal films include chlorine and boron trichloride.

### ***Metallization***

To interconnect electrical devices on an integrated circuit and to provide for external connections, metallic layers (usually aluminum) are deposited onto the wafer by evaporation, sputtering (also called physical vapor deposition or PVD), or chemical vapor deposition. Evaporation consists of vaporizing a metal under a vacuum at a very high temperature. Sputtering processes involve bombarding metallic targets with a plasma gas, which displaces ions from the target and deposits them on the wafer. Chemical vapor deposition of metal is similar to the other deposition processes described in the Thin Films section, except that the reactive gas is a metal-containing vapor. Devices may have a single layer or multiple layers of metal.



The use of copper as a replacement for aluminum is under investigation by many companies. Copper metallization may be accomplished by CVD or PVD methods as described above, or by electrolytic or electroless plating.

Examples of chemicals used in PVD metallization processes include argon as the plasma gas, and aluminum as the deposited metal. CVD metallization processes typically use gases such as tungsten hexafluoride.

### ***Cleaning***

Cleaning of the wafers is required to prepare them for each chemical and physical process to ensure that contaminants on the wafer surfaces do not affect the electrical performance of the final integrated circuit. Wafers may be cleaned before, and sometimes after, they are subjected to any specialized manufacturing processes, they are typically immersed in or sprayed with various aqueous and/or organic solutions, and in some cases mechanically scrubbed in some manner to remove films, residues, bacteria, or other particles. Two basic types of tools are widely used in various cleaning applications: wet hoods and spray tools. Fog chambers may be used for wafer cleaning in some cases.

Examples of chemicals used in cleaning processes include a wide variety of inorganic acids, ammonium hydroxide, various alcohols, and various amines.

### ***Chemical Mechanical Planarization***

Chemical mechanical planarization (CMP) is used in semiconductor manufacturing to remove the top layer of material from the wafer in a controlled manner, leaving a smooth, flat surface for further processing. There are two major applications of this technology. The first is to selectively remove the top part of a layer or film to reduce the topography on the wafer (also called planarization). This is normally performed on the nonconducting layers. The end result is an increase in the process margin for both deposition and photolithography. The second use is removal of excess material from the surface. This is normally performed on conducting layers (metals). After a blanket pattern, conducting material is deposited on the underlayer, and the wafer is polished down to the patterned underlayer. The result is a smooth, flat surface that has conducting material left in the patterned crevices.

As the name implies, CMP slurries are composed of two components; a chemical component to react with the film on the wafer surface, and a mechanical component to abrade the reacted surface layer and remove it. Typical chemical components include bases such as potassium hydroxide and oxidizers such as ferric nitrate or hydrogen peroxide. Typical mechanical components are very fine (submicron) silica and alumina particles.

### 2.1.3 SEMICONDUCTOR ASSEMBLY

The final steps in the assembly of semiconductors involves:

- Testing each chip (i.e., die);
- Mounting the functional chips onto a protective enclosure (i.e., package);
- Electrically connecting the chips to packages; and
- Enclosing the chips within the packages to protect them.

Protective enclosures may be made from plastic, ceramic, or other materials; however, plastic is most commonly used (EPA, 1995a). Marking, and in some cases metal finishing, processes may follow the encapsulation steps to make the packaged chip easy to install in the final consumer product.

The packaging process typically employs solvents such as isopropyl alcohol, acetone, and terpenes to clean chips and packages prior to connection. Depending on the packaging technology, aqueous metal plating solutions may be used to prepare the chip for connection to the package, or to prepare the packaged chip for installation in the consumer product.

## 2.2 EMISSION SOURCES

The physical and chemical processing steps discussed in Section 2.1 occur at three general types of process areas:

- Wet chemical stations such as those used for wafer cleaning and wet etch;
- Coating application stations such as those used in photolithography; and
- Gaseous operation stations such as those used in etching, thin film deposition, and doping.

A variety of pollutants may be emitted at these stations. These include acid fumes and organic solvent vapors from cleaning, rinsing, resist drying, developing, and resist stripping; hydrogen chloride, hydrogen fluoride, and vapors from etching; and other various vapors from spent etching solutions, spent acid baths, and spent solvents (EPA, 1995a).

In addition to process-related emissions, air emissions may also result from on-site treatment of industrial wastewater. Potential liquid wastes include rinse water containing acids and organic

solvents from cleaning, developing, etching, and resist stripping processes; rinse water from aqueous developing systems; spent etching solutions; spent solvents; and spent acid baths. For a discussion of air emissions from industrial wastewater collection and treatment, refer to Chapter 5 of this volume.

If fossil fuel fired boilers and generators are used, criteria pollutant emissions will be generated. Criteria pollutants may also be emitted from the combustion of organic pollutants in control devices. Refer to Chapter 2 of this volume for estimating emissions from boilers and other combustion sources.

### **2.2.1 WET CHEMICAL STATIONS**

Wet chemical stations are used to clean wafers, remove resist, and etch patterns into silicon or metal. Materials used during the wet process may include acids (sulfuric, phosphoric, nitric, hydrofluoric, and hydrochloric), solvents (various alcohols, glycol ethers, amines), oxidizers (hydrogen peroxide), bases (ammonium hydroxide), and other solutions.

There are generally two types of tools used for wet chemical processes: wet hoods and spray tools. Wet hoods have a sequence of open or covered tanks with various chemicals, usually with a dedicated rinse tank for each chemical tank. The wafers travel through each chemical bath and rinse in proper sequence, until the clean, etch or strip process is complete. Spray tools typically have one or two dedicated chambers for the wafers, into which various chemicals (and subsequent rinses) flow or are sprayed in sequence until the clean, etch or strip process is complete. Wet hoods use time- or throughput-based chemical dumps. Spray tools may use time- or throughput-based dumps, or may use chemicals only once then dump to drain. The two tools may have very different emissions characteristics for identical chemical use, and the nature of the emissions from each tool type is strongly dependent on the way the tool is operated.

Wet chemical stations of any type generally emit acids, bases or solvents to an exhaust system. Depending on the emission rate and concentration, conventional emissions control technology can be employed to reduce emissions where necessary.

### **2.2.2 COATING APPLICATIONS**

Coating applications include any process where materials are applied to wafers using track equipment or other mechanical means. This would include photoresists, developers, rinse solutions, spin on glass, edge bead removers, adhesives, resins, etc. Emissions occur as these materials are applied, either through evaporation or atomization (aerosols).

For example, once the resist material has been spun onto the wafer, solvents in the resist are evaporated by baking the wafer at low temperatures. During the lithography step, developers are used that may also cause emissions.

Because of the critical nature of lithography steps in wafer processing, all of these chemicals are typically used once then routed to drains. This scenario makes emission rates linearly proportional to chemical use rates.

Coating applications stations typically emit solvents and sometimes bases to an exhaust system. Depending on the emission rate and concentration, conventional emissions control technology can be employed to reduce emissions where necessary.

### 2.2.3 GASEOUS OPERATIONS

Many of the processes at semiconductor manufacturing facilities occur in gaseous environments, and most are in the cleaning, doping, plasma etching, and thin film deposition areas. Specific processes include atmospheric and low pressure CVD, plasma-enhanced CVD, ion implantation, diffusion, plasma etching, plasma/ion etching, and plasma resist stripping.

Because the process feeds are primarily gaseous, emissions from these processes are normally higher on a percent of inlet feed basis than for wet chemical processes. However, the absolute emissions are normally much lower because of the relatively small amount of chemicals used. Emissions for some very reactive chemicals may be nearly zero as they are consumed in the process or in the exhaust system prior to discharge. Emissions of very stable chemicals may approach the inlet feed rate, as very little chemical utilization is achieved in the process. The emission rates for each chemical, tool and process will depend on many factors (flow, pressure, temperature, coupled RF or microwave power, geometry, etc.), but is typically linear with the process feed rates of the chemicals.

In dry chemical stations, PFC gases such as carbon tetrafluoride and hexafluoroethane are used for etching wafers and cleaning reactors in plasma processes. The PFC gases in the reactor chamber form fluorine species, including hydrogen fluoride (HF). However, the conversion of PFC gases to HF is incomplete, and a complete accounting of each fluorine species is difficult to obtain. The mixture of gaseous products exhausted from the reactor chamber may contribute significantly to the total HF emissions from a semiconductor manufacturing facility.

Gaseous operations stations emit a wide variety of chemicals to an exhaust system. Some of these chemicals may be easy to remove with conventional air pollution control systems, but many pose unique challenges. Compounds such as PFCs are very stable and have very low water solubility, and are not removed to any appreciable extent by conventional treatment. Compounds such as silane and phosphine are very reactive and may start fires in an exhaust system, so must

be treated as quickly as possible. The industry's approach to reducing emissions from these processes is widely varied, and continues to evolve in response to improving new control technologies.

#### **2.2.4 MISCELLANEOUS OPERATIONS**

In addition to the major chip production and cleaning processes, there are usually other miscellaneous processes occurring at a semiconductor manufacturing facility which may result in emissions. These would include wipe cleaning, equipment maintenance and assembly, and final mark and pack operations associated with packaging the product for distribution. Typically these processes are minor as far as contribution to facility-wide emissions, but should be accounted for in a complete inventory assessment.

### **2.3 PROCESS DESIGN AND OPERATING FACTORS INFLUENCING EMISSIONS**

Emissions from semiconductor manufacturing processes may be affected by many different process, equipment design, and air pollution control equipment parameters. This section describes process equipment design, control devices, and chemical substitution methods. In some cases, adjustment of these parameters can be used to reduce the amount of pollutant-containing material used, as well as to reduce emissions from those pollutant-containing materials that are used.

#### **2.3.1 PROCESS MODIFICATIONS**

Process modifications are changes in equipment design or operating practices employed to reduce emissions. For example, open-top vapor cleaners (OTVCs) are often used for cleaning of electronic components (EPA, 1993). Air currents within an OTVC can disturb the vapor zone and cause excessive solvent emissions. Some machines have covers of varying design to limit chemical losses and contamination during downtime or idling. Additional control of the chemical vapor is provided by the freeboard, which is that part of the tank wall extending from the top of the solvent vapor level to the tank lip. The freeboard reduces the effect of room draft (EPA, 1993).

Emissions from these machines are also influenced by the solvent-air interface area, which equals the surface area of the cleaning tanks. Machines that do not expose the cleaning solvent to the ambient air during or between the cleaning of parts, such as vacuum-to-vacuum machines, do not have a solvent-air interface. These systems operate in a closed loop and the solvent is not exposed to the air outside of the machine (EPA, 1995b).

Emissions from batch vapor and in-line machines can be reduced with covers on the machine openings. Covers should be closed whenever possible to minimize vapor loss. For machines without covers, vapor emissions can be decreased by reducing room draft. This can be accomplished by increased freeboard height and slower parts handling (e.g., hoist speed). Primary condensers on vapor cleaning machines consist of liquid- or gas-chilled cooling coils that condense rising solvent vapors. To effectively reduce emissions, primary condensers must be maintained to create a controlled vapor zone. Lip exhausts, used to reduce worker exposure to solvents, dramatically increase overall solvent air emissions if there are no control devices (EPA, 1995b).

Except for inlets and exits for parts, in-line conveyors are almost always enclosed to reduce solvent losses (EPA, 1993).

### **2.3.2 CONTROL DEVICES**

Because of the need for an ultra-clean manufacturing environment and to ensure worker protection, a relatively large amount of air is exhausted from a typical wafer fab. The semiconductor manufacturing industry in general is characterized by very dilute concentrations of pollutants in very high flow exhaust streams. The low concentrations give only low driving forces for separation, and can make high removal efficiency difficult. The exhaust streams are usually segregated to some degree, so that appropriate emissions control can be applied to the corresponding pollutants. Air pollutant emissions may be controlled through the use of add-on control devices or point-of-use control systems.

#### ***Add-on Controls***

Add-on control devices are used to control emissions once they are generated. They may be designed to destroy pollutants (such as through combustion) or to recover them for reuse or recycling off-site (as with adsorption or absorption). Zeolite rotor concentrators may be used to concentrate dilute streams of organics prior to sending them to a destruction or recovery device.

Scrubbers are typically employed to control acid or base emissions, and thermal oxidizers or adsorbers are used to control organic solvent emissions. Additionally, semiconductor facilities use a "burn box" to safely control emissions of pyrophoric and toxic gases such as silane and phosphine. Such burn boxes may or may not use supplemental fuels.

A prototype system has been recently developed for concentration and recovery of PFC gases (Tom et al., 1994). Using a dual-bed adsorber, activated carbon is used in a PFC concentrate and recovery unit (CRU). In this system, concentrated PFC gases are sent to one bed in adsorption mode while the other bed is regenerated, evacuated by vacuum, and then recompressed. This method can produce recycled gases of 97 percent concentration; however, in

an initial test of this system, the percentage of unreacted PFCs (i.e., “leakage” through the bed) gradually increased to 30 percent due to fluctuating bed temperatures. Other technologies for treating PFC emissions are currently under development as well.

Table 6.2-1 lists add-on control technologies commonly found at semiconductor manufacturing plants.

### ***Point-of-Use Control (POU) Systems***

Point-of-use (POU) control systems are designed for treating air emissions from the outlet of the semiconductor process to remove the compounds of interest and prevent them from entering the main exhaust ductwork. Only recently has reduction of air emissions been a consideration in the use of POU control systems. Historically, POU control systems have been installed for reducing production downtime and for health and safety reasons. Typically, POU control systems are interlocked with the process equipment (i.e., when a POU control system fails, the process equipment is shut down). The main reasons for the use of POU control systems are as follows:

- Prevent exhaust restrictions (blocked ductwork) - reactions between gases, solids from the process, or condensation of vapors produce solid build-up in ductwork. This build-up can cause production downtime to clean ductwork, repair collapsed ductwork, etc. An additional issue is the handling and disposal of these solids during and after removal.

TABLE 6.2-1

**ADD-ON CONTROL TECHNOLOGIES EMPLOYED AT SEMICONDUCTOR FACILITIES**

Control Technology	Pollutant	Comments
Horizontal wet scrubbers (cross flow)	Acids or Bases	Can have bypass problems with poor design. Will not remove mists of particulates smaller than $5\mu\text{m}$ .
Vertical wet scrubbers (counter flow)	Acids or Bases	Will not remove mists of particulates smaller than $5\mu\text{m}$ .
Regenerative thermal oxidizers	VOCs	Prone to static pressure instability due to frequent air path switching.
Zeolite rotor concentrators with recuperative thermal oxidizers	VOCs	Zeolite type and capability is variable and should be selected based on inlet stream composition to maximize destruction/removal efficiency.
Fluidized bed polymer adsorption with recuperative thermal oxidizer or hot nitrogen regeneration	VOCs	Increased bed fires can result from poor desorber performance. If regeneration is used, waste is generated that may be burnable for heat recovery off-site.
Fixed bed carbon adsorption with steam stripping	VOCs	Carbon bed fires are a risk due to ketones used. Waste is generated that may be burnable for heat recovery off-site.
Fluidized bed carbon adsorption with hot nitrogen desorption	VOCs	Waste is generated that may be burnable for heat recovery off-site.

- Prevent ductwork fires/explosions - flammable (hydrogen, etc.) and pyrophoric (silane, etc.) gases are used in semiconductor equipment and can cause a fire and/or explosion in the ductwork, possibly resulting in major facility damage and personnel injury.
- Prevent duct corrosion - etching gases (chlorine, etc.) and byproducts (i.e., hydrogen chloride from boron trichloride) can corrode metal ductwork and other materials of construction. This results in production downtime and possible personnel exposure to these gases in the area outside of ductwork.



- Prevent exposure to personnel - toxic gases (hydrides, chlorine, etc.) are controlled near the semiconductor equipment outlet to reduce the likelihood that any toxic gases can migrate into the area outside ductwork where personnel are located.
- Prevent ammonium compounds formation - ammonia will react with acid compounds (hydrogen chloride, nitric acid, etc.) to form ammonium compounds (ammonium chloride, ammonium nitrate, etc.). These ammonium compounds will aggregate in the ductwork and possibly generate a sub-micron particle visible opacity at the stack outlet (generally at 1 ppmv or greater at stack outlet).
- Comply with air regulatory requirements - emissions limits may need to be met in specific regulatory jurisdiction that require POU control systems to be used. Some of this need is due to the lower removal efficiencies for compounds of interest at the centralized ("end-of-pipe") scrubbers (e.g., chlorine).

Table 6.2-2 lists suggested POU technologies for 14 semiconductor applications. These applications were compiled from a survey of nine semiconductor suppliers (Sherer, 1996).

TABLE 6.2-2

**POU CONTROL SYSTEM TECHNOLOGIES FOR VARIOUS SEMICONDUCTOR  
MANUFACTURING APPLICATIONS**

<b>Application</b>	<b>POU<sup>a</sup> Control System Technologies</b>
Wet clean hood with NH <sub>4</sub> OH/H <sub>2</sub> O <sub>2</sub> bath	Wet scrubbing (with chemical addition)
Wet spray etcher with aqua regia	Wet scrubbing (with chemical addition)
Epitaxial silicon with hydrogen vented	Wet scrubbing (without chemical addition)
Epitaxial silicon with hydrogen abated	Oxidation with hydrogen present/wet scrubbing
Ion implant	Cold bed
Poly deposition; non-PFC <sup>b</sup> clean	Oxidation using electric/wet scrubbing; or oxidation using fuel/wet scrubbing; or pre-pump reactor and post-pump wet scrubbing
Doped poly deposition; PFC clean	Oxidation using electric/wet scrubbing; or pre-pump reactor and post-pump wet scrubbing
Metal etch (aluminum)	Cold bed; or hot chemical bed; or wet scrubbing (high pH) control with chemical addition
Nitride deposition with silane; PFC clean	Oxidation using electric/wet scrubbing; or pre-pump reactor and post-pump wet scrubbing
Nitride deposition with dichlorosilane; PFC clean	Hot chemical bed/ammonia control system; or oxidation using electric/wet scrubbing; or pre-pump reactor and post-pump wet scrubbing (with low pH control with chemical addition)
Oxide deposition; PFC clean	Cold bed; or hot chemical bed; or oxidation using electric/wet scrubbing; or pre-pump reactor and post-pump wet scrubbing
Tungsten deposition; PFC clean	Cold bed; or hot chemical bed; or oxidation using electric/wet scrubbing; or pre-pump reactor and post-pump wet scrubbing; or wet scrubbing only (if low silane removal is acceptable)
Poly etch	Cold bed; or hot chemical bed; or wet scrubbing
BPSG <sup>c</sup> oxide deposition; PFC clean	Hot chemical bed; or oxidation using electric/wet scrubbing; or pre-pump reactor and post-pump wet scrubbing

<sup>a</sup> POU = Point of Use<sup>b</sup> PFC = Perfluorocarbons<sup>c</sup> BPSG = Boron phosphorous silicon glass

Source: Sherer, 1996

### 2.3.3 CHEMICAL SUBSTITUTION

Solvent substitution is the replacement of pollutant-containing materials with less volatile, or pollutant-free materials that serve the same function. Process substitution is similar, but instead of an alternative material, a different process is used to obtain the same result. For example, in some cases, dry stripping of resists using only oxygen (in a plasma) can be substituted for wet stripping of resists which use solvents such as N-methyl 2 pyrrolidone.

One manufacturer found that total solvent cleaning usage was decreased significantly by replacing broad spectrum cleaning solvents and mixtures (i.e., one cleaner for all contaminants) with lesser amounts of contaminant-specific cleaning agents (Shire, 1994).

Another manufacturer evaluated several classes of cleaning solvents to replace trichloroethylene usage in the assembly process and found *d*-limonene, a terpene cleaning solvent, was a satisfactory substitute (Meier, 1993). Yet another manufacturer of wafers modified the cleaning, stripping, and photoresist processes to reduce usage of xylenes, and 1,2,4-trichlorobenzene by 33 percent while eliminating usage of chlorofluorocarbons (CFCs) and 1,1,1-trichloroethane (1,1,1-TCA). Xylene usage was decreased by replacing polyisoprene-based negative photoresist with a conventional, propylene glycol monomethyl ether acetate (PGMEA)-based positive resist and, more recently, with negative-tone I-line photoresists (Shire, 1994). Consequently, PGMEA-based photoresists have successfully replaced ethylene glycol ether-based resists at this same facility (Shire, 1994). CFC-113 usage for vapor degreasing was replaced with a high-pressure water jet/detergent-type “dishwasher” that is also used for cleaning wafer trays and cassettes (Shire, 1994).

Criteria considered in selection of an alternate cleaning solvent may include:

- Compatibility with existing solvent cleaning stations (e.g., aqueous cleaning could not be substituted for existing heated bath cleaning);
- Flash point (e.g., high flash points for heated baths);
- Odor;
- Soils loading (e.g., cured photoresist); and
- Cost (i.e., initial and disposal) (Shire, 1994).

Additional quality considerations in solvent substitution include material compatibility, corrosion resistance, cleaning effectiveness, product quality, and manufacturing efficiency (Meier, 1993).

Temperature and agitation are two specific parameters that affect the effectiveness of cleaning solvents at cleaning stations. Substitution of a solvent used for wax removal may also require selection of a replacement wax that is soluble in the solvent and has a similar consistency and melting point as the original wax.

# 3

## OVERVIEW OF AVAILABLE METHODS

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### 3.1 EMISSION ESTIMATION METHODOLOGIES

Several methodologies are available for calculating emissions from semiconductor manufacturing processes. The best method to use depends upon available data, available resources, and the degree of accuracy required in the estimate. In general, site-specific data that are representative of normal operations at a particular site are preferred over data obtained from other similar sites, or industry-averaged data. This section discusses the methods available for calculating emissions from semiconductor manufacturing operations and identifies the preferred method of calculation on a pollutant basis. A comparison of the methods is also presented.

#### 3.1.1 MATERIAL BALANCE

A material balance approach may be used to estimate emissions when the quantities of a material used, recycled, and disposed of are known. For liquid applications, such as wet chemical stations or coating/solvent application stations, usage figures would typically be in gallons. The difference (by mass) of the amount of a liquid used and the amount of the liquid recovered, either through product recovery or disposal, is assumed to equal releases to the air.

Similarly, estimating emissions for gaseous operations would require knowledge of pollutant-containing gas usage. Annual usage may be based on gross purchased amount (in cubic feet.) Normally, only those gases that are considered hazardous or toxic air pollutants (or which can generate them) would need to be considered. However, some states define air hazardous pollutants very broadly, so gaseous compounds such as perfluorocompounds may also need to be tracked even if they do not appear on the Federal HAP list.

When operations have several recipes for different batches, a conservative emissions estimate for each pollutant may be developed based on the recipe with the highest pollutant usage. It should be noted that no waste is typically collected from gaseous operations which may make a complete material balance difficult to determine.

#### 3.1.2 EMISSION FACTORS

Emission factors are used to estimate emissions based on known relationships between process rates and emission rates, or between chemical use and emission rates. The use of emission factors to estimate emissions from semiconductor manufacturing facilities is an appropriate

approach. Development of an accurate emission factor would require detailed knowledge of the process conditions and chemical usage rates during the time period for which emissions are known. Emission factors should be applied to similar-type processes utilizing similar or identical chemical recipes.

### 3.1.3 SOURCE TESTS

While technologies such as gas chromatography (GC), mass spectrometry (MS), and infrared spectroscopy (IS) may be available for use at semiconductor manufacturing facilities (Strang et al., 1989), data are not available to evaluate their actual use in this industry. One study stated that fourier transform infrared (FTIR) monitors may be appropriate for quantitative monitoring of selected compounds at semiconductor facilities (Strang et al., 1989), and work is currently being done to validate this technique.

EPA has published test methods for determining air emissions in Title 40 CFR Part 60, Appendix A. Methods that would be applicable to semiconductor manufacturing would be Method 18 (speciated organics), Method 25 (volatile organic compounds or VOCs), and Method 0030 (speciated organics).

Recently, work has been completed by Sematech, a consortium of U.S. semiconductor manufacturers, to develop a source test and analytical procedure using gas chromatography/mass spectrometry (GC/MS) and FTIR designed specifically to estimate air emissions from semiconductor manufacturing. Several companies have recently used this type of method for quantifying emissions from individual manufacturing tools. The method utilizes a quadrupole mass spectrometer to perform in-line sampling at the exhaust line coming directly out of the process tool or physical processing unit (Higgs, 1996).

### 3.1.4 ENGINEERING CALCULATIONS

In the absence of other data, engineering calculations may be used to estimate emissions from some processes. For example, for any process that involves transfer of a chemical species from the liquid phase to the vapor phase, the saturation (equilibrium) vapor pressure and exhaust flow rate from the process can be used to establish the upper limit of emissions from that process. This is a conservative approach because of the assumption that the total airflow is saturated. A typical air dilution to saturation ratio may be assumed to be as high as 800 to 1.

An alternative method, based on mass transfer kinetics, is presented in the EPA document *Estimating Releases and Waste Treatment Efficiencies for the Toxic Chemical Release Inventory Form* (EPA, 1987). This approach does not assume airflow saturation and results in a lower emission rate estimate than would be obtained assuming saturation.

## 3.2 COMPARISON OF AVAILABLE EMISSION ESTIMATION METHODOLOGIES

Table 6.3-1 identifies the preferred and alternative emission estimation approaches for the primary types of pollutants emitted at semiconductor manufacturing facilities. The preferred method for estimating organic compound (VOC and HAP) emissions is through the use of a material balance. It should be noted that while this method would result in an accurate estimate, each fate of the chemical must be known. It should also be noted that determining individual organic HAPs through mass balance may not be feasible if the HAP in question makes up a very small portion of the total VOC stream. This approach is appropriate for estimating emissions from solvent stations, cleaning stations, and processes where solvents evaporate. The preferred method for estimating emissions of inorganic HAPs (especially acids and other chemical process-related byproducts) is through the use of source testing. In using source testing data, it must be understood that semiconductor fab emissions can be highly variable, so caution must be used in attempting to scale up a short term source test in an annual emissions estimate.

**TABLE 6.3-1**

### SUMMARY OF PREFERRED AND ALTERNATIVE EMISSION ESTIMATION METHODS FOR SEMICONDUCTOR MANUFACTURING OPERATIONS

Pollutant	Preferred Emission Estimation Approach	Alternative Emission Estimation Approaches
VOC (total)	Material Balance	Source Testing Engineering Calculations Emission Factors <sup>a</sup>
Speciated Organics (including HAPs, toluene, xylenes, ethylbenzene, CFCs, PFCs)	Material Balance	Source Testing Engineering Calculations Emission Factors <sup>a</sup>
Inorganic HAPs (acids, bases)	Source Testing	Engineering Calculations Emission Factors <sup>a</sup>

<sup>a</sup> Emission factors obtained using site-specific source testing data are preferred over those obtained from other sources.

Emission factors and engineering calculations may be based on sources other than site-specific data and should only be used if one of the preferred methods is not a viable alternative due to lack of data or resources. It is possible to obtain high-quality emissions estimates using emission

factors, but only if they were developed at the facility in question, or a similar facility, using one of the preferred methods mentioned above.

### 3.2.1 MATERIAL BALANCE

A material balance approach is the preferred method for estimating emissions of VOCs, including specific HAPs (xylene, ethylbenzene, toluene, etc.) from solvent stations and other solvent sources. This approach is suitable for these types of pollutants because they are not involved in chemical reactions. Also, their usage and waste rates may already be tracked for purchasing reasons as well as other non-air-related environmental reporting purposes.

For other pollutants emitted at semiconductor manufacturing facilities, a material balance may not be appropriate due to the uncertainty in the extent of chemical reactions occurring. For example, while hydrofluoric acid is used in baths and spray tools, it is also formed from the use of PFCs (carbon tetrafluoride, hexafluoroethane, sulfur hexafluoride, and nitrogen trifluoride) in dry etching and CVD processes. In addition no waste is collected from many of these processes, so a material balance cannot be performed in the same manner that is done with VOCs.

In addition, many of the processes occurring in the semiconductor manufacturing industry occur in radio frequency plasma environments. This makes it very difficult to determine the origin and fate of all the chemical species involved.

### 3.2.2 EMISSION FACTORS

Emission factors may be also be used to estimate emissions from semiconductor manufacturing. However, because of the highly variable nature of the semiconductor manufacturing process, whenever possible, emission factors should be determined using site-specific data. There are three principal ways to derive emission factors for semiconductor manufacturing operations:

- Through the use of emissions test data (preferably performed at tool exhausts);
- Use of a material balance approach; or
- Use of engineering calculations.

Once derived, these factors may be applied to estimate emissions based on production ratios or other appropriate parameters (e.g., usage rates of a particular chemical). This approach provides an alternative method of estimating emissions over a longer term or for a different processing scenario based on short-term emission estimates (i.e., during the time of the test) obtained from individual process steps. Emission factors for one process may be appropriate to use for



estimating emissions from similar processes occurring within a facility or at other similar facilities.

### **3.2.3 SOURCE TESTS**

Standard EPA test methods may be used to obtain emission estimates from semiconductor manufacturing processes for specific classes of compounds. However, because of the nature of the exhaust streams found in semiconductor manufacturing facilities (high flow and low pollutant concentration), emissions are often below reliable detection limits of standard tests (Higgs, 1996). FTIR methods are able to detect multiple pollutants simultaneously, and FTIR is being used currently in this industry. The EPA Method 301 validation has been performed successfully for this technology.

It should be noted that short-term source testing is often used to develop site-specific emission factors, which are in turn used to develop long-term emission estimates. In most cases this is the preferred method for estimating emissions. For semiconductor facilities, this method should use tool-specific source tests. This is because end of pipe emission rates may be difficult to correlate to tool-specific chemical usage rates due to a large number of tools vented to a single stack. Tool-specific emission factors may then be combined to develop an overall, weighted average emission factor for an entire facility.

### **3.2.4 ENGINEERING CALCULATIONS**

In the absence of sufficient data to apply one of the other methods, engineering calculations may be used to estimate organic compound (VOC and/or HAP) and inorganic HAP emissions. Engineering calculation approaches are based on theoretical equations and not measured values, and are the least preferred of the options discussed within this document. However, for some operations, such as hooded acid baths, an estimate of emissions can be calculated using the evaporation rate equation. Engineering calculation approaches are justified where no other approaches are economically or technically feasible.

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# 4

## PREFERRED METHODS FOR ESTIMATING EMISSIONS

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The preferred method for estimating VOC and speciated organic emissions (including HAPs) from semiconductor manufacturing processes is the use of a material balance. This approach can be used to estimate emissions of pollutants not involved in chemical reactions from solvent, coating application, and wet chemical stations. Material balance uses the raw material usage rate and material disposal rate (present in product or waste streams) to estimate emissions.

The preferred methods for estimating inorganic HAP emissions (e.g., acids) are the use of source testing or engineering calculations.

The equations and examples in this section present how material balance and source testing data may be used to estimate VOC, speciated organic, and speciated inorganic emissions. Table 6.4-1 lists the variables and symbols used in the following discussions.

**TABLE 6.4-1**

### LIST OF VARIABLES AND SYMBOLS

Variable	Symbol	Units
Total emissions of pollutant x	$E_x$	typically lb/hr; also ton/yr
Material entering the process	$Q_{in}$	gal/hr
Material leaving the process as waste, recovered, or in product	$Q_{out}$	gal/hr
Concentration of pollutant x	$C_x$	parts per million by volume dry (ppmvd) or lb/gal
VOC content of material	$C_{voc}$	lb/gal
Total VOC emissions	$E_{voc}$	lb/hr
Density of material	$d$	lb/gal or lb/ft <sup>3</sup>

**TABLE 6.4-1****(CONTINUED)**

Variable	Symbol	Units
Percentage by weight of pollutant x in material	wt% <sub>x</sub>	%
Molecular weight of pollutant x	MW <sub>x</sub>	lb/lb-mole
Stack gas volumetric flow rate	V	dry standard cubic feet per hour (dscf/hr)
Molar volume	M	cubic feet (ft <sup>3</sup> )/lb-mole
Annual emissions of pollutant x	E <sub>a</sub>	ton/yr
Operating hours	OH	hr/yr

## 4.1 EMISSIONS CALCULATION USING MATERIAL BALANCE

Material balance is the preferred method for estimating emissions of VOCs and organic HAPs used in semiconductor manufacturing as carrier solvents, cleaners, etc. VOC emissions from semiconductor manufacturing may be estimated using a material balance approach by applying Equation 6.4-1:

$$E_x = (Q_{in} - Q_{out}) * C_x \quad (6.4-1)$$

where:

- E<sub>x</sub> = Total emissions of pollutant x (lb/hr)
- Q<sub>in</sub> = Material entering the process (gal/hr)
- Q<sub>out</sub> = Material leaving the process as waste, recovered, or in product (gal/hr)
- C<sub>x</sub> = Concentration of pollutant x (lb/gal)

The term Q<sub>out</sub> may actually involve several different “fates” for an individual pollutant. This could include the amount recovered (or recycled), the amount leaving the process in the product, the amount leaving the process in the wastewater, or the amount of material shipped off-site as hazardous waste. Complete information of the different fates for the pollutant of interest is necessary for an accurate emissions estimate. Example 6.4-1 illustrates the use of Equation 6.4-1.

Example 6.4-1

This example shows how VOC emissions may be calculated using Equation 6.4-1 for a cleaning process given the following data:

$$\begin{aligned}
 Q_{in} &= 2 \text{ gal/hr} \\
 Q_{out} &= 1.5 \text{ gal/hr} \\
 C_{VOC} &= 7.5 \text{ lb VOC/gal} \\
 E_{VOC} &= (Q_{in} - Q_{out}) * C_{VOC} \\
 &= (2 \text{ gal/hr} - 1.5 \text{ gal/hr}) * 7.5 \text{ lb VOC/gal} \\
 &= 3.75 \text{ lb VOC/hr}
 \end{aligned}$$

Speciated VOC emissions may be estimated by a material balance approach using Equation 6.4-2:

$$E_x = (Q_{in} - Q_{out}) * d * (\text{wt}\%_x)/100 \quad (6.4-2)$$

where:

$$\begin{aligned}
 E_x &= \text{Total emissions of pollutant x (lb/hr)} \\
 Q_{in} &= \text{Material entering the process (gal/hr)} \\
 Q_{out} &= \text{Material leaving the process as waste, recovered, or in product (gal/hr)} \\
 d &= \text{Density of material (lb/gal)} \\
 \text{wt}\%_x &= \text{Percentage by weight of pollutant x in material (\%)}
 \end{aligned}$$

Example 6.4-2 illustrates the use of Equation 6.4-2.

Example 6.4-2

This example shows how toluene emissions may be estimated for a cleaning process using toluene-containing solvent given the following data:

$$\begin{aligned} Q_{\text{in}} &= 2 \text{ gal/hr} \\ Q_{\text{out}} &= 1.5 \text{ gal/hr} \\ d &= 7.5 \text{ lb/gal} \\ \text{wt}\%_x &= 25\% \text{ toluene} \end{aligned}$$

$$\begin{aligned} E_x &= (Q_{\text{in}} - Q_{\text{out}}) * d * (\text{wt}\%_x)/100 \\ &= (2 \text{ gal/hr} - 1.5 \text{ gal/hr}) * 7.5 \text{ lb/gal} * 25/100 \\ &= 0.94 \text{ lb/hr} \end{aligned}$$

## 4.2 EMISSIONS CALCULATION USING SOURCE TEST DATA

Pollutant-specific test methods can be used to estimate inorganic HAP emission rates from semiconductor manufacturing (e.g., EPA Office of Solid Waste (OSW) Method 9057 for Hydrochloric Acid (HCl)).

Sampling test reports often provide chemical concentration data in parts per million by volume dry (ppmvd).

If the concentration is known, an hourly emission rate can be determined using Equation 6.4-3:

$$E_x = (C_x * MW_x * V)/(M * 10^6) \quad (6.4-3)$$

where:

$$\begin{aligned} E_x &= \text{Total emissions of pollutant } x \text{ (lb/hr)} \\ C_x &= \text{Concentration of pollutant } x \text{ (ppmvd)} \\ MW_x &= \text{Molecular weight of pollutant } x \text{ (lb/lb-mole)} \\ V &= \text{Stack gas volumetric flow rate (dscf/hr)} \\ M &= \text{Molar volume; i.e., volume occupied by 1 mole of ideal gas at standard temperature and pressure (385.5 ft}^3\text{/lb-mole at 68}^\circ\text{F and 1 atm)} \end{aligned}$$

Please note that Equation 6.4-3 calculates emissions per hour. The equation is valid for any time period as long as consistent units are used throughout. This example equation is intended to show how an emission rate may be obtained from volumetric flowrate and pollutant concentration data. Airflow rates can be determined from flow rate meters or from pressure drops across a critical orifice (e.g., EPA Method 2).

Emissions in tons per year can be calculated by multiplying the average hourly emission rate (lb/hr) from Equation 6.4-3 by the number of operating hours (as shown in Equation 6.4-4 below) or by multiplying an average emission factor (lb/gal) by the total annual amount of material used (gal). If emissions in tons per year are calculated from an average hourly rate, it is beneficial to have multiple hourly data points to average. Since emissions from semiconductor manufacturing processes fluctuate, no single hourly measurement can be assumed to be representative of the average hourly emissions over a year.

$$E_a = E_x * OH * 1 \text{ ton}/2,000 \text{ lb} \quad (6.4-4)$$

where:

$$\begin{array}{lll} E_a & = & \text{Annual emissions of pollutant x (ton/yr)} \\ E_x & = & \text{Total hourly emissions of pollutant x (lb/hr)} \\ OH & = & \text{Operating hours (hr/yr)} \end{array}$$

Example 6.4-3 illustrates the use of Equations 6.4-3 and 6.4-4.

Concentration data obtained from testing may be presented in a variety of units, including parts per million (ppm) or grams per dry standard cubic feet (g/dscf), and in a variety of conditions, such as wet, dry, or excess O<sub>2</sub>. Conversion of concentration data to consistent units may be required for compatibility with the equations given above.

Example 6.4-3

This example shows how annual hydrogen fluoride (HF) emissions can be calculated using the data obtained from an emissions test. The concentration of HF is provided, hourly emissions are calculated using Equation 6.4-3, and annual emissions are calculated using Equation 6.4-4.

Given:

$$\begin{aligned} C_{a,x} &= 15.4 \text{ ppmvd (measured as F}^-) \\ MW_x &= 20.0 \text{ lb/lb-mole of HF} \\ V &= 109,020 \text{ dscf/hr} \\ OH &= 1,760 \text{ hr/yr} \\ M &= 385.5 \text{ ft}^3/\text{lb-mole} \\ 2,000 &= 2,000 \text{ lb/ton} \end{aligned}$$

Hourly emissions are calculated using Equation 6.4-3:

$$\begin{aligned} E_x &= (C_x * MW_x * V)/(M * 10^6) \\ &= 15.4 \text{ ppmvd} * 20.0 \text{ lb/lb-mole} * 109,020 \text{ dscf/hr} / (385.5 \text{ ft}^3/ \\ &\quad \text{lb-mole} * 10^6) \\ &= 0.09 \text{ lb/hr} \end{aligned}$$

Annual emissions are calculated using Equation 6.4-4:

$$\begin{aligned} E_a &= E_x * OH * 1 \text{ ton}/2,000 \text{ lb} \\ &= 0.09 \text{ lb/hr} * 1,760 \text{ hr/yr} * 1 \text{ ton}/2,000 \text{ lb} \\ &= 0.08 \text{ ton HF/yr} \end{aligned}$$



# 5

## ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

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Source testing, engineering calculations, and emission factors are alternative methods for estimating organic compound emissions (including VOC and HAP). Engineering calculations and emission factors are alternative methods for estimating emissions of inorganic HAPs.

The following equations and examples present how emission factors and engineering calculations may be used to estimate VOC, speciated organic, and speciated inorganic emissions. Table 6.5-1 lists the variables and symbols used in the following discussions.

**TABLE 6.5-1**

### LIST OF VARIABLES AND SYMBOLS

Variable	Symbol	Units
Concentration of pollutant x	$C_x$	ppmvd or lb/gal
Total emissions of pollutant x	$E_x$	typically lb/hr
Molecular weight of pollutant x	$MW_x$	lb/lb-mole
Stack gas volumetric flow rate	$V$	dscf/hr
Molar volume	$M$	ft <sup>3</sup> /lb-mole
Annual emissions of pollutant x	$E_a$	ton/yr
Operating hours	OH	hr/yr
Emission factor for pollutant x	$EF_x$	lb/units
Activity factor	AF	units/hr
Saturation vapor pressure of pollutant x	$P_{sat,x}$	atmosphere (atm)
Total pressure of pollutant x	$P_t$	atm

TABLE 6.5-1

(CONTINUED)

Variable	Symbol	Units
Density of pollutant x	$d_x$	lb/gal or lb/ft <sup>3</sup>
Evaporation rate of pollutant x	$W_x$	lb/sec
Gas-phase mass transfer coefficient	K	ft/sec
Surface area	A	ft <sup>2</sup>
Vapor pressure of pollutant x	$P_{vap,x}$	pounds per square inch absolute (psia)
Ideal gas constant	R	psia * ft <sup>3</sup> /degrees Rankine (°R) * lb-mole
Temperature	T	°R
Wind speed	U	miles/hr

## 5.1 EMISSIONS CALCULATION USING SOURCE TEST DATA

Various pollutant-specific stack sampling test methods can be used to estimate VOC and speciated organic emission rates from semiconductor manufacturing. Pollutant concentration data can be obtained using grab sample methods (e.g., EPA Method 18) and airflow rates can be determined from flow rate meters or from pressure drops across a critical orifice (e.g., EPA Method 2).

Sampling test reports often provide chemical concentration data in parts per million by volume dry (ppmvd).

If the concentration is known, an hourly emission rate can be determined using Equation 6.5-1:

$$E_x = (C_x * MW_x * V)/(M * 10^6) \quad (6.5-1)$$

where:

$$E_x = \text{Total emissions of pollutant x (lb/hr)}$$

- $C_x$  = Concentration of pollutant x (ppmvd)  
 $MW_x$  = Molecular weight of pollutant x (lb/lb-mole)  
 $V$  = Stack gas volumetric flow rate (dscf/hr)  
 $M$  = Molar volume; i.e., volume occupied by 1 mole of ideal gas at standard temperature and pressure (385.5 ft<sup>3</sup>/lb-mole at 68°F and 1 atm)

Please note that Equation 6.5-1 calculates emissions per hour. The equation is valid for any time period as long as consistent units are used throughout and is intended to show how an emission rate may be obtained from volumetric flowrate and pollutant concentration data.

Emissions in tons per year can be calculated by multiplying the average hourly emission rate (lb/hr) from Equation 6.5-1 by the number of operating hours (as shown in Equation 6.5-2 below) or by multiplying an average emission factor (lb/gal) by the total annual amount of material used (gal).

$$E_a = E_x * OH * 1 \text{ ton}/2,000 \text{ lb} \quad (6.5-2)$$

where:

- $E_a$  = Annual emissions of pollutant x (ton/yr)  
 $E_x$  = Total hourly emissions of pollutant x (lb/hr)  
 $OH$  = Operating hours (hr/yr)

Example 6.5-1 illustrates the use of Equations 6.5-1 and 6.5-2.

Concentration data obtained from testing may be presented in a variety of units, including parts per million (ppm) or grams per dry standard cubic feet (g/dscf), and in a variety of conditions, such as wet, dry, or excess O<sub>2</sub>. Conversion of concentration data to consistent units may be required for compatibility with the equations given above.

Example 6.5-1

This example shows how annual toluene emissions can be calculated using the data obtained from a process emissions test. The concentration of toluene is provided, hourly emissions are calculated using Equation 6.5-1, and annual emissions are calculated using Equation 6.5-2.

Given:

$$\begin{aligned} C_x &= 15.4 \text{ ppmvd} \\ MW_x &= 92.0 \text{ lb/lb-mole of toluene} \\ V &= 109,020 \text{ dscf/hr} \\ OH &= 1,760 \text{ hr/yr} \\ M &= 385.5 \text{ ft}^3/\text{lb-mole} \\ 2,000 &= 2,000 \text{ lb/ton} \end{aligned}$$

Hourly emissions are calculated using Equation 6.5-1:

$$\begin{aligned} E_x &= (C_x * MW_x * V)/(M * 10^6) \\ &= 15.4 \text{ ppmvd} * 92.0 \text{ lb/lb-mole} * 109,020 \text{ dscf/hr} / (385.5 \text{ ft}^3/ \\ &\quad \text{lb-mole} * 10^6) \\ &= 0.40 \text{ lb/hr} \end{aligned}$$

Annual emissions are calculated using Equation 6.5-2:

$$\begin{aligned} E_a &= E_x * OH * 1 \text{ ton}/2,000 \text{ lb} \\ &= 0.40 \text{ lb/hr} * 1,760 \text{ hr/yr} * 1 \text{ ton}/2,000 \text{ lb} \\ &= 0.35 \text{ ton toluene/yr} \end{aligned}$$

## 5.2 EMISSIONS CALCULATION USING EMISSION FACTORS

Emission factors may be used to estimate VOC, organic HAP, and inorganic HAP emissions from semiconductor manufacturing operations using Equation 6.5-3:

$$E_x = EF_x * AF \quad (6.5-3)$$

where:

$$\begin{aligned} E_x &= \text{Emissions of pollutant } x \text{ (lb/hr)} \\ EF_x &= \text{Emission factor for pollutant } x \text{ (lb/units)} \end{aligned}$$

AF = Activity factor (units/hr)

Example 6.5-2 illustrates the use of Equation 6.5-3. It should be noted that *AP-42* does not contain emission factors for semiconductor manufacturing, and emission factors will need to be developed specific to the processes or operations of interest. Emission factors are generally developed from process-specific sampling or engineering calculations and may be expressed as a function of production or a function of total chemical use. The activity factor may be expressed in terms of production units or amount of chemical used per unit time.

#### Example 6.5-2

The emission factor used in this example was developed with site-specific data from a semiconductor manufacturing facility. This example shows how HF emissions may be calculated using emission factors and Equation 6.5-4 given the following data:

$$\begin{aligned} \text{EF}_{\text{HF}} &= 6.0 * 10^{-6} \text{ lb HF/wafer} \\ \text{AF} &= 30 \text{ wafers/hour} \\ \\ \text{E}_{\text{HF}} &= \text{EF}_{\text{HF}} * \text{AF} \\ &= 6.0 * 10^{-6} \text{ lb HF/wafer} * 30 \text{ wafers/hr} \\ &= 1.8 * 10^{-4} \text{ lb HF/hr} \end{aligned}$$

### 5.3 EMISSIONS ESTIMATION USING ENGINEERING CALCULATIONS

For any process that involves transfer of a chemical species from the liquid phase to the vapor phase, the saturation (equilibrium) vapor pressure and exhaust flow rate from the process can be used to establish the upper limit of emissions from that process through the use of Equation 6.5-4:

$$E_x = (P_{\text{sat},x}/P_t) * V * d_x \quad (6.5-4)$$

where:

$$\begin{aligned} E_x &= \text{Emissions of pollutant } x \text{ (lb/hr)} \\ P_{\text{sat},x} &= \text{Saturation vapor pressure of pollutant } x \text{ (atm)} \\ P_t &= \text{Total pressure (atm)} \\ V &= \text{Stack gas volumetric flow rate (dscf/hr)} \\ d_x &= \text{Density of pollutant } x \end{aligned}$$

Example 6.5-3 illustrates the use of Equation 6.5-4.

### Example 6.5-3

This example shows how methanol emissions may be estimated from a hooded process using Equation 6.5-5 given the following data:

$$\begin{aligned}
 P_{\text{sat},x} &= 0.13 \text{ atm} \\
 P_t &= 1 \text{ atm} \\
 V &= 6,000 \text{ dscf/hr} \\
 d_x &= 0.083 \text{ lb/ft}^3 \\
 E_{\text{methanol}} &= (P_{\text{sat},x}/P_t) * V * P_x \\
 &= (0.13 \text{ atm}/1 \text{ atm}) * 6,000 \text{ ft}^3/\text{hr} * 0.083 \text{ lb/ft}^3 \\
 &= 64.7 \text{ lb methanol/hr}
 \end{aligned}$$

The approach used in Equation 6.5-4 provides an extremely conservative estimate of emissions due to the assumption of airflow saturation. As mentioned previously, a dilution to saturation ratio (based on testing) may be applied to this equation to provide a more realistic estimate of pollutant concentration.

EPA has published an alternative method in the document *Estimating Releases and Waste Treatment Efficiencies for the Toxic Chemical Release and Inventory Form* (EPA, 1987), which is based on mass transfer kinetics. For this alternative, use Equation 6.5-5:

$$W_x = (MW_x * K * A * P_{\text{vap},x}) / (R * T) \quad (6.5-5)$$

where:

$$\begin{aligned}
 W_x &= \text{Evaporation rate of pollutant } x \text{ (lb/sec)} \\
 MW_x &= \text{Molecular weight of pollutant } x \text{ (lb/lb-mole)} \\
 K &= \text{Gas-phase mass transfer coefficient (ft/sec)} \\
 &= 0.00438 * U^{0.78} * (18/MW_x)^{1/3} \\
 U &= \text{Wind speed (miles/hr)} \\
 A &= \text{Surface area (ft}^2\text{)} \\
 P_{\text{vap},x} &= \text{Vapor pressure of pollutant } x \text{ (psia)} \\
 R &= \text{Ideal gas constant (10.73 psia * ft}^3\text{/}^\circ\text{R * lb-mole)}
 \end{aligned}$$

T = Temperature ( $^{\circ}\text{R}$ )

Example 6.5-4 illustrates the use of Equation 6.5-5.

#### Example 6.5-4

This example shows how methanol emissions from semiconductor manufacturing may be estimated using mass transfer kinetics and Equation 6.5-6 given the following data:

$$\begin{aligned} \text{MW}_x &= 32 \text{ lb/lb-mole} \\ U &= 1.7 \text{ miles/hr} \\ A &= 1 \text{ ft}^2 \\ P_{\text{vap},x} &= 1.91 \text{ psia} \\ T &= 533^{\circ}\text{R} \\ R &= 10.73 \text{ psia} \cdot \text{ft}^3/^{\circ}\text{R} \cdot \text{lb-mole} \end{aligned}$$

First, calculate the mass transfer coefficient, K:

$$\begin{aligned} K &= 0.00438 \cdot U^{0.78} \cdot (18/\text{MW}_x)^{1/3} \\ &= 0.00438 \cdot (1.7 \text{ miles/hr})^{0.78} \cdot (18/32 \text{ lb/lb-mole})^{1/3} \\ &= 0.00547 \text{ ft/sec} \end{aligned}$$

Then, calculate  $W_x$ :

$$\begin{aligned} W_x &= (\text{MW}_x \cdot K \cdot A \cdot P_{\text{vap},x}) / (R \cdot T) \\ &= (32 \text{ lb/lb-mole} \cdot 0.00547 \text{ ft/sec} \cdot 1 \text{ ft}^2 \cdot 1.91 \text{ psia}) / (10.73 \text{ psia} \cdot \text{ft}^3/533^{\circ}\text{R} \cdot \text{lb-mole})(533^{\circ}\text{R}) \\ &= 5.84 \cdot 10^{-5} \text{ lb/sec} \end{aligned}$$

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# 6

## QUALITY ASSURANCE/QUALITY CONTROL

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Quality assurance (QA) and quality control (QC) are essential elements in producing high quality emission estimates and should be included in all methods used to estimate emissions. QA/QC of emissions estimates is accomplished through a set of procedures that ensures the quality and reliability of data collection and processing. These procedures include the use of appropriate emission estimation methods, reasonable assumptions, data reliability checks, and accuracy/logic checks of calculations. Volume VI of this series, *Quality Assurance Procedures*, describes methods and tools for performing these procedures.

In addition, Chapter 1 of this volume, *Introduction to Stationary Point Source Emission Inventory Development*, provides QA/QC guidance for preparing point source emission estimates. The following sections discuss QA/QC considerations that are specific to the emission estimation methods presented in this chapter for estimating emissions from semiconductor manufacturing.

### 6.1 QA/QC FOR USING MATERIAL BALANCE

The material balance method for estimating emissions may use various approaches; the QA/QC considerations will also vary and may be specific to an approach. Generally, the fates of all materials of interest are identified, and then the quantity of material allocated to each fate determined. Identifying these fates, such as material contained in a product or material leaving the process in the wastewater, is usually straightforward. However, estimating the amount of material allocated to each fate may be complicated and is the prime QA/QC consideration in using the material balance approach. Amounts obtained by direct measurement are more accurate and produce emission estimates of higher quality than those obtained by engineering or theoretical calculations. QA/QC of an emissions estimate developed from a material balance approach should include a thorough check of all assumptions and calculations. Also, a reality check of the estimate in the context of the overall process is recommended.

## 6.2 QA/QC FOR USING EMISSION FACTORS

When using emission factors to estimate emissions from semiconductor manufacturing, the applicability and representativeness of the emission factor are the first criteria to consider. To assess applicability, the reviewer needs to examine how closely the process of interest matches the process for which the emission factor is available. Similarly, the reviewer should look at how well the range of conditions on which the available emission factor is based compares to the conditions of interest. For example, an emission factor that is based on a process rate of 100 wafers per hour may not be the best emission factor to use for a process rate of 10 wafers per hour.

## 6.3 QA/QC FOR USING SOURCE TEST DATA

In reviewing stack sampling or FTIR data, the first consideration is whether the method measures the pollutant of interest or can only be used as a surrogate. For example, if fluorine concentration in a hood exhaust is measured, HF emissions could be estimated only after assuming all, or a given percentage, of the fluorine is present as HF. Next, the reviewer should determine whether the sampling conditions represent the operating conditions of interest for the emission estimate. For example, if the data are to be used to estimate emissions during typical operations, then sampling should have been done during typical operating conditions.

The accuracy of source testing data depends heavily on maintaining calibration. Thus, the reviewer should evaluate the calibration information. Parameters that should be evaluated in QA/QC of stack sampling data and the acceptance criteria for stack sampling are presented in Chapter 1 of this volume.

## 6.4 QA/QC FOR USING ENGINEERING CALCULATIONS

In most cases, engineering calculations are less accurate than the other methods for estimating emissions due to the lack of any site-specific measurement data. In the case of the approaches outlined for semiconductor manufacturing, the calculations are based on theoretical equations that were developed independent of the source. In certain cases, engineering calculations may be presented in the form of an emissions model that has been calibrated for an individual source by using emissions estimates from one of the preferred calculation approaches (in Section 4.0). For example, plasma chemistry models could be used to determine the percentage of fluorine present in PFCs converted to HF.

## 6.5 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

One measure of emission inventory data quality is the DARS score. Chapter 4 of Volume VI, *Quality Assurance Procedures*, and the QA/QC section in Chapter 1 of this volume provide a complete discussion of DARS. DARS assumes activity data and factor data are used to generate an inventory and provides criteria that are used to assign a numerical score to each data set. The activity score is multiplied by the factor score to obtain a composite score for the emissions estimate. The highest possible value for an individual or composite score is 1.0. The composite score for the emissions estimate can be used to evaluate the quality and accuracy of the estimate.

DARS was used to evaluate the methods for estimating emissions that are presented in this document to provide an idea of the relative quality of each method. This was accomplished by assuming an inventory was developed using each method and using DARS to score each inventory. Because the inventories are hypothetical, it was necessary to make some assumptions. The first three assumptions were that emissions are for a 1-year period, from one process or from one facility, and for normal operating conditions. Also, all material usage data used were assumed to be reasonably accurate. Some scores are expressed as a range, with the lower value representing an estimate developed from low- to medium-quality data and the upper value representing an estimate based on relatively high-quality data. Tables 6.6-1 through 6.6-4 present the DARS scores for the different emission estimation methods presented in this chapter. It should be noted that the DARS scoring is currently applied manually, but the system will eventually be publicly available as a software tool.

Comparing the scores for the different methods, the preferred methods (material balance and source testing) received the highest scores and the alternative methods (emission factors and engineering calculations) received the lowest. The material balance method for estimating emissions received the highest DARS score (0.98), as shown in Table 6.6-1. Note that the score is based on the assumption that the factor data were measured intermittently during the year (the inventory period). Also, note that if factor data and activity data are measured continuously over the year, a perfect score (1.0) is possible for an emissions estimate when using material balance.

The source testing approach received the next highest overall score (0.78-0.93), as shown in Table 6.6-2. As indicated by the scores, the major parameters affecting the quality of stack sampling data are the number of tests (range of loads; numerous tests performed over the year) and the frequency of measurement of activity data (intermittent or continuous). A high DARS score for an emissions estimate based on stack sampling data is possible if the factor data are the result of numerous tests performed during typical operations and the activity data are the result of continuous measurements over the inventory period.

In using DARS to score the emission factor approach, the example provided shows how the representativeness (or quality) of an emission factor may vary and how emission factor quality

affects emission estimates. The example shown in Table 6.6-3 assumes the emission factor was developed from a process that is similar, if not identical, to the process for which the emissions estimate was made. Because the emission factor represents a process similar to the inventory process, a high score is assigned. Assuming the activity data were measured continuously, a composite score of 0.83 to 0.90 results. The lower value reflects the score assigned to an estimate based on a lower-quality emission factor and the upper value reflects an estimate based on a higher-quality emission factor. As shown by the scores in Table 6.6-3, the quality of an emissions estimate developed from emission factors is directly affected by the quality of the emission factors and can vary greatly. The scores also indicate that a source-specific emission factor may produce an emissions estimate of higher quality than an estimate developed from a factor developed for a similar process.

For engineering calculations, the DARS score of 0.68 to 0.86 results, as shown in Table 6.6-4. The main parameter lowering the score is the Source Specificity parameter, which has low scores for both the Factor Score and the Activity Score. This is because the equations were calculated independently of the actual source. Although it is hard to define the Spatial and Temporal Congruity attributes for this method, a score of 0.9 to 1.0 was assigned because the approaches presented would not vary temporally or spatially.

The examples provided in the tables are given as an illustration of the relative quality of each estimation method. If DARS was applied to actual inventories developed using the preferred and alternative methods and data of reasonably good quality were used for each method, the scores could be different; however, the relative ranking of the methods would be expected to remain the same.

TABLE 6.6-1

**DARS SCORES: MATERIAL BALANCE DATA<sup>a</sup>**

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/Method	0.9	0.9	0.81	Factor is based on accurate data.	Intermittent measurement of activity.
Source Specificity	1.0	1.0	1.0	Factor developed specifically for the intended source.	Activity data represent the emission process exactly.
Spatial Congruity	1.0	1.0	1.0	Factor developed for and specific to the given spatial scale.	Activity data developed for and specific to the inventory area (one process).
Temporal Congruity	1.0	1.0	0.95	Factor developed for and applicable to the same temporal scale.	Activity data specific to 1 year.
Composite Score	0.98	1.0	0.98		

<sup>a</sup> The “activity” is the amount of material (pollutant) used in a year and is directly measurable. The “factor” is the fraction of material used that is emitted to the atmosphere. The fraction is based on engineering calculations and is assumed to remain constant over the year.

TABLE 6.6-2

## DARS SCORES: SOURCE TEST DATA

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/Method	0.7 - 0.9	0.9 - 1.0	0.63 - 0.9	Lower score reflects a small number of tests at typical process rates; upper score represents numerous tests over a range of process loads.	Lower score reflects direct, intermittent measurement of activity; upper score reflects direct, continuous measurement of activity.
Source Specificity	1.0	1.0	1.0	Factor developed specifically for the intended source.	Activity data represent the emission process exactly.
Spatial Congruity	1.0	1.0	1.0	Factor developed for and specific to the given spatial scale (one process).	Activity data developed for and specific to the inventory area (one process).
Temporal Congruity	0.7 - 0.9	0.7 - 0.9	0.49 - 0.81	Lower score reflects factor developed for a shorter time period with moderate to low temporal variability; upper score reflects factor derived from an average of numerous tests during the year.	Lower score reflects activity data representative of short period of time with low to moderate temporal variability; upper score reflects activity data measured numerous times during the year.
Composite Score	0.85 - 0.95	0.90 - 0.98	0.78 - 0.93		

TABLE 6.6-3

**DARS SCORES: SOURCE-SPECIFIC EMISSION FACTOR DATA<sup>a</sup>**

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/Method	1.0	0.9 - 1.0	0.9 -1.0	Continuous or near-continuous measurement of pollutant.	Lower scores reflect direct, intermittent measurement of activity; upper scores reflect direct, continuous measurement of activity.
Source Specificity	0.8	1.0	0.8	Factor developed for a similar category; low variability.	Activity data represent the emission process exactly.
Spatial Congruity	0.9	1.0	0.9	Factor developed from a process of similar size; low variability.	Activity data developed for and specific to the inventory area (one process).
Temporal Congruity	1.0	0.7 - 0.9	0.7 - 0.9	Factor developed for and applicable to a period of 1 year.	Lower score reflects activity data representative of short period of time with low to moderate temporal variability; upper score reflects activity data measured numerous times during the year.
Composite Score	0.93	0.90 - 0.98	0.83 - 0.90		

<sup>a</sup> Assumes emission factor was developed from an identical or similar facility and is of high quality.

TABLE 6.6-4

## DARS SCORES: ENGINEERING CALCULATIONS

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/Method	1.0	0.9 - 1.0	0.9 - 1.0	Continuous or near continuous measurement of activity; data capture >90%.	Lower scores reflect direct, intermittent measurement of activity; upper scores reflect direct, continuous measurement of activity.
Source Specificity	0.5 - 0.7	0.5 - 0.7	0.25 - 0.49	Factor developed for a somewhat similar process.	Activity data are somewhat correlated with emission process.
Spatial Congruity	0.9 - 1.0	1.0	1.0	Factor developed for a similar spatial scale (one process).	Activity data developed for and specific to the inventory area (one process).
Temporal Congruity	0.9 - 1.0	0.9 - 1.0	0.81 - 1.0	Factor derived from a nonspecific temporal scale.	Activity data measured for a similar period of time.
Composite Score	0.83 - 0.93	0.83 - 0.93	0.68 - 0.86		



# 7

## DATA CODING PROCEDURES

---

This section describes the methods and codes available for characterizing emission sources at semiconductor manufacturing facilities. Consistent categorization and coding will result in greater uniformity among inventories. In addition, the procedures described here will assist the reader who is preparing data for input to the Aerometric Information Retrieval System (AIRS) or a similar database management system. The use of the Source Classification Codes (SCCs) provided in Table 6.7-1 is recommended for describing various semiconductor manufacturing operations. Refer to the Clearinghouse for Inventories and Emission Factors (CHIEF) help desk (919-541-1000) or internet address: [www.epa.gov/ttn/chief](http://www.epa.gov/ttn/chief) for these codes and any additional codes that may be added to describe semiconductor manufacturing operations.

### 7.1 SOURCE CLASSIFICATION CODES

SCCs for various processes occurring at semiconductor manufacturing facilities are presented in Table 6.7-1. These include the following processes:

- Cleaning Processes (wet chemical);
- Cleaning Processes (plasma);
- Photoresist Operations;
- CVD Operations;
- Etching Processes (wet chemical); and
- Etching Processes (plasma).

**TABLE 6.7-1****SOURCE CLASSIFICATION CODES FOR SEMICONDUCTOR  
MANUFACTURING PROCESSES**

<b>Source Description</b>	<b>Process Description</b>	<b>SCC</b>	<b>Units</b>
Integrated Circuit Manufacturing	General	3-13-065-00	1000 Wafers
Cleaning Processes	Wet Chemical	3-13-065-01	Gallons Solution Consumed (Specify Aqueous Solution)
	Plasma Process	3-13-065-02	1000 Cubic Feet (Specific Gas Used)
Photoresist Operations	General	3-13-065-05	Tons Photoresist
Chemical Vapor Deposition	General	3-13-065-10	1000 Cubic Feet (Specify Gas Used)
Diffusion Process	Deposition Operation	3-13-065-20	1000 Cubic Feet (Specify Gas Used)
Etching Process	Wet Chemical	3-13-065-30	Gallons Solution Consumed (Specify Aqueous Solution)
	Plasma/Reactive Ion	3-13-065-31	1000 Cubic Feet (Specify Gas Used)

## 7.2 AIRS CONTROL DEVICE CODES

Control device codes that may be applicable to semiconductor manufacturing operations are presented in Table 6.7-2. These should be used to enter the type of applicable emission control device into the AIRS Facility Subsystem (AFS). The "099" control code may be used for miscellaneous control devices that do not have a unique identification code.

**TABLE 6.7-2**

### **AIRS CONTROL DEVICE CODES FOR SEMICONDUCTOR MANUFACTURING**

<b>Control Device</b>	<b>Code</b>
Wet Scrubber - High Efficiency	1
Wet Scrubber - Medium Efficiency	2
Wet Scrubber - Low Efficiency	3
Direct Flame Afterburner	21
Direct Flame Afterburner with Heat Exchanger	22
Catalytic Afterburner	19
Catalytic Afterburner with Heat Exchanger	20
Miscellaneous Control Device	99

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# **APPENDIX A**

## **EXAMPLE DATA COLLECTION FORMS AND INSTRUCTIONS - SEMICONDUCTOR MANUFACTURING**

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**EXAMPLE DATA COLLECTION FORMS INSTRUCTIONS -  
SEMICONDUCTOR MANUFACTURING FACILITIES**

1. These forms may be used as a worksheet to aid the plant engineer in collecting the information necessary to calculate emissions from semiconductor manufacturing facilities. The information requested on the forms relate to the methods (described in Sections 3, 4, and 5) for quantifying emissions. These forms may also be used by the regulatory agency to assist in areawide inventory preparation.
2. If the information requested is unknown, write "unknown" in the blank. If the information requested does not apply to a particular unit or process, write "NA" in the blank.
3. If you want to modify the form to better serve your needs, an electronic copy of the form may be obtained through the EIIP on the Clearinghouse for Inventories and Emission Factors (CHIEF) web site ([www.epa.gov/ttn/chief/](http://www.epa.gov/ttn/chief/)).
4. Collect all Material Safety Data Sheets (MSDSs) for all materials containing potential air contaminants that are used at the facility.
5. The plant engineer should maintain all material usage information and MSDSs in a reference file.
6. The completed forms should be maintained in a reference file by the plant engineer with other supporting documentation.

**EXAMPLE DATA COLLECTION FORM****FORM A: GENERAL INFORMATION**

Business Name:

SIC Code:

SCC:

SCC Description:

Location

County:

City:

State:

Plant Geographical Coordinates

Latitude:

Longitude:

UTM Zone:

Date of Initial Operation:

Equipment Type (Check one or more and complete corresponding forms)

☐ Solvent Stations {Forms B1, C1, D - F}☐ Wet Chemical Stations {Forms B2, C2, D - F}☐ Coating/Solvent Application {Forms B3, C3, D - F}☐ Gaseous Operations {Forms B4, C4, D - F}

Contact Name:

Title:

Telephone Number:

## EXAMPLE DATA COLLECTION FORM

---

**FORM B1: SOURCE INFORMATION - Solvent Stations**


---

Location:

Unit Description	Number of Units	Surface Area (ft <sup>2</sup> )	Manufacturer	Date Installed	Date Modified
Solvent Station Hoods					

Operating Schedule

Hours/Day: \_\_\_\_\_

Days/Week: \_\_\_\_\_

Weeks/Year: \_\_\_\_\_

Typical % of Total Annual Usage:

Dec-Feb \_\_\_\_\_ %

Mar-May \_\_\_\_\_ %

Jun-Aug \_\_\_\_\_ %

Sep-Nov \_\_\_\_\_ %

Raw Material Used:

Material Name and Code	Constituents	Mass %	Annual Usage (gallons)	Reclaim (gallons)

## EXAMPLE DATA COLLECTION FORM

**FORM B2: SOURCE INFORMATION - Wet Chemical Stations**

Location:

Unit Description	Number of Units	Surface Area (ft <sup>2</sup> )	Manufacturer	Date Installed	Date Modified
Wet Chemical Station Hoods					

Operating Schedule

Hours/Day: \_\_\_\_\_

Days/Week: \_\_\_\_\_

Weeks/Year: \_\_\_\_\_

Typical % of Total Annual Usage:

Dec-Feb \_\_\_\_\_ %

Mar-May \_\_\_\_\_ %

Jun-Aug \_\_\_\_\_ %

Sep-Nov \_\_\_\_\_ %

Raw Material Used:

Material Name and Code	Constituents	Mass %	Annual Usage (gallons)	Reclaim (gallons)

### EXAMPLE DATA COLLECTION FORM

---

**FORM B3: SOURCE INFORMATION - Coating/Solvent Application**


---

Location:

Unit Description	Number of Units	Manufacturer	Date Installed	Date Modified
Photoresist Developer Negative				
Photoresist Maskant Applicator Negative				
Photoresist Developer Positive				
Photoresist Maskant Applicator Positive				
Polyimide Applicator				
Polymer Resin Applicator				
Solvent/Solvent Mixture Applicator				
Spin-On Dopant/Glass Applicator				
Other: (Describe)				

---

**Operating Schedule**

Hours/Day: \_\_\_\_\_

Days/Week: \_\_\_\_\_

Weeks/Year: \_\_\_\_\_

---

**Typical % of Total Annual Usage:**

Dec-Feb \_\_\_\_\_ %

Mar-May \_\_\_\_\_ %

Jun-Aug \_\_\_\_\_ %

Sep-Nov \_\_\_\_\_ %

**FORM B3: SOURCE INFORMATION - Coating/Solvent Application (cont.)**[illegible]

### EXAMPLE DATA COLLECTION FORM

---

**FORM B4: SOURCE INFORMATION - Gaseous Operations**


---

Location:

Unit Description	Number of Units	Manufacturer	Date Installed	Date Modified
Chemical Vapor Deposition, Atmospheric				
Chemical Vapor Deposition, Low Pressure				
Diffusion Furnace Chambers				
Ion Implementation Chambers				
Plasma Ashing Chambers				
Plasma/Ion Etch Chambers				
Siliconizing Reactors				
Sputtering Chambers				
Other: (Describe)				

---

**Operating Schedule**

Hours/Day: \_\_\_\_\_

Days/Week: \_\_\_\_\_

Weeks/Year: \_\_\_\_\_

---

**Typical % of Total Annual Usage:**

Dec-Feb \_\_\_\_\_ %

Mar-May \_\_\_\_\_ %

Jun-Aug \_\_\_\_\_ %

Sep-Nov \_\_\_\_\_ %

**FORM B4: SOURCE INFORMATION - Gaseous Operations (cont.)**[illegible]



## EXAMPLE DATA COLLECTION FORM

### FORM C1: CONTROL DEVICE INFORMATION - Solvent Stations

Location:

Unit Description	Device Type	Device Number	% Flow	Pollutant Controlled	Control Efficiency	Manufacturer	Date Installed	Date Modified	Hours/Day	Days/Week	Weeks/Year
Solvent Station Hoods	1)										
	2)										
	3)										
	4)										

## EXAMPLE DATA COLLECTION FORM

**FORM C2: CONTROL DEVICE INFORMATION - Wet Chemical Stations**

Location:

Unit Description	Device Type	Device Number	% Flow	Pollutant Controlled	Control Efficiency	Manufacturer	Date Installed	Date Modified	Hours/ Days	Days/ Weeks	Weeks/Year
Wet Chemical Station Hoods	1)										
	2)										
	3)										
	4)										

## EXAMPLE DATA COLLECTION FORM

### FORM C3: CONTROL DEVICE INFORMATION - Coating/Solvent Application Equipment

Location:

Unit Description	Device Type	Device Number	% Flow	Pollutant Controlled	Control Efficiency	Manufacturer	Date Installed	Date Modified	Hours/Day	Days/Week	Weeks/Year
Photoresist Developer Negative	1)										
	2)										
	3)										
	4)										
Photoresist Maskant Applicator Negative	1)										
	2)										
	3)										
	4)										
Photoresist Developer Positive	1)										
	2)										
	3)										
	4)										
Photoresist Maskant Applicator Positive	1)										
	2)										
	3)										
	4)										
Polyimide Applicator	1)										
	2)										
	3)										
	4)										

## EXAMPLE DATA COLLECTION FORM

**FORM C3: CONTROL DEVICE INFORMATION - Coating/Solvent Application Equipment (cont.)**

Location:

Unit Description	Device Type	Device Number	% Flow	Pollutant Controlled	Control Efficiency	Manufacturer	Date Installed	Date Modified	Hours/Day	Days/Week	Weeks/Year
Polymer Resin Applicator, other	1)										
	2)										
	3)										
	4)										
Solvent/Solvent Mixture Applicator	1)										
	2)										
	3)										
	4)										
Spin-On Dopant/Glass Applicator	1)										
	2)										
	3)										
	4)										
Other: (Describe)	1)										
	2)										
	3)										
	4)										

## EXAMPLE DATA COLLECTION FORM

**FORM C4: CONTROL DEVICE INFORMATION - Gaseous Operations**

Location:

Unit Description	Device Type	Device Number	% Flow	Pollutant Controlled	Control Efficiency	Manufacturer	Date Installed	Date Modified	Hours/Day	Days/Week	Weeks/Year
Chemical Vapor Deposition, Atmospheric	1)										
	2)										
	3)										
	4)										
Chemical Vapor Deposition, Low Pressure	1)										
	2)										
	3)										
	4)										
Diffusion Furnace Chambers	1)										
	2)										
	3)										
	4)										
Ion Implantation Chambers	1)										
	2)										
	3)										
	4)										
Plasma Ashing Chambers	1)										
	2)										
	3)										
	4)										

## EXAMPLE DATA COLLECTION FORM

**FORM C4: CONTROL DEVICE INFORMATION - Gaseous Operations (cont.)**

Location:

Unit Description	Device Type	Device Number	% Flow	Pollutant Controlled	Control Efficiency	Manufacturer	Date Installed	Date Modified	Hours/Day	Days/Week	Weeks/Year
Plasma/Ion Etch Chambers	1)										
	2)										
	3)										
	4)										
Siliconizing Reactors	1)										
	2)										
	3)										
	4)										
Sputtering Chambers	1)										
	2)										
	3)										
	4)										
Other: (Describe)	1)										
	2)										
	3)										
	4)										

**EXAMPLE DATA COLLECTION FORM****Form D: Stack Information** (if applicable)

Stack ID:

Unit ID

Stack (Release) Height (ft):

Stack Diameter (inch)

Stack Gas Temperature (°F):

Stack Gas Velocity (ft/sec):

Stack Gas Flow Rate (dscf/hr):

Source(s) Linked to this Stack:

**FORM E: Material Data Forms** (to be completed for each material used)

Material Description or Brand Name and Number:

☐ Gallons    ☐ Pounds    ☐ Cubic Feet    ☐ Other \_\_\_\_\_

Density: \_\_\_\_\_ lb/gal      or      \_\_\_\_\_ lb/ft<sup>3</sup>

Volatile Organic Compound (VOC) Content: \_\_\_\_\_ lb/gal or  
 \_\_\_\_\_ wt % VOC in the material

Solids Content: \_\_\_\_\_ wt % solids in the material

True Vapor Pressure \_\_\_\_\_ psia  
@ 70°F:

Boiling Point: \_\_\_\_\_ °F

A \_\_\_\_\_ B \_\_\_\_\_  
C \_\_\_\_\_ Ref \_\_\_\_\_

Molecular Weight: \_\_\_\_\_ lb/lb-mole

Fuels: Heat Content	Btu usage/unit
---------------------	----------------



**EXAMPLE DATA COLLECTION FORM****FORM E: Material Data Forms** (to be completed for each material used) (cont.)

Component Name	CAS# <sup>a</sup>	Wt % in Material	ppmv in Material

<sup>a</sup> CAS# = Chemical Abstract Service number.

**EXAMPLE DATA COLLECTION FORM****FORM F: Emission Results**

Pollutant	Emission Estimation Method	Emissions Value	Units of Emissions	Emission Factor	Emission Factor Units	Comments

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**VOLUME II: CHAPTER 7**

# **PREFERRED AND ALTERNATIVE METHODS FOR ESTIMATING AIR EMISSIONS FROM SURFACE COATING OPERATIONS**

**July 2001**



Prepared by:  
Eastern Research Group, Inc.

Prepared for:  
Point Sources Committee  
Emission Inventory Improvement Program

## **DISCLAIMER**

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

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# 1

## INTRODUCTION

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The purposes of the preferred methods guidelines are to describe emission estimation techniques for point sources in a clear and unambiguous manner and to provide concise example calculations to aid regulatory and non-regulatory personnel in the preparation of emission inventories. While emissions estimates are not provided, this information may be used to select an emissions estimation technique best suited to a particular application. This chapter describes the procedures and recommends approaches for estimating emissions from surface coating operations.

Section 2 of this chapter contains definitions of terms commonly used to describe surface coating operations and general descriptions of major surface coating source categories. Section 3 of this chapter provides an overview of available emissions estimation methods. Section 4 presents the preferred method for estimating emissions from surface coating operations and Section 5 presents the alternative emission estimation techniques. Quality assurance and control procedures associated with the emission estimation methods are described in Section 6. Coding procedures used for data input and storage are discussed in Section 7. Some states use their own unique identification codes, so non-regulatory personnel developing an inventory should contact individual state agencies to determine the appropriate coding scheme to use. References cited in this document are provided in Section 8. Appendix A provides example data collection forms to assist in information gathering prior to emissions calculations.

During the inventory planning phase, the preparer should decide whether a source category should be inventoried as a point or area source. When an inventory contains major (point) and area source contributions it is possible that emissions could be double counted. A discussion of this issue is included in Section 2.2. Data collection activities should be planned accordingly.

**NOTE: The following change has been made since the September 2000 version of this chapter. An incorrect emission factor was discovered for PM<sub>10</sub> in the Factor Information Retrieval (FIRE) System, and that factor was used in Example 7.5-1. The incorrect factor of 6.4 lb PM<sub>10</sub> per ton VOC has been changed to the correct value of 4.52 lb PM<sub>10</sub> per ton VOC. Additionally, discussion was expanded in Section 2 for Powder Coatings and Ultraviolet Coatings.**

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## 2

# SOURCE CATEGORY DESCRIPTIONS

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This section presents a general discussion of surface coating terms and a description of source categories that are known to use surface coating in many production activities. For a more detailed discussion of surface coating and these categories, refer to *AP-42* or the regulatory documents applicable to the specific source (EPA, 1995a). There may be many other source categories that also utilize surface coating; the principles and emissions estimating procedures discussed here are likely to apply to these sources as well.

There are many different types of coatings that are used in the surface coating industry such as paints, varnishes, printing inks, polishes, sealers, etc. Typically, coatings provide protection or decoration to a substrate or surface. In a typical coating sequence, three types of coatings are used: a primer, an intermediate coat, and a topcoat.

The majority of emissions that occur during surface coating are volatile organic compounds that evaporate from the solvents contained in the coatings. Individual hazardous air pollutants (HAPs) associated with surface coating operations are listed on Table 7.2.1. The most common solvents are organic compounds such as ketones, esters, aromatics, and alcohols. To obtain or maintain certain application characteristics, solvents are also added to coatings immediately before use. Other ingredients of the coatings, such as metals and particulates, may also be emitted during coating operations.

A wide variety of materials is used in surface coatings. In general, coatings can be divided into two classifications: thermoplastic and thermoset. Thermoplastics can be dissolved back into a liquid state by their original thinner or other selected solvents, and dried by solvent evaporation only. Examples of thermoplastic coatings include vinyls and lacquers. Thermoset coatings are materials that cannot be returned to their original state by contact with their original thinner or most other solvents. These coatings cure by solvent evaporation and chemical cross-linking of the coating components. Examples of thermoset coatings include epoxies, enamels, and urethanes.

Surface coating may be performed in a spray booth or in an open environment. Some previously open surface coating operations have been enclosed and the exhaust vented through a stack. Surface coatings may be applied manually or with automatic devices such as spray guns.

TABLE 7.2-1

## HAZARDOUS AIR POLLUTANTS ASSOCIATED WITH SURFACE COATING OPERATIONS

**Auto and Light Duty Truck (Surface Coating)**

Ethylene Glycol	Methyl Ethyl Ketone (2-Butanone)	Xylenes (includes o, m, and p)
Glycol Ethers	Methyl Isobutyl Ketone (Hexone)	
Lead & Compounds	Toluene	

**Fabric Coating and Printing (Surface Coating)**

Ethyl Acrylate	Methyl Ethyl Ketone (2-Butanone)	Styrene
Ethylene Glycol	Methanol	Toluene
Formaldehyde	Methyl isobutyl ketone	Vinyl acetate
Glycol Ethers	Methylene chloride	Vinyl chloride
	Phenol	

**Flat Wood Paneling (Surface Coating)**

Ethylene Glycol	Methyl Ethyl Ketone (2-Butanone)	Toluene
Glycol Ethers	Methyl Isobutyl Ketone (Hexone)	Xylenes (includes o, m, and p)

**Large Appliance (Surface Coating)**

Ethylene Glycol	Methyl Ethyl Ketone (2-Butanone)	Xylenes (includes o, m, and p)
Glycol Ethers	Toluene	

**Magnetic Tape (Surface Coating)**

Methyl Ethyl Ketone (2-Butanone)	Methyl Isobutyl Ketone (Hexone)	Toluene
----------------------------------	---------------------------------	---------

**TABLE 7.2-1**  
**(CONTINUED)**

**Metal Can (Surface Coating)**

Ethylene Glycol	Methyl Ethyl Ketone (2-Butanone)	Toluene
Glycol Ethers	Methyl Isobutyl Ketone (Hexone)	Xylenes (includes o, m, and p)

**Metal Coil (Surface Coating)**

Ethylene Glycol	Methyl Ethyl Ketone (2-Butanone)	Toluene
Glycol Ethers	Methyl Isobutyl Ketone (Hexone)	Xylenes (includes o, m, and p)

**Metal Furniture (Surface Coating)**

Ethylene Glycol	Methyl Ethyl Ketone (2-Butanone)	Toluene
Glycol Ethers	Methyl Isobutyl Ketone (Hexone)	Xylenes (includes o, m, and p)

**Miscellaneous Metal Parts and Products (Surface Coating)**

Ethylene Glycol	Methyl Ethyl Ketone (2-Butanone)	Toluene
Glycol Ethers	Methyl Isobutyl Ketone (Hexone)	Xylenes (includes o, m, and p)

**Paper and Other Webs (Surface Coating)**

1,1,2-Trichloroethane	Cumene	Methyl Ethyl Ketone (2-Butanone)
1,4-Dioxane (1,4-Diethyleneoxide)	Cyanide Compounds	Methyl Isobutyl Ketone (Hexone)
2,4-Toluene Diisocyanate	Dibutyl Phthalate	Methyl Methacrylate
Acetaldehyde	Diethanolamine	Methylene Chloride
Acetonitrile	Diethyl Sulfate	N,N-Dimethylaniline
Acrylamide	Dimethyl Sulfate	Nickel & Compounds
Acrylic Acid	Ethyl Acrylate	Phenol
Acrylonitrile	Ethylbenzene	Phthalic Anhydride
Aniline	Ethylene Dichloride	Polycyclic Organic Matter as 16-PAH



**TABLE 7.2-1**  
**(CONTINUED)**

**Paper and Other Webs (Surface Coating) (Continued)**

Antimony & Compounds	Ethylene Glycol	Propylene Dichloride
Asbestos	Ethylene Oxide	Propylene Oxide
Benzene	Formaldehyde	Selenium Compounds
Biphenyl	Glycol Ethers	Styrene
Bis(2-ethylhexyl)phthalate	Hydrochloric Acid (HCl gas only)	Tetrachloroethylene
Cadmium & Compounds	Hydrogen Fluoride (Hydrofluoric Acid)	Toluene
Catechol	Hydroquinone	Trichloroethylene
Chlorine	Lead & Compounds	Vinyl Acetate
Chlorobenzene	Maleic Anhydride	Vinyl Chloride
Chloroform	Manganese & Compounds	Vinylidene Chloride
Chromium & Compounds	Methanol	Xylenes (includes o, m, and p)
Cobalt Compounds	Methyl Bromide (Bromomethane)	
Cresols (includes o,m,p)	Methyl Chloroform (1,1,1-Trichloroethane)	

**Printing/Publishing (Surface Coating)**

1,4-Dioxane (1,4-Diethyleneoxide)	Cumene	Methyl Ethyl Ketone (2-Butanone)
2-Nitropropane	Cyanide Compounds	Methyl Isobutyl Ketone (Hexone)
4-4'-Methylenediphenyl Diisocyanate	Dibutyl Phthalate	Methylene Chloride
Acrylic Acid	Ethylbenzene	Nickel & Compounds
Antimony & Compounds	Ethylene Glycol	Phenol
Arsenic & Compounds (inorganic including Arsine)	Formaldehyde	Phthalic Anhydride
Benzene	Glycol Ethers	Polycyclic Organic Matter as 16-PAH
Bis(2-ethylhexyl)phthalate	Hydrochloric Acid (HCl gas only)	Tetrachloroethylene
Cadmium & Compounds	Lead & Compounds	Toluene
Chlorine	Maleic Anhydride	Trichloroethylene

**TABLE 7.2-1**  
**(CONTINUED)**

**Printing/Publishing (Surface Coating) (Continued)**

Chromium & Compounds	Methanol	Vinyl Acetate
Cobalt Compounds	Methyl Chloroform (1,1,1-Trichloroethane)	Xylenes (includes o, m, and p)

**Shipbuilding and Ship Repair (Surface Coating)**

Glycol Ethers	Methyl Isobutyl Ketone (Hexone)	Xylenes (includes o, m, and p)
Methyl Ethyl Ketone (2-Butanone)	Toluene	

**Wood Furniture (Surface Coating)**

Glycol Ethers	Methyl Isobutyl Ketone (Hexone)	Xylenes (includes o, m, and p)
Methyl Ethyl Ketone (2-Butanone)	Toluene	

Source: EPA, 1998.

## **2.1 COMMON TERMS USED TO DESCRIBE SURFACE COATING OPERATIONS**

### **2.1.1 COATINGS**

#### ***Enamels***

Enamels are thermoset topcoatings that can be either acrylic- or alkyd-based. Acrylic enamels require catalysts to facilitate curing. An alkyd enamel is a mixture of an alcohol, an acid, and an oil. Both types have a natural high gloss. Enamel coatings have a longer drying time than lacquer coatings.

#### ***Guide Coatings***

A guide coating, also called a primer surface, is applied between the primer and the topcoat to build film thickness, to fill in surface imperfections, and to permit sanding between the primer and topcoat. Guide coats are applied by a combination of manual and automatic spraying and can be solventborne, waterborne, or powder. Guide coating is used especially after electrodeposition (EDP).

#### ***High-solids Coatings***

Coatings that typically contain greater than 60 percent solids by volume are referred to as high-solids coatings (Environmental Protection Agency [EPA], 1992). High-solids coatings require less solvent content, therefore, volatile organic compound (VOC) emissions reductions ranging from 50 to 80 percent can be achieved by converting to coatings that contain higher solids. High-solids coatings can be applied electrostatically or manually by roll coating or spraying. Because of the higher viscosity of high-solids coatings, additional mechanical, thermal, or electrical energy may be necessary for pumping and adequate atomization. Transfer efficiencies are usually better than those achieved through conventional coatings, especially when sprayed electrostatically. In addition, because there is less solvent in high-solids coatings, the minimum air flow required for dilution of air in a spray booth may be reduced, resulting in an energy savings for fan operation.

#### ***Intermediate or Midcoat***

The intermediate coat serves to seal the primer and fill any voids or porosities in the primer coat. They also provide an additional layer of corrosion protection by acting as a barrier coat. An intermediate/midcoat also provides a surface to which subsequent coats can adhere. In instances where a primer and a topcoat are not compatible (such as a thin film topcoat and a zinc-filled primer), intermediate coats can serve as a tie coat between the two coats.

## **Lacquers**

Lacquers are thermoplastic topcoatings that dry faster than most enamels and urethanes, making them more attractive to sources (e.g., automobile body shops) that do not have spray booths. Lacquer finishes, however, are not as durable as enamel and urethane finishes.

## **Powder Coatings**

Powder coatings are applied electrostatically by spraying or dipping, or by dipping a preheated object into a fluidized bed of coating. After a powder coating is applied to an object, the object is placed in an oven to melt the powder particles and create a flow to form a continuous, solid film.

Electrostatic powder spray coating can be performed automatically or manually. As charged powder particles leave a spray gun, they are attracted to the grounded object that is to be coated. With this method, powders are able to wrap around edges of complicated forms. Film thickness can be controlled by adjusting the voltage. Like conventional spraying, powder spraying requires a booth. However, the ventilation requirements for powder spray booths are much less stringent than for solvent coating spray booths if the powder is applied automatically and the booth is, therefore, not occupied.

Dipping is also used to apply powder coatings. There are two ways that powders can be applied by dipping: fluidized bed or electrostatic fluidized bed. In a fluidized bed, a preheated object is immersed into the bed and held there until a desired film thickness is reached. In electrostatic fluidized bed coating, the powder particles are attracted to grounded, usually unheated, objects moving through the bed. A disadvantage of dipping is that powder coatings can only be applied in thick films.

Although powders are essentially 100 percent solids, they may produce small quantities of organic materials which may be released during the curing process. Up to five weight percent of VOCs can be released from powders during this process (RTI 2000). Most powder overspray can be reclaimed and reused; however, some reclaimed overspray must be reprocessed because it may contain larger and heavier granules that are not acceptable for reuse.

## **Primer**

The primer is the first film of coating applied in a coating operation that facilitates bonding between the surface and subsequent coats. Without adequate primer adhesion to the surface, the subsequent coatings may not adhere properly. In addition, primers serve to prevent corrosion in one of three ways: physically, as a barrier; chemically, with the use of corrosion-inhibiting agents; or electrochemically. Primers also prevent dulling of the topcoat caused by the

penetration of topcoat solvents into the lower coat(s). If imperfections remain on the surface after primer application, a primer surfacer may be applied to build thickness and smooth over any imperfections. Some primers are water-based and contain little or no organic solvent.

### ***Topcoat***

The topcoat is the final film of coating applied after a surface has been prepared and is free of defects. Topcoats provide the final color and appearance. They also provide additional resistance to the environment and help protect the primer and intermediate coats from exposure to weather and chemicals. Topcoats may be single-, two-, or three-stage coating systems. An oven bake may follow each topcoat application, or the coating may be applied wet on wet. The final topcoat may be baked in a high-temperature oven. Two-stage systems may have either a solid color or metallic basecoat, covered with a transparent clearcoat for protection. These systems are eye appealing because of their deep, rich finish. Three-stage systems consist of a basecoat, midcoat, and clearcoat. Topcoats have traditionally been solventborne lacquers and enamels. Recent trends have been to use topcoats with higher solids content, such as powder topcoats.

### ***Ultraviolet (UV) Coatings***

UV coatings are formulated to cure at room temperature with the assistance of UV light. Photoinitiators in the coating act as catalysts. Upon adsorption of UV light, the photoinitiators cleave to yield free radicals that begin the polymerization process. No VOC emissions occur from using UV coatings. However, sprayable UV-cured coatings often contain water or solvent to reduce the viscosity of the coating for easier application (EPA, 2001).

### ***Urethanes***

Urethanes are thermoset topcoatings formed by a chemical reaction between a hydroxyl-containing material and a polyisocyanate catalyst. Urethane coatings have a higher volume percentage of solids content than lacquers and a slightly higher percentage than enamels. Urethane coatings are popular because of their superior gloss retention, durability, corrosion protection, and versatility. This coating type is strongly adherent to metal surfaces and can resist both chemical attack and abrasion. Their clarity and resistance to weather make them valuable for severe industrial service. Urethane coatings dry more slowly than lacquer or enamel coatings and, because of the slower drying time, spray booths are often required to provide a clean, dust-free curing environment.

## ***Vinyl Coatings***

Coatings that are based on vinyl resins formed by the polymerization of vinyl compounds are called vinyl coatings. The most common resins are based on polyvinyl chloride (PVC) copolymers. These resins form films by solvent evaporation. Freshly applied coatings are dry to the touch within one hour and are fully dried within seven days. Vinyl coatings are particularly useful when fast drying, particularly at low temperatures (0 to 10°C [32 to 50°F]), is required.

Coatings based on vinyl polymers perform well in immersion situations and are frequently used to protect submerged structures such as the underwater hull of a ship. These coatings have excellent resistance to many chemicals and are good weather-resistant materials. Vinyl coatings are softened by heat and are not suitable for sustained use above 66°C (150°F). Vinyl paint systems require the use of a thin coat of wash primer (containing acids to etch the surface) as the first coat to ensure good adhesion to steel.

## ***Waterborne Coatings***

Coatings manufactured using water as the primary solvent are referred to as waterborne or water-based coatings and offer some advantages over organic solvent systems because they do not exhibit as great an increase in viscosity with increasing molecular weight of solids, are nonflammable, and have limited toxicity. There are three major classes of waterborne coatings: water solutions, water emulsions, and water dispersions. All of the waterborne coatings, however, contain a small amount (up to 20 percent of volume) of organic solvent that acts as a stabilizing, dispersing, or emulsifying agent. Because of the relatively slow evaporation rate of water, however, it is difficult to achieve a smooth finish with waterborne coatings. A bumpy "orange peel" surface often results. For this reason, their main use is as a prime coat.

Waterborne primer is most often applied in an electrodeposition bath. The composition of the bath is about 5 to 15 volume percent solids, 2 to 10 volume percent solvent, and the rest water. The solvents used are typically organic compounds of higher molecular weight and low volatility, like ethylene glycol monobutyl ether (EPA, 1995a).

### **2.1.2 COATING APPLICATION**

#### ***Brush Coating***

Coating applied with a brush is called brush coating. A transfer efficiency of 100 percent may be achieved using this method. However, brush coating is not a practical method for painting large parts.

### ***Dip Tanks***

Objects to be coated are immersed manually or by conveyor into a dip tank full of coating. After removal from the tank, any excess coating is allowed to drain back into the tank. Dip coating operations can be totally enclosed and vented by a roof exhaust system, or may have a ventilation system adjoining the dip tank. The advantages of dip coating include minimal coating loss. Dip coating operations are common (but not limited) to the following industries; metal furniture, miscellaneous metal parts, aircraft, appliances, automobiles, and light-duty trucks.

### ***Electrodeposition***

In EDP, a direct-current voltage is applied between the coating bath (or carbon or stainless-steel electrodes in the bath) and the part to be coated. The part, which can act as the cathode or the anode, is dipped into the bath. Coating particles are attracted from the bath to the part because they are oppositely charged, yielding an extremely even coating. The coatings used in EDP tanks are waterborne solutions. Transfer efficiencies for EDP are commonly above 95 percent (Turner, 1992).

### ***Flash***

Flash refers to the evaporation of solvents (VOC) from a coated product from the time the product is coated until the product reaches the dryer/curing oven. If the product is air dried, VOCs flash off the product until the product is dry or until all VOCs are evaporated. The evaporated VOCs will either be collected by a capture system or be released as a fugitive emission.

### ***Flow Coating***

Flow coating is a coating process by which the object to be coated is conveyed over an enclosed sink where pumped streams of coating are allowed to hit the object from all angles, flow over the object and coat it, and drip back into the sink. Typically, a series of nozzles (stationary or oscillating) are positioned at various angles to the conveyor, and shoot out streams of coating that "flow" over the object. Flow coating can achieve up to 90 percent transfer efficiency. Examples of industries using flow coating include automobile, flat wood paneling, metal furniture, and miscellaneous metal parts.

"Vacuum coating" is a kind of flow coating. The coating chamber is flooded with coating and vacuum pulls the coating across the product.

"Curtain coating" is also a type of flow coating. In this process, the coating is not pumped from all angles but instead cascades over the part as a waterfall. Curtain coating is used mostly for flat goods.

### ***Phosphating***

Phosphating is a process that prepares metal surfaces for the primer application. Since iron and steel rust readily, a phosphate treatment is necessary. Phosphating also improves the adhesion of the primer and the metal. The phosphating process occurs in a multistage washer, with detergent cleaning, rinsing, and coating of the metal surface with zinc or iron phosphate. The metal surfaces then pass through a water spray cooling process. If solventborne primer is to be applied, they are oven-dried prior to priming.

### ***Roller Coating***

Roller coating machines typically have three or more power-driven rollers. One roller runs partially immersed in the coating and transfers the coating to a second, parallel roller. The strip or sheet to be coated is run between the second and third roller and is coated by transfer of coating from the second roller. If the cylindrical rollers move in the same direction as the surface to be coated, the system is called a direct roll coater. If the rollers move in the opposite direction of the surface to be coated, the system is a reverse roll coater (EPA, 1995a). The quantity of coating applied to the sheet or strip is established by the distance between the rollers.

### ***Spray Booths***

Spray booths provide a clean, well-lit, and well-ventilated enclosure for coating operations. Coatings that have long drying times are best applied in spray booths to minimize potential dust and dirt from adhering to a wet coating. Some spray booths are equipped with a heating/baking system that promotes faster drying times. Some facilities use portable heating units that can be rolled into a spray booth after an object has been painted. Some spray booths draw in air through filters to assure a flow of clean air over the object to be coated, and other booths draw in air through unfiltered openings. Air is drawn out of the booth to promote drying and to provide a safer working environment for the painter by removing solvent vapors from the work area. Filters for the discharge from the booth remove coating overspray (the portion of the coating solids that does not adhere to the surface being sprayed) from the exhaust air.

The three most common types of spray booths are: crossdraft, downdraft, and semi-downdraft. Crossdraft spray booths operate by pulling incoming air into the booth at one end, with air crossing over the object being coated and then passing out of the booth at the opposite end. Downdraft booths employ a vertical air flow from the top to the bottom of the booth. Because downdraft booths provide the cleanest drying/curing environment with low air turbulence and



increased worker safety, they are regarded as state-of-the-art. Semi-downdraft booths are available that combine both crossdraft and downdraft booth designs. Air enters the booth through the ceiling (like a downdraft booth) and exits at the back of the booth (like a crossdraft booth).

### **Spray Equipment**

Spray equipment includes conventional air spray guns such as electrostatic, high volume/low pressure, and low volume/low pressure, and airless spray guns, and spray guns that utilize carbon dioxide injection.

**Airless Spray Systems.** Hydraulic pressure alone is used to atomize the fluid at high pressure (400-4,500 pounds per square inch [psi]) through a small orifice in the spray nozzle. Upon exiting the spray nozzle at high pressure, the fluid breaks up into fine droplets resulting in a fine atomized spray. Since the coating is discharged at a high velocity after atomization, sufficient momentum remains to carry the small particles to the surface being coated. The pressure required to properly atomize the fluid depends on the viscosity of the material being applied. Airless spray systems are cleaner and faster to use than conventional spray systems. Coatings can be applied as fast as the painter can move the gun and as thick as desired. The primary advantage of the airless spray method is that it greatly reduces particle "bounce" (i.e., coating particles that ricochet off the substrate surface), often to less than half of what might occur while using conventional spray equipment. In addition, low overspray and significant material savings are benefits of airless spray systems. The primary problem observed with airless spray systems is nozzle plugging. Due to very minute nozzle orifices, coatings fed to the gun must first pass through filters with openings slightly larger than the nozzle orifice. Since filters are usually located at the pump discharge, deposits on the filters may cause plugging.

**Carbon Dioxide (CO<sub>2</sub>) Injection Spray Systems.** CO<sub>2</sub> injection spray systems are a relatively new spray technology that uses supercritical CO<sub>2</sub> to replace the solvent that is normally present in conventional coatings. The CO<sub>2</sub> is mixed with the coating concentrate as the coating is sprayed. The spray solution generally contains 10 to 50 percent by weight of dissolved CO<sub>2</sub>, depending upon the solubility, solids level, pigment loading, temperature, and pressure. To preserve the CO<sub>2</sub> in solution, the gun pressure is maintained at 1,200 to 1,600 psi (i.e., pressures typical of airless spraying). Due to the rapid decrease in temperature as the CO<sub>2</sub> expands through the nozzle, the solution is typically heated to 100 to 160°F (38 to 71°C). The transfer efficiency of this system approaches that of a conventional airless spraying system. There are several disadvantages of this system though, such as a slower fluid delivery rate than exists for conventional air guns, lack of coatings formulated to allow for application with CO<sub>2</sub> injection, and high capital cost.

**Conventional Spray Guns.** Conventional guns are hand-held guns that use air pressure to atomize a coating. Conventional air spray guns provide a fine decorative-type finish and allow precise spray adjustments by the operator. The coating and air enter the gun through separate passages and are mixed and discharged through an air nozzle, providing a controlled spray pattern. There are three basic types of conventional spray guns: vacuum type, pressure type, and gravity type.

Conventional vacuum spray guns contain the coating in a cup that is directly attached to the spray gun. The swift air flow through the air line and spray gun creates a vacuum that siphons coating from the cup and forces it through the gun nozzle. Since this system must be filled often, it is best suited for spot painting, as opposed to applications requiring larger amounts of coating. Also, it is difficult to achieve proper atomization of some modern coatings.

Conventional pressure spray guns contain the coating in a "pot" that is attached by fluid hose lines to the spray gun. By introducing compressed air to the pot, the liquid is pushed through the hose and out of the spray nozzle. Pressure-type systems are normally used when large amounts of material are required, when the material is too heavy to be siphoned from a container, or when fast application is required.

Conventional gravity-fed spray guns contain the coating reservoir (cup) above the gun, thus requiring less air pressure to force the coating through the gun. Gravity-fed guns provide substantially better transfer efficiency than vacuum guns.

**Electrostatic Spray.** Electrostatic spray is a method of applying a spray coating in which opposite electrical charges are applied to the substrate and the coating. The coating is attracted to the substrate by the electrostatic potential between them. The system works best when used in surface coating operations where the objects to be coated are relatively small and uniform in density. Varying densities may present problems because higher density areas can be more conductive, thus attracting more coating material than an area that is less dense. With large objects, it can be difficult to attain a good ground. Grounding also becomes increasingly difficult as each additional layer of coating is applied. These systems are generally accepted as providing the highest transfer efficiency possible. Unfortunately, the applicability of electrostatic spray systems tends to be limited due to the principles employed.

**Low Volume/Low Pressure (LVLP) Spray Systems.** LVLP spray guns atomize coatings, and the atomized spray is discharged at low pressure (9.5-10 psi) and lower velocities than conventional air spray guns. The transfer efficiency of LVLP spray guns is approximately the same as for HVLP spray guns. The main difference between the two types is that LVLP guns use a significantly smaller volume of air for coating atomization (45 to 60 percent less). As a result, energy costs for air compression are lower than for HVLP spray guns.

**High Volume/Low Pressure (HVLP) Spray Systems.** With HVLP spray systems, low pressure (typically 10 psi or less) is used with large volumes of air to atomize coatings. The air source for an HVLP system can be conventional compressed air or a turbine. Most HVLP systems are designed to be compatible with a wide range of coatings. Because the atomized spray exits the gun at a lower velocity than in conventional air spraying, there is less particle bounce. Consequently, higher transfer efficiencies can be obtained with a reduction in overspray. Higher transfer efficiencies and reduced overspray both contribute to lower VOC emissions. HVLP systems are also noted for their good operating control, portability, ease to clean, and ability to spray well into recesses and cavities. Disadvantages of HVLP spray systems include slow application rate, high maintenance cost, and increased operator training.

### ***Transfer Efficiency***

The ratio of the amount of coating solids deposited onto the surface of the coated object to the total amount of coating solids that exit the coating device is referred to as transfer efficiency. Coating that is sprayed but fails to deposit on the surface to be coated is referred to as "coating overspray." Increased transfer efficiency results in less overspray. The level of transfer efficiency is usually used in a description of spray devices.

High transfer efficiency has several benefits: reduces the amount of coating used and, consequently, reduces emissions; reduces solvent concentration around the worker; reduces time spent in applying coatings, since more coating reaches the substrate; and reduces the amount of solvent needed for overspray cleanup.

The transfer efficiency of spray equipment is influenced by several factors including the shape of the surface being coated, type of gun, velocity of the aerosol, skill and diligence of the operator, and extraneous air movement within the spray area (or booth).

Typical transfer efficiencies can be obtained from equipment manufacturers or technical references such as Section 4.0, *AP-42* (EPA, 1995a).

## **2.1.3 AUXILIARY PROCESS**

### ***Cleaning***

Surface coating application equipment is cleaned with solvent cleaners. Spray guns can be cleaned manually or with several different types of gun cleaning systems specially designed for this purpose. Cleaning of equipment results in VOC emissions. Solvent emissions from gun cleaning equipment occur both during actual cleaning operations ("active losses") and during standby ("passive losses") periods.

## 2.1.4 AIR POLLUTION CONTROL TECHNIQUES AND POLLUTION PREVENTION

Emissions from surface coating operations may be vented directly to the atmosphere, released as uncaptured emissions, or routed to an air pollution control device or pollution prevention system. The following discussion presents air pollution control techniques and pollution prevention alternatives that may be used to reduce either VOC or particulate matter (PM) or PM less than or equal to an aerodynamic diameter of  $10\ \mu\text{m}$  ( $\text{PM}_{10}$ ) emissions. It should be noted that any particular control technique may be very effective at removing one pollutant from the exhaust stream, but may have no effect on other pollutants. Table 7.2-2 summarizes typical control efficiencies for the control technologies that are applicable to the various surface coating operations.

### ***Capture***

Capture systems may be used to collect the evaporated VOC emissions by vacuum or other exhaust mechanism and direct them to a control device or vent the VOCs to the atmosphere. Capture systems may not collect all VOCs allowing some to escape as uncaptured emissions. The capture efficiency indicates the percentage of the emission stream that is taken into the control system, and the control efficiency indicates the percentage of the air pollutant that is removed from the emission stream before release to the atmosphere. For example, if a control device is rated at 99 percent efficiency, but the capture is only 50 percent, then the emissions would be estimated as uncontrolled emissions \* 50% \* 99%.

### ***Carbon Adsorption***

Carbon adsorption refers to a control system where the collected coating exhaust is passed over a bed of carbon where pollutants are adsorbed and collected. Carbon adsorption units work best with lower-temperature operations. It is important to remove any entrained liquids and PM that may be in the inlet gas prior to passing through a carbon adsorber to avoid plugging up the carbon bed and reducing its adsorption efficiency.

Recovery of solvents that have been adsorbed onto carbon beds is common. When a mixture of solvents is collected, the recovered mixture is often used as fuel to fire a boiler or other fuel-consuming process unit. In some facilities, the mixture is separated by distillation, and the recovered solvents are reused (EPA, 1977a, 1977b). If properly operated and maintained, VOC control efficiencies as high as 95 percent can be achieved (EPA, 1992).

### ***Catalytic Incineration***

Incineration where a catalyst is used to lower the activation energy needed for oxidation is referred to as catalytic incineration. When a waste gas stream passes through a catalytic

TABLE 7.2-2

## TYPICAL EMISSION CONTROL TECHNIQUES FOR SURFACE COATING VOC OPERATIONS

Emission Source	Control Device Type	Average Control Efficiency (%)
General	Carbon Adsorber	90 <sup>a</sup>
	Thermal Incinerator	90
Liquid Storage	Thermal Incinerator	96-99
Spray Booth	Carbon Adsorber	90
Bake Oven	Catalytic Incinerator	96
	Thermal Incinerator	96
Coating Line	Carbon Adsorber	80
Curing Oven Exhaust	Thermal Incinerator	90
Drying Ovens	Carbon Adsorber	95
	Thermal Incinerator	95
Waste Solvent Reclamation	Carbon Adsorber	95 <sup>b</sup>
Entire Process	Carbon Adsorber	90
Automobile Manufacturer, Bake Oven Exhaust	Thermal Incinerator	90 <sup>a</sup>
Can Manufacturer General	Thermal Incinerator	90 <sup>b</sup>
Can Coating, Exterior	Catalytic Incinerator	90
	Thermal Incinerator	90
Can Coating, Interior	Carbon Adsorber	90
	Catalytic Incinerator	90
	Thermal Incinerator	95-97
Fabric Coating	Carbon Adsorber	95
	Thermal Incinerator	95

TABLE 7.2-2

(CONTINUED)

Emission Source	Control Device Type	Average Control Efficiency (%)
	Inert Gas Condensation System <sup>a</sup>	99
Flatwood Paneling	Thermal Incinerator	94 <sup>b</sup>
Magnet Wire Production	Thermal Incinerator	90
Metal Coating	Carbon Adsorber	90
Metal Coil Coating	Catalytic Incinerator	95
	Thermal Incinerator	95
Paper Film	Thermal Incinerator	95
Paper Film/Foil	Carbon Adsorber	95
	Thermal Incinerator	98
Polymeric Coating	Carbon Adsorber	95
	Catalytic Incinerator	98
	Thermal Incinerator	98
	Vapor Recovery	95
Vinyl Coating/Primer	Vapor Recovery	90 <sup>a</sup>

Source: EIIP, 2000

<sup>a</sup> Reported minimum value.<sup>b</sup> Reported maximum value.

incinerator, the catalyst bed initiates and promotes the oxidation of VOCs without being permanently altered itself. Catalytic-aided combustion takes place at a considerably lower temperature than in noncatalytic incineration (EPA, 1978). Major disadvantages of catalytic incineration include the need to replace the catalyst because of pollutant poisoning and the high cost of catalyst replacement. VOC control efficiencies of 98 percent can be achieved through the use of catalytic incinerators (EPA, 1992).

### ***Combination Adsorption/Incineration Systems***

A control system that incorporates carbon adsorption and catalytic or thermal incineration is available for emissions control. With these types of systems, the contaminants from a waste gas stream are initially collected on a carbon adsorption bed. A smaller volume of air is used for regeneration and then sent to an incinerator. As a result, a smaller incinerator is needed for these systems than what would be required for a conventional thermal incinerator. These systems are capable of achieving 90 percent control (Eisenmann Corporation). In addition, by concentrating the VOCs in the gas stream, fuel costs for incineration are reduced. The primary disadvantage of these systems is that high capital investment is required.

### ***Dry Filters***

PM emissions from spray booths can be controlled with dry filters that capture PM before entering the exhaust air. When the filters become loaded with PM to the point that the pressure drop across the filters reaches a certain level, they must be replaced.

### ***Solvent Recovery***

Solvent recovery is a pollution prevention technique that can be used to reduce emissions. Solvent condensation is one such technique capable of recovering a reusable solvent. Carbon adsorption is another type of solvent recovery often used and was described earlier.

### ***Thermal Incineration***

Thermal incineration is the process of raising waste gas to a temperature that is adequate to oxidize organic compounds. The most important factors to ensure proper oxidation include the following: temperature in the combustion chamber, time that the VOC-laden exhaust air resides in the combustion chamber, mixing of the gaseous components before and within the combustion chamber, oxygen content of the waste gas stream, and the type of contaminants present in the waste gas stream (EPA, 1992; Eisenmann Corporation). The products of incineration are water, CO<sub>2</sub>, nitrogen oxides (NO<sub>x</sub>), and carbon monoxide (CO).

Many thermal incinerators use heat exchangers to reduce fuel costs. In recuperative heat exchange designs, a heat exchanger upstream of the incinerator uses the heat content of the incinerator flue gas to heat the incoming VOC-laden stream into the incinerator, thus reducing the thermal energy required in the oxidizer (Eisenmann Corporation). VOC control efficiencies of 98 percent can be achieved through the use of thermal incinerators (EPA, 1992).

### ***Waterborne, High-solids, and Powder Coatings***

Pollution prevention techniques such as use of waterborne coatings, high-solids coatings, and others can be used to reduce VOC emissions. Emissions reductions depend on several variables, such as the amount of VOCs in the original solvent borne coating, the amount of VOCs in the replacement coating, relative transfer efficiency of the coatings, and the relative film thickness required. For this reason, emission reductions are difficult to predict, but may range from 60 to 99 percent reduction. The primary disadvantage of using waterborne coatings is that water evaporates slowly, making it difficult to achieve a smooth finish. For this reason, their main use is as a primer coat. The primary disadvantage of high-solids coatings is that additional mechanical, thermal, or electrical energy may be necessary for pumping and adequate atomization because of the higher viscosity of the coatings.

### ***Waterwash***

Particulate emissions from spray booths can be controlled with a water curtain or waterwash filtration system. Coating exhaust air is passed through a water "wall" that traps coating overspray that leads to PM emissions. The spent water is allowed to settle, creating a sludge from the solids, the water is then recirculated through the system. The sludge that is generated must be properly disposed of in accordance with applicable state and local hazardous waste disposal requirements.

## **2.2 SURFACE COATING SOURCE CATEGORIES**

Surface coating operations are an integral part of the manufacturing phase for a variety of materials and products. Major types of surface coating activities are described below and are organized by substrate category. Table 7.2-3 lists point source categories by SIC code that typically have surface coating operations. The information in this table should assist the regulatory agency in point source inventory preparation for these categories. For additional information on surface coating operations and emission estimation guidance, please refer to the *Architectural and Industrial Surface Coating* chapters within Volume III, *Area Sources Preferred and Alternative Methods*.



TABLE 7.2-3

**STANDARD INDUSTRIAL CLASSIFICATION (SIC) CODES FOR  
SURFACE COATING SOURCE CATEGORIES**

Source Category	SIC Code	SIC Description
Aircraft Manufacturing	3721	Aircraft
Appliances	363	Household Appliances
Automobiles and Light-duty Trucks	3711	Motor Vehicles and Passenger Car Bodies
	3713	Truck and Bus Bodies
Automobile Refinishing	7532	Top and Body Repair and Paint Shops
Fabric Coating and Printing	2200	Textile Mill Products
	2260	Textile Finishing, except Wool
	2261	Finishing Plants, cotton
	2262	Finishing Plants, manmade
	2269	Finishing Plants, n.e.c.
	2295	Coated Fabrics, not rubberized
Flat Wood Product Manufacturing	2435	Hardwood Veneer and Plywood
	2436	Softwood Veneer and Plywood
Heavy-duty Truck Manufacturing	3531	Construction Machinery
	3537	Industrial Trucks and Tractors
	3713	Truck and Bus Bodies
Magnet Wire	3357	Nonferrous Wiredrawing and Insulating
Metal Cans (Two- or Three-piece)	3411	Metal Cans
Metal Coil	3479	Metal Coil Coating
Metal Furniture	2514	Metal Household Furniture
Miscellaneous Metal Parts	34	Fabricated Metals Products
	35	Industrial Machinery and Equipment
	36	Electronic and Other Electric Equipment
	37	Transportation Equipment

**TABLE 7.2-3****(CONTINUED)**

<b>Source Category</b>	<b>SIC Code</b>	<b>SIC Description</b>
Paper Coating	2671	Paper Coated and Laminated Packaging
Plastic Parts	357	Computer and Office Equipment
Ships	3731	Ship Building and Repairing
Steel Drums	3412	Metal barrels, drums, and pails
Wood Furniture Coating	2434	Wood Kitchen Cabinets
	2511	Wood Household Furniture
	2517	Wood TV and Radio Cabinets
	2521	Wood Office Furniture
	2541	Wood Partitions and Fixtures

Although EPA has minimum requirements for determining whether a source is a point or area source, the state or local agency may have additional requirements, and should therefore, be contacted for ultimate guidance when determining point/area source status of industrial surface coating facilities.

When an inventory contains major and area source contributions from the same process, it is possible that emissions could be double counted. The opportunity for this situation most frequently occurs when a top-down estimation method is used for the area source category. For example, emissions from large wood furniture manufacturing establishments (major sources) are included in an inventory. Emissions from small wood furniture manufacturing (below some specified cutoff) would be treated as an area source using a top-down approach. The area source inventory must be adjusted downward by subtracting the major source contributions to avoid double counting. Volume III of the EIIP series describes in detail how such adjustments can be made and provides a list of example sources that may share processes with point and major sources.

EPA procedures for identifying and handling point versus area sources for inventory purposes are described in Volume III, *Introduction to Area Sources Emission Inventory Development* and in the U.S. EPA's *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone. Volume I: General Guidance for Stationary Sources* (EPA, 1991).

For regulatory purposes, state and local agencies may have policies for categorizing surface coating operations, particularly when a process does not obviously fit into a regulated category. The state or local agency, therefore, should be contacted for ultimate guidance when determining applicable regulations.

### **2.2.1 AIRCRAFT MANUFACTURING**

Aircraft manufacturing is defined to be any fabrication, process, or assembly of aircraft parts, or completed unit of any aircraft, including but not limited to airplanes, helicopters, missiles, rockets, and space vehicles.

Surface coating operations used in aircraft manufacturing include the use of spray booths, dip tanks, or the use of enclosed areas, such as a hangars, for the application of one or more coating types (e.g., primer, topcoat) (EPA, 1995a).

Primers are applied to aircraft for corrosion prevention, protection from the environment, functional fluid resistance, and adhesion of subsequent coatings. Topcoatings are applied to aircraft for appearance, identification, camouflage, or protection (California Air Resources Board, 1994).

### 2.2.2 APPLIANCES

Appliances include metal ranges, ovens, microwave ovens, refrigerators, freezers, washing machines, dryers, dishwashers, water heaters, or trash compactors. Appliance parts are coated for protection or decoration.

Appliance parts are first cleaned with organic degreasers or a caustic detergent (or both) to remove grease and mill scale accumulated during handling. This is often followed by a process to improve the grain of the metal. A phosphate bath is then used to provide corrosion resistance to the appliance surface and to increase the surface area of the part, thereby allowing superior coating adhesion. Often the metal surfaces of the appliance are then coated with a rust inhibitor to prevent rusting prior to painting.

A protective primer coating that also covers surface imperfections and contributes to total coating thickness is then added followed by a final decorative topcoat. Single-coat systems, however, where only a primer coat or topcoat is applied, are becoming more common. For parts not exposed to customer view, a primer coat alone may be used. For exposed parts, a protective coating may be formulated and applied as a topcoat.

There are many different surface coating application techniques in the appliance industry, including manual, automatic, and electrostatic spray operations, and several dipping methods. Selection of a particular method depends mainly upon the geometry and use of the part, the production rate, and the type of coating being used.

A wide variety of coating formulations is used by the appliance industry. The prevalent coating types include epoxies, epoxy/acrylics, acrylics, and polyester enamels. Liquid coatings may use either an organic solvent or water as the main carrier for the paint solids (EPA, 1977b).

### 2.2.3 AUTOMOBILES AND LIGHT-DUTY TRUCKS

This category includes passenger cars, vans, motorcycles, trucks, farm machinery, construction equipment, and all other mobile equipment that is capable of being driven or drawn upon a highway and is coated during manufacturing and assembly (EPA, 1977c; EPA, 1979). Refinishing of automobiles that occurs subsequent to the original assembly, and includes vehicle repair after accidents, maintenance coating, dock repair of imported automobiles, and dealer repair of transit damage before the sale of an automobile, is a separate source category discussed below.

Surface coating of a newly manufactured automobile body is a multistep operation carried out on an assembly line with an automatic conveyor system. Although finishing processes vary from

plant to plant, there are some common characteristics. Major steps in the coating process are primer coating, guide coating, topcoating, and finishing.

Application of coating to the vehicles may take place in a dip tank or spray booth; curing occurs in a bake oven. The application and curing processes are usually contiguous to prevent exposure of the wet body to the ambient environment before the coating is totally cured (EPA, 1979).

Phosphating, primer coat, guide coat, and top coating processes may all be used on the vehicles during manufacturing. Approximately half of all plants use solventborne primers with a combination of manual and automatic spray application. The rest use waterborne primers; however, the use of waterborne primers is expected to increase.

The current trend in the industry is toward base coat/clear coat (BC/CC) topcoating systems, which consist of a relatively thin application of highly pigmented metallic base coat followed by a thicker clear coat. These BC/CC topcoats have a more appealing appearance than do single-coat metallic topcoats, and competitive pressures are expected to increase their use by U.S. manufacturers. The VOC content of most BC/CC coatings in use today, however, is higher than that of conventional enamel topcoats. Development and testing of lower VOC content (higher solids) BC/CC coatings are being done by automobile manufacturers and coating suppliers.

#### **2.2.4 FABRIC COATING AND PRINTING**

The textile industry supplies the largest non-durable consumer product market in the country. The industry consists of complex product mixes such that each facility has unique physical and chemical production processes, machinery, raw materials, and environmental issues. Facilities may be engaged in performing any one of the following operations:

- Fabric Preparation;
- Fabric Dyeing;
- Fabric Printing;
- Fabric Finishing; and
- Fabric Coating.

This section provides just a brief overview of the fabric coating industry. Detailed information can be found in the document, *Preliminary Industry Characterization: Fabric Printing, Coating, and Dyeing* (EPA, 1998).

Coating is a specialized chemical finishing technique designed to produce fabric to meet high performance requirements, e.g., for end products such as tents, tire cord, roofing, soft baggage, marine fabric, drapery linings, flexible hoses, hot-air balloons, and awnings. Coatings generally

impart elasticity to substrates, as well as resistance to one or more element such as abrasion, water, chemicals, heat, fire, and oil.

The major components of a coating process include the following:

- Coating preparation;
- Fabric preparation;
- Fabric let-off;
- Coating application onto substrate (including impregnation or saturation);
- Lamination (including the use of adhesives, hot melts, and extrusions) - optional;
- Drying and/or curing of coating;
- Bonding machine lamination (pressure and heat) - optional;
- Decoration machine (embossing or printing) - optional; and
- Takeup-recovery of carrier film or intertwining webs.

Both the substrates coated as well as the coating itself vary. Any number of different textile substrates can be coated including rayon, nylon, polyester, cotton, and blends. Coating chemicals used vary depending on end use of the coated fabric. Examples of coating chemicals include vinyl, urethane, silicone, and styrene-butadiene rubber.

VOC or HAP emissions from coating systems result primarily from vaporization of solvents during coating and drying/curing. Trace amounts of plasticizers and reaction by-products (cure-volatiles) may also be emitted. Solvent-based coating systems are expected to be among the largest emitters of HAPs such as methyl ethyl ketone (MEK) and toluene in this source category. HAPs will likely be emitted during application and drying/flashoff operations and also possibly during mix preparation (filling, coating transfer, intermittent activities such as changing filters, and the mixing process if proper covers are not installed). In addition, HAP emissions from solvent storage tanks occur during filling and from breathing losses.

### **2.2.5 HEAVY-DUTY TRUCK MANUFACTURING**

Surface coating of heavy-duty trucks during manufacturing includes many of the operations used in automobile and light-duty trucks. Surface coating operations are divided into the preparation and painting of the cab and the chassis (Turner, 1992).

All of the truck cab assemblies, with the exception of the fiberglass hoods, initially go through a metal finishing line known as the E-coat process, which includes alkaline cleaning and rinsing, surface treatment using zinc phosphate followed by a chrome rinse for steel and chromic acid for aluminum, rinsing, and then passage through an electrodeposition bath, rinsing and drying. Following E-coating, the cab assemblies go to the undercoating and interior paint line. The exact flow on the line depends on the construction material of the cabs; however, some form of seam-

sealing, interior painting, and undercoating is conducted for all of the cabs prior to the main cab painting line. Cab painting generally includes some sanding and painting, and then drying in an oven prior to final assembly. However, the number of sanding, drying, and painting steps will vary depending on the number of colors used on the cab.

Chassis painting is simpler and involves three steps: spot priming, topcoat, and drying prior to final assembly. Assembly incorporates the cabs with the chassis. Due to the custom nature of the manufacturing operation, there is a significant amount of paint touch-up done on all cabs before they leave the facility. The facility also paints some of the individual small parts.

### **2.2.6 AUTOMOBILE REFINISHING**

Automobile refinishing is usually a nonmanufacturing category of surface coating and involves the painting of damaged or worn highway vehicles (EPA, 1994a). Many of the coatings used for newly manufactured vehicles are also used in refinishing operations, with the possible exception of the surface primer coatings. Refinishing operations may be performed in enclosed, partially enclosed, or open areas. Water curtains or filler pads are widely used to control paint particulate emissions; however, they have little or no effect on escaping solvent vapors.

### **2.2.7 FLAT WOOD PRODUCT MANUFACTURING**

Finished flat wood products are interior panels made of hardwood plywoods (natural and lauan), particle board, and hardboard. Fewer than 25 percent of the manufacturers of such flat wood products coat the products in their own plants; in some of the plants that do coat, only a small percentage of total production is coated (EPA, 1995a). At present, most coating is done by toll coaters (which is the industry term for custom coaters) who receive panels from manufacturers and undercoat or finish them according to customer specifications and product requirements.

Some of the layers and coatings that can be factory-applied to flat woods are filler, sealer, groove coat, primer, stain, basecoat, ink, and topcoat. Solvents used in organic flat wood base coatings are usually component mixtures, including methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), toluene, xylene, butyl acetates, propanol, ethanol, butanol, naphtha, methanol, amyl acetate, mineral spirits, SoCal<sup>®</sup> I and II, glycols, and glycol ethers. Those most often used in waterborne coatings are glycol, glycol ethers, propanol, and butanol (Turner, 1992).

Various forms of roll coating are the preferred techniques for applying coatings to flat woods. Coatings used for the surface cover can be applied with a direct roller coater; reverse roll coaters are generally used to apply fillers. Precision coating and printing (usually with offset gravure grain printers) are also forms of roll coating. Most inks are pigments dispersed in alkyd resin, although waterbased inks are available and are desirable because of their clarity, cost, and low environmental impact. Several types of curtain coating may also be employed (usually for

topcoat application) with flat wood products. Spray techniques and brush coating may also be used.

Finishing techniques are used to cover the original surface and to produce various decorative effects. Groove coatings, sealers, fillers, and topcoats may be used for this purpose. The coatings may be water- or solvent-based, catalyzed, or UV-cured.

### **2.2.8 MAGNET WIRE**

Magnet wire coating is the process of applying a coating of electrically insulating varnish or enamel to aluminum or copper wire for use in electrical machinery. The wire is called magnet wire because, in equipment such as electrical motors, generators, and transformers, the wire carries an electrical current that creates an electromagnetic field. The wire coating must meet rigid specifications of electrical, thermal, and abrasion resistance.

In a typical wire coating operation, the wire is passed through an annealing furnace that softens the wire and cleans it by burning off oil and dirt. Usually, the wire then passes through a bath in the coating applicator and is drawn through an orifice or coating die to scrape off the excess. It is then dried and cured in a dual temperature zone oven. Wire may pass through the coating applicator and the oven as many as 12 times to acquire the necessary thickness of coating (EPA, 1977d).

### **2.2.9 METAL CANS (TWO- OR THREE-PIECE)**

Cans may be made from a rectangular sheet with two circular ends (three pieces), or they can be drawn and wall ironed from a shallow cup to which an end is attached after the can is filled (two pieces). There are major differences in coating practices, depending on the type of can and the product packaged in it.

Three-piece can coating includes sheet coating with a base coat and printing. When the sheets have been formed into cylinders, the seam is sprayed, usually with a lacquer, to protect the exposed metal. If the cans are to contain an edible product, the interiors are spray coated, and the cans baked at up to 220°C (425°F) (EPA, 1977c).

Two-piece cans are used largely by beer and other beverage industries. The exteriors may be reverse roll coated in white and cured. Several colors of ink are then transferred (sometimes by lithographic printing) to the cans. A protective varnish may be roll coated over the inks. The coating is then cured in a single or multipass oven, recoated, and cured again (EPA, 1977c).



### 2.2.10 METAL COIL

Metal coil surface coating is a linear process by which protective or decorative organic coatings are applied to metal sheets or strips packaged in rolls or coils (EPA, 1977c). A metal strip is uncoiled at the entry to a coating line and is passed through a wet section, where the metal is thoroughly cleaned and given a chemical treatment to inhibit rust and promote coatings adhesion to the metal surface. In some installations, the wet section contains an electrogalvanizing operation. The metal strip is then dried and sent through a coating application station, where rollers coat one or both sides of the metal strip. The strip then passes through an oven where the coatings are dried and cured. As the strip exits the oven, it is cooled by a water spray and dried again. If it is a tandem line, a prime coat is applied first, followed by another top or finish coat.

The more prevalent coil coating types include polyesters, acrylics, polyfluorocarbons, urethanes, alkyds, vinyls, and plastisols. About 85 percent of the coatings used are organic solvent-based and have solvent contents ranging from near 0 to 80 volume percent, with the prevalent range being 40 to 60 volume percent. Most of the remaining 15 percent of coatings are waterborne, but contain organic solvent in the range of 2 to 15 volume percent. High-solids coatings, in the form of plastisols, organosols, and powders, are also used to some extent by the industry, but the hardware is different for powder applications.

The solvents most often used in the coil coating industry include xylene, toluene, MEK, Cellusolve Acetate™, butanol, diacetone alcohol, Cellusolve™, Butyl Cellusolve™, Solvesso 100™ and 150™, isophorone, butyl carbinol, mineral spirits, ethanol, nitropropane, tetrahydrofuran, Panasolve™, MIBK, Hisol 100™, Tenneco T-125™, isopropanol, and diisoamyl ketone (EPA, 1995a).

Major markets for metal coil coating operations include the transportation industry, the construction industry, and appliance, furniture, and container manufacturers. Many steel and aluminum companies have their own coil coating operations, where the metal they produce is coated and then formed into end products. They are also more likely to use waterborne coatings than toll coaters.

### 2.2.11 METAL FURNITURE

The metal furniture surface coating process is a multistep operation consisting of surface cleaning, coatings application, and curing. Items such as desks, chairs, tables, cabinets, bookcases, and lockers are normally fabricated from raw material to finished product in the same facility. The industry uses primarily solventborne coatings applied by spray, dip, or flow coating processes. Spray coating is the common application technique used. The components of spray coating lines generally consist of the following: three- to five-stage washer, dryoff oven, spray booth, flashoff area, and bake oven.

The items to be coated are first cleaned and dried. They are then conveyed to the spray booth, where the surface coating is applied, and then through a flashoff area to a bake oven, where the surface coating is cured. Although most metal furniture products receive only one coat of paint, some facilities apply a prime coat before the topcoat to improve the corrosion resistance of the product. In these cases, a separate spray booth and bake oven for application of the prime coat are added to the line, following the dryoff oven.

The coatings used in the industry are primarily solventborne resins including acrylics, amines, vinyls, and cellulose. Some metallic coatings are also used on office furniture. The solvents used are mixtures of aliphatics, xylene, toluene, and other aromatics. Typical coatings that have been used in the industry contain 65 volume percent solvent and 35 volume percent solids. Other types of coatings now being used in the industry are waterborne, powder, and solventborne high-solids coatings (EPA, 1977a).

## **2.2.12 MISCELLANEOUS METAL PARTS**

A wide variety of metal parts and products are coated for decorative or protective purposes. These are used by hundreds of small industrial categories that include large farm machinery and small appliances. Some facilities manufacture and coat metal parts and then assemble them to form a final product to be sold directly for retail. Others, often called "job shops," manufacture and coat products under contract with specifications differing from product to product. The metal parts are then shipped to the final product manufacturer to be assembled with other parts into some final product. Such facilities are often located in the vicinity of the manufacturers for whom they perform this service.

The size of each facility is dependent on things such as the number of coating lines, size of parts or products coated, type of coating operation (i.e., spray, dip, flow, or roll coat), and number of coats of paint applied.

The coatings are a critical constituent of the metal parts industry. In many cases, the coatings must provide aesthetic appeal, but in all cases they must protect the metal from the atmosphere in which it will be used. Both enamels and lacquers are used, although enamels are more common. Coatings are often shipped by the manufacturer as a concentrate but thinned prior to application. Alkyds are popular with industrial and farm machinery manufacturers. Most of the coatings contain several different solvents including ketones, esters, alcohols, aliphatics, ethers, aromatics, and terpenes.

Single or double coatings are applied in conveyor or batch operations. Spraying is usually employed for single coats. Flow and dip coating may be used when only one or two colors are applied. For two-coat operations, primers are usually applied by flow or dip coating, and topcoats are almost always applied by spraying. Electrostatic spraying is also common.

A manual two-coat operation may be used for large items like industrial and farm machinery. The coatings on large products are often air-dried rather than oven-baked, because the machinery, when completely assembled, includes heat-sensitive materials and may be too large to be cured in an oven. Miscellaneous parts and products can be baked in single- or multipass ovens.

### 2.2.13 PAPER COATING

Paper is coated for various decorative and functional purposes with waterborne, organic solventborne, or solvent-free extruded materials. Paper coating, not to be confused with printing operations, use contrast coatings that must show a difference in brightness from the paper to be visible. Coating operations are the application of a uniform layer or coating across a substrate; printing, on the other hand, results in an image or design on the substrate.

Waterborne coatings improve printability and gloss but cannot compete with organic solventborne coatings in resistance to weather, scuff, and chemicals. Solventborne coatings, as an added advantage, permit a wide range of surface textures. Most solventborne coating is done by paper-converting companies that buy paper from mills and apply coatings to produce a final product. Among the many products that are coated with solventborne materials are adhesive tapes and labels, decorated paper, book covers, zinc oxide-coated office copier paper, carbon paper, typewriter ribbons, and photographic film (EPA, 1977c).

Organic solvent formulations generally used are made up of film-forming materials, plasticizers, pigments, and solvents. The main classes of film formers used in the paper coating are cellulose derivatives (usually nitrocellulose) and vinyl resins (usually the copolymer of vinyl chloride and vinyl acetate). Three common plasticizers are dioctyl phthalate, tricresyl phosphate, and castor oil. The major solvents used are toluene, xylene, methyl ethyl ketone, isopropyl alcohol, methanol, acetone, and ethanol. Although a single solvent is frequently used, a mixture is often necessary to obtain the optimum drying rate, flexibility, toughness, and abrasion resistance.

A variety of low-solvent coatings, with negligible emissions, have been developed for some uses to form organic resin films equal to those of conventional solventborne coatings. They can be applied up to 1/8-inch thick (usually by reverse roller coating) to products like artificial leather goods, book covers, and carbon paper. Smooth hot-melt finishes can be applied over rough textured paper by heated gravure or roll coaters at temperatures from 65 to 230°C (150 to 450°F).

Plastic extrusion coating is a type of hot-melt coating in which a molten thermoplastic sheet (usually low- or medium-density polyethylene) is extruded from a slotted die at temperatures of up to 315°C (600°F). The substrate and the molten plastic coat are united by pressure between a rubber roll and a chill roll that solidifies the plastic. Many products, such as the polyethylene-coated milk carton, are coated with solvent-free extrusion coatings (EPA, 1977c).

A typical paper coating line that uses organic solventborne formulations usually incorporates a reverse roller, a knife, or a rotogravure printer. Knife coaters can apply solutions of much higher viscosity than roll coaters and thus emit less solvent per pound of solids applied. The gravure printer can print patterns or can coat a solid sheet of color on a paper web (EPA, 1977c; Turner, 1992).

Many paper coatings need to be cured in an oven. Natural gas is the fuel most often used in direct-fired ovens, but fuel oil is used sometimes. Some of the heavier grades of fuel oil can create problems because sulfur oxide (SO) and PM may contaminate the paper coating. Distillate fuel oil usually can be used satisfactorily. Steam produced from burning solvent retrieved from an absorber or vented to an incinerator may also be used to heat curing ovens.

### **2.2.14 PLASTIC PARTS**

Surface coating of plastic parts for business machines is defined as the process of applying coatings to plastic business machine parts to improve the appearance of the parts, to protect the parts from physical or chemical stress, and/or to attenuate electromagnetic interference/radio frequency interference (EMI/RFI) that would otherwise pass through plastic housings (EPA, 1995a). Plastic parts for business machines are synthetic polymers formed into panels, housings, bases, covers, or other business machine components. The business machines category includes items such as typewriters, electronic computing devices, calculating and accounting machines, telephone and telegraph equipment, photocopiers, and miscellaneous office machines.

The process of applying an exterior coating to a plastic part can include surface preparation, spray coating, and curing, with each step possibly being repeated several times. Surface preparation may involve merely wiping off the surface, or it could involve sanding and puttying to smooth the surface. The plastic parts are placed on racks or trays, or are hung on racks or hooks from an overhead conveyor track for transport among spray booths, flashoff areas, and ovens. Coatings are sprayed onto parts in partially enclosed booths. An induced air flow is maintained through the booths to remove overspray and to keep solvent concentrations in the room air at safe levels. Although low-temperature bake ovens (60°C or less [140°F]) are often used to speed up the curing process, coatings may also be partially or completely cured at room temperature.

### **2.2.15 SHIPS**

This category includes surface coating operations at shipbuilding and ship repair facilities. Due to the size and limited accessibility of ships, most shipyard painting operations are performed outdoors. When painting and/or repairs are needed below the water line of a ship, it must be removed from the water using a floating dry dock, graving dock, or marine railway. In new construction operations, assembly is usually modular, and painting is done in several stages at

various locations throughout the shipyard. There are five general areas of ship structures that have special coating requirements: antennas and superstructures (including freeboard), exterior deck areas, interior habitability areas, tanks (fuel, water, ballast, and cargo), and underwater hulls (EPA, 1994b).

Marine coatings are vital for protecting the ship from corrosive and biotic attacks from the ship's environment. Many marine paints serve specific functions such as corrosion protection, heat/fire resistance, and antifouling. Marine coatings are usually applied as a "system." A typical coating system comprises a primer coat, an intermediate coat, and a topcoat. The primer is usually a zinc-rich material that will provide galvanic corrosion protection if the overlying paint system is damaged but would quickly be consumed by sacrificial corrosion without a protective topcoat (EPA, 1994b).

### **2.2.16 STEEL DRUMS**

This category includes surface coating operations in the steel container shipping industry. It includes coating processes for newly manufactured metal shipping barrels, drums, kegs, and pails; and surface coating of steel drums after reclamation, or reconditioning.

Metal shipping containers can be grouped according to size into two major categories: drums, which include barrels and kegs and are 13 to 110 gallons (49 - 416 L); and pails, which are 1 to 12 gallons (4 - 45L) [20]. They consist of a cylindrical body with a welded side seam and top and bottom heads. Drums and pails are generally fabricated from commercial grade cold-rolled sheet steel; however, stainless steel, nickel, and other alloys are used for special applications.

#### ***Surface Preparation***

During new metal shipping container fabrication, parts are pretreated to protect against flash rust and to remove oil and dirt from the surfaces prior to surface coating. This is generally achieved using a spray washer and zinc or iron phosphate solution. The following is an example of a typical pretreatment process for new metal shipping containers:

- Hot water or detergent, oil skimming;
- Rinse;
- Cleaner or phosphate;
- Rinse; and
- Final rinse sealer (optional).

In some facilities, dry steel is used to manufacture new shipping containers. Dry steel is steel received from the mill with no rust inhibiting oil on the surface. In cases where dry steel is used, the surface preparation process may be eliminated.

Spray washing is also the initial step in preparation of the reconditioning process. Alkaline-sodium hydroxide solutions are generally used to remove residue of prior container contents. Shot blasting is also used during reconditioning operations to clean the exterior of tight head drums and the interior and exterior of open head drums. Other operations performed before surface coating may include acid washing, chaining, dedenting, leak testing, and corrosion inhibiting.

### ***Coating Application***

Metal shipping containers are coated using either roll coating or spray application methods. Roll coating is used mostly for the coating of coil. Spray coating is performed after metal has been formed into shells or parts. Shells and parts are coated in spray booths using HVLP, airless, or conventional coating apparatus. Drum and pail parts usually receive one or two coats and may be coated on both inside and outside surfaces. After coating, parts are given a brief flash-off period to allow separation of solvents in the coating. Parts are typically cured in natural-gas fired ovens. This curing takes place for 5 to 15 minutes at 300 to 500°F.

### ***Coatings***

Waterbased, high-solids, polyesters, alkyds, epoxy phenolics and phenolics are typically used to coat metal shipping containers. The selection of interior coatings is based on several factors. The most important considerations are the compatibility of a coating with the products to be shipped or stored within the container and the performance of a coating under various tests (i.e., reverse impact and rubbing). Though solvent-borne paints are still used for exterior coating, there is a trend in the industry toward low-VOC exterior coatings. The types of pigments used in exterior coatings affect the color consistency, application thickness, and surface adhesion of that coating. Thus, some colors may be more compatible with low-VOC coatings than others.

### ***Emission Control Techniques***

Low-VOC coatings, such as high-solids and waterborne coatings, are commonly used to minimize emissions from surface coating operations.

## **2.2.17 WOOD FURNITURE COATING**

The wood furniture industry encompasses the manufacture of many diverse products, such as wood kitchen cabinets; wood residential furniture; upholstered residential and office furniture; wood television, radio, phonograph, and sewing machine cabinets; wood office furniture and fixtures; and partitions, shelving, and lockers. There may also be other wood furniture not described by one of the above categories.

Despite the broad range of products manufactured by this source category, some manufacturing operations are common. There are four basic wood furniture manufacturing operations: finishing, gluing, cleaning, and washoff. Only finishing is considered a coating operation (Code of Federal Regulations [CFR], 1994).

Wood furniture finishing operations include those in which a finishing material is applied to a substrate. The types of finishing materials include stains, base coats, wash coats, glazes, fillers, sealers, highlights, enamels, and topcoats that all serve different functions. The number, sequence, and type of finishing materials varies by the type and quality of the furniture being finished. All of the finishing materials may contain hazardous air pollutants (HAPs) that are emitted during application.

After the finishing material is applied, the wood substrate typically enters a flashoff area where the more volatile solvents evaporate and the finishing material begins to cure. Then the material enters an oven where curing of the finishing material and evaporation of the volatile solvents continues.

Facilities may finish the furniture in components and then assemble it, but more commonly, the piece of furniture is assembled and then finished. The furniture or furniture components may be moved manually from one finishing application station to the next or on tow lines that automatically move through the finishing lines. Finished furniture that does not meet specification may need to be refinished; the cured coating is removed by washing off the old coating using solvent. This process is called washoff.

# 3

## OVERVIEW OF AVAILABLE METHODS

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### 3.1 EMISSION ESTIMATION METHODS

Several methods are available for calculating emissions from surface coating operations. The best method to use depends upon available data, available resources, and the degree of accuracy required in the estimate. In general, site-specific data that are representative of normal operations at that site are preferred over industry-average data such as *AP-42* emission factors.

This section discusses the methods available for calculating emissions from surface coating operations and identifies the preferred method of calculation on a pollutant basis. Although preferred methods are identified, this document does not mandate any emission estimation method. Industry personnel using this manual should contact the appropriate State or local air pollution control agency regarding suggested methods prior to their use. A comparison of the methods is also presented in this section.

#### 3.1.1 MATERIAL BALANCE

Material balance utilizes the raw material usage rate to estimate the amount of pollutant emitted. Other information relating to material usage, such as fraction of the pollutant in the raw material and the amount of material recycled, disposed, or converted to another form, is also included in a material balance calculation. Material balance is used most often where a relatively consistent amount of material is emitted during use, and/or all air emissions are uncaptured. The material balance emission rate is calculated by multiplying the raw material used times the amount of pollutant in the coating, and subtracting the amount of pollutant recycled, disposed, or converted to another form. For VOC-containing materials, the amount of pollutant emitted is often assumed to be 100 percent of the amount of pollutant contained in the material unless a control device is used to remove or destroy VOC in the exhaust stream. To estimate VOC emissions from vented operations where a VOC control device is present, it is necessary to estimate the efficiency of both the capture (exhaust) system and the control device. **(Note, though, that VOC control devices are not frequently employed for Surface Coating Operations.)**

The material balance method may also be used to calculate PM/PM<sub>10</sub> emissions if an engineering judgement is made regarding the transfer efficiency of the application equipment and the control efficiency of any PM/PM<sub>10</sub> control devices (for vented operations). These data are used in conjunction with the manufacturer's data or calculated solids content of the coating to estimate PM/PM<sub>10</sub> emissions.



### 3.1.2 SOURCE SAMPLING

Source sampling provides a "snapshot" of emissions during the period of the test. Some test methods provide real-time results, while other air samples are taken from the exhaust vent of a coating area (e.g., spray booth or totally enclosed and vented coating operation) and passed into canisters or through various filter media on which the pollutants are captured. The canisters or filters are sent to a laboratory for analysis. Pollutant concentrations are obtained by dividing the amount of pollutant collected during the test by the sample gas volume. Emission rates are determined by multiplying the pollutant concentration by the vent gas exhaust rate. A modification of this technique can be used for open surface coating areas that are temporarily enclosed for sampling purposes and vented through a stack. The calculation of emission rates for this situation is more complicated than for permanently enclosed areas and involves some assumptions about the conditions in the source area.

Source sampling methods can be used to measure VOC, HAP (organic and inorganic), and PM/PM<sub>10</sub> emissions.

### 3.1.3 PREDICTIVE EMISSION MONITORING (PEM)

Predictive emission monitoring (PEM) is based on developing a correlation between pollutant emission rates and an easily measured process parameter. The most accurate PEM data will result from using source sampling results. These data can be correlated with surface coating operation parameters, such as coating usage rates, pieces of equipment coated, or time. The most appropriate data are obtained from, and defined for, specific surface coating operations (e.g., applying topcoats) and for specific industries (e.g., furniture manufacturing). The more specific the emissions data are to the operation to be inventoried, the more appropriate and accurate the PEM data will be for the intended use. The CHIEF website provides useful guidance materials and can be accessed at: [www.epa.gov/ttn/chief/](http://www.epa.gov/ttn/chief/)

PEM data are usually presented as emissions curves, where the x-axis is a source parameter, such as coating usage or time, and the y-axis is emissions. For data that form a straight line, the PEM data can be expressed as an emission factor that is equal to the slope of the emissions curve. For example, if the slope of a PEM curve is 20 pounds VOCs emitted per 100 pounds of surface coating used, this factor can be multiplied times the amount of surface coating used on a daily, weekly, monthly, or annual basis to estimate the amount of VOCs emitted. This is true only if the coating usage is consistent during the test data process and is representative of other time periods.

Periodic sampling may be required to verify that the emission curves are still accurate or to develop new curves to represent changes in source operation.

### 3.1.4 EMISSION FACTORS

An emission factor is a pollutant emission rate relative to a source activity (e.g., pound of VOCs emitted per gallon of surface coating applied). Emission factors are available for some surface coating operations and are based on the results of source tests or material balances performed for one or more facilities within an industry. Chapter 1, *Introduction to Point Source Emission Inventory Development*, contains a detailed discussion of the reliability and quality of available emission factors. The EPA provides compiled emission factors for criteria and hazardous air pollutants in *AP-42*, the *Locating and Estimating Emissions of . . .* (L&E) series of documents, and the Factor Information Retrieval (FIRE) System (EPA, 2000).

Due to their availability and acceptance, emission factors are commonly used to prepare emission inventories. However, the emissions estimate obtained from using emission factors is likely to be based upon emission testing performed at similar but not identical facilities and may not accurately reflect emissions at a single source. Thus, the user should recognize that, in most cases, emission factors are averages of available industry-wide data with varying degrees of quality and uncertainty, and may not be representative for an individual facility within that industry. Average emission factors based on solvent or coating used are generally more accurate than emission factors based on parts or area painted.

Source-specific emission factors can be developed from multiple source test data, PEM data, or from single source tests. These emission factors, when used for the specific operations for which that they are intended, are generally more representative than the average emission factors found in *AP-42* or FIRE (EPA, 1995a and 2000). However, VOC emissions from uncontrolled surface coating operations are usually best estimated by assuming that all solvent in the coating will be emitted.

## 3.2 COMPARISON OF AVAILABLE EMISSION ESTIMATION METHODOLOGIES

Tables 7.3-1 and 7.3-2 identify the preferred and alternative emission estimation approaches for selected pollutants, for vented coating operations and open coating operations, respectively. For many of the pollutants emitted from surface coating operations, several of the previously defined emission estimation methodologies can be used.

TABLE 7.3-1

**SUMMARY OF PREFERRED AND ALTERNATIVE EMISSION  
ESTIMATION METHODS FOR SURFACE COATING OPERATIONS:  
VENTED COATING OPERATIONS<sup>a</sup>**

<b>Parameter</b>	<b>Preferred Emission Estimation Approach<sup>b</sup></b>	<b>Alternative Emission Estimation Approach</b>
VOC	Material Balance	Source Testing PEM Emission Factor
Speciated Organics (HAPs)	Material Balance	Source Testing PEM Emission Factor
PM/PM <sub>10</sub>	Source Testing	Material Balance PEM Emission Factor

<sup>a</sup> Vented coating operations include those operations that are vented to the atmosphere or to a control device either directly or through the use of a capture/collection system.

<sup>b</sup> Where there is a choice of methods, material balance is generally preferred over an emission factor unless the assumptions needed to perform a material balance (e.g., estimate of fugitive flashoff) have a high degree of uncertainty and/or the emission factor is site-specific.

The preferred method for estimating VOC emissions from both vented and open surface coating operations is material balance. The preferred method for estimating PM/PM<sub>10</sub> emissions from vented coating operations is source testing and from open coating operations is material balance. Source testing or PEM methods may provide accurate emission estimates, but the quality of the data will depend on a variety of factors including the number of data points generated, the representativeness of those data points, and the proper operation and maintenance of the equipment being used to record the measurements. With PEM, care must be taken to ascertain that the data capture represents typical surface coating operating conditions for the source. Otherwise, the PEM data should not be used to estimate annual emissions or any time period much longer than the PEM sampling period. Additionally, source testing and PEM data are often difficult and costly to obtain for surface coating operations.

For a detailed discussion of statistical measures of uncertainty and data quality, refer to the volume on *Quality Assurance Procedures* (Volume VI, Chapters 3 and 4).

**TABLE 7.3-2**

**SUMMARY OF PREFERRED AND ALTERNATIVE EMISSION  
ESTIMATION METHODS FOR SURFACE COATING OPERATIONS:  
OPEN COATING OPERATIONS<sup>a</sup>**

<b>Parameter</b>	<b>Preferred Emission Estimation Approach<sup>b</sup></b>	<b>Alternative Emission Estimation Approach</b>
VOC	Material Balance	PEM Emission Factor Source Testing
Speciated Organics (HAPs)	Material Balance	PEM Emission Factor Source Testing
PM/PM <sub>10</sub>	Material Balance	PEM Emission Factor Source Testing

<sup>a</sup> Open coating operations include those operations that are open to the atmosphere or nonvented operations.

<sup>b</sup> Where there is a choice of methods, material balance is generally preferred over an emission factor unless the assumptions needed to perform a material balance (e.g., estimate of fugitive flashoff) have a high degree of uncertainty and/or the emission factor is site-specific.

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# 4

## PREFERRED METHODS FOR ESTIMATING EMISSIONS

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The preferred method for estimating VOC and speciated organic emissions (including hazardous air pollutants) from all surface coating operations is the use of a material balance. This approach can be used to estimate VOC and speciated VOC emissions from vented coating operations as well as open coating operations. Material balance is also the preferred method for estimating PM/PM<sub>10</sub> emissions from open coating operations. Material balance uses the raw material usage rate to estimate the amount of pollutant emitted.

The preferred method for estimating PM/PM<sub>10</sub> emissions from vented coating operations is source testing. Source testing uses sampling results to estimate PM/PM<sub>10</sub> and the respective component emissions.

As discussed in this document, vented coating operations include those surface coating operations that vent to pollution control equipment or the atmosphere either directly or through the use of some capture/collection equipment. Open coating operations are those operations that are not vented to a pollution control device or the atmosphere either directly or through the use of some capture/collection device. For material balance calculations, total emissions can be separated into captured and uncaptured emissions. Captured emissions are typically exhausted directly to the atmosphere or to pollution control equipment and then to the atmosphere and are, therefore, typically point source emissions. Uncaptured emissions are those emissions not captured and vented to a pollution control equipment or directly to the atmosphere. For open coating operations, all emissions will be fugitive; therefore, for these operations, total emissions will equal uncaptured emissions.

The following equations and examples present how to use a material balance or source testing approach to estimate total VOC, PM/PM<sub>10</sub>, and speciated emissions from vented or open coating operations. Table 7.4-1 lists the variables and symbols used in the following discussions.

TABLE 7.4-1

## LIST OF VARIABLES AND SYMBOLS

Variable	Symbol	Units
Total VOC emissions	$E_{\text{VOC}}$	lb/hr or ton/yr
Captured VOC emissions	$E_{\text{VOC,p}}$	lb/hr or ton/yr
Fugitive VOC emissions	$E_{\text{VOC,f}}$	lb/hr or ton/yr
Material usage rate	$Q$	typically gal/hr or gal/yr
VOC content of material	$C_{\text{VOC}}$	lb/gal
Capture efficiency	$\text{Cap}$	%
Fraction of solvent volatilized	$F$	fraction
Density of material used	$d$	lb/gal
Weight percentage of pollutant x in material	$\text{wt}\%_x$	%
Speciated emissions of pollutant x	$E_x$	lb/hr or lb/yr
Speciated captured emissions of pollutant x	$E_{x,p}$	lb/hr or lb/yr
Speciated uncaptured emissions of pollutant x	$E_{x,f}$	lb/hr or lb/yr
Total material usage rate of multiple-part coating	$Q_T$	gal/hr or gal/yr
Number of parts of component i in multiple-part coating	$N_i$	dimensionless
Total number of components in multiple-part coating	$n$	dimensionless
PM/PM <sub>10</sub> emissions	$E_{\text{PM}}$	lb/hr or ton/yr
PM/PM <sub>10</sub> or solids content of material	$C_{\text{PM}}$	lb/gal
Transfer efficiency of application equipment	T.E.	%
Stack gas concentration of pollutant x	$C_x$	grains per dry standard cubic feet (dscf)
Stack gas volumetric flow rate	$V$	dry standard cubic feet per minute (dscfm)
Annual emissions of pollutant x	$A_x$	ton/yr
Operating hours	OH	hr/yr

## 4.1 CALCULATION OF VOC EMISSIONS USING MATERIAL BALANCE (VENTED AND OPEN COATING OPERATIONS)

Material balance can be used to estimate VOC emissions from all surface coating operations. Total emissions include both captured (point source) and fugitive losses. Calculate total VOC emissions using Equation 7.4-1.

$$E_{\text{VOC}} = Q * C_{\text{VOC}} \quad (7.4-1)$$

where:

$$\begin{aligned} E_{\text{VOC}} &= \text{Total VOC emissions (lb/hr) (captured and fugitive)} \\ Q &= \text{Material usage rate (gal/hr)} \\ C_{\text{VOC}} &= \text{VOC content of material (lb/gal)} \end{aligned}$$

The VOC content of the material ( $C_{\text{VOC}}$ ) can be obtained through the manufacturer's technical specification sheet or EPA Reference Method 24 may be used to determine VOC content. The VOC content should account for solvent or other material added to the coating.

Captured and uncaptured emissions can be calculated separately. Use Equation 7.4-2 to calculate captured emissions:

$$E_{\text{VOC,p}} = E_{\text{VOC}} * \text{Cap}/100 * F \quad (7.4-2)$$

where:

$$\begin{aligned} E_{\text{VOC,p}} &= \text{Captured VOC emissions (lb/hr)} \\ E_{\text{VOC}} &= \text{Total VOC emissions (lb/hr)} \\ \text{Cap} &= \text{Capture efficiency (\%)} \\ F &= \text{Fraction of solvent volatilized at this step in the coating process (e.g., application area, drying area)} \end{aligned}$$

Capture efficiency (Cap) is typically a design parameter that can be determined by reviewing equipment specifications or by contacting the equipment manufacturer. Equipment such as hoods, spray booths, and totally enclosed processes typically have a capture efficiency. Open coating operations are nonvented operations and, therefore, have no capture efficiency.



The fraction of solvent volatilized at any particular step in a coating process (F) can be estimated using available resources. Table 7.4-2 presents a distribution of VOC emissions for selected coating industries. Coating manufacturers may also be able to provide solvent evaporation curves that can be used to distribute solvent losses. Reference books may also provide solvent evaporation curves. In cases where the coating application and drying steps are vented to the same capture system, the variable F in Equation 7.4-2 equals 1. Example 7.4-1 illustrates the use of solvent evaporation curves to distribute VOC emissions from a coating operation.

In a material balance calculation, all unaccounted for VOCs can be assumed to be uncaptured emissions. Use Equation 7.4-3 to estimate uncaptured emissions based on a material balance:

$$E_{\text{VOC},f} = E_{\text{VOC}} - E_{\text{VOC},p} \quad (7.4-3)$$

where:

$E_{\text{VOC},f}$  = Fugitive VOC emissions (lb/hr)

$E_{\text{VOC}}$  = Total VOC emissions (lb/hr)

$E_{\text{VOC},p}$  = Captured VOC emissions (lb/hr)

For open coating operations, the captured emission component ( $E_{\text{VOC},p}$ ) of Equation 7.4-3 is zero, therefore, fugitive VOC emissions ( $E_{\text{VOC},f}$ ) are equal to total VOC emissions ( $E_{\text{VOC}}$ ).

Total annual VOC emissions can be calculated using material balance by applying annual rather than hourly material usage rates in Equation 7.4-1.

Examples 7.4-2 through 7.4-4 illustrate the use of Equations 7.4-1 through 7.4-3 to calculate both hourly and annual total, captured, and uncaptured emissions. These examples also illustrate the conversion of annual emissions from lb/yr to ton/yr.

TABLE 7.4-2

**DISTRIBUTION OF VOC EMISSIONS EMITTED DURING SURFACE  
COATING OPERATIONS FOR SELECTED INDUSTRIES**

Coating Industry	Percentage of Total VOC Emissions	
	Spray Booth or Application Area and Flashoff	Bake Oven
Metal furniture	70	30
Automobile and light-duty truck	85 - 90	10 - 15
Large appliance	80	20
Coil coating <sup>a</sup>	8	90

<sup>a</sup> Remaining VOC emissions (2%) come from the quench section after the bake/curing oven.

Source: Air Pollution Engineering Manual (Turner, 1992)

Example 7.4-1

This example calculates the solvent distribution fraction for a coating process in which parts are coated in a spray booth and moved to a drying oven given the following data:

Time in spray booth               = 10 minutes  
Time to transport to drying oven   = 20 minutes  
Type of coating                    = acrylic

According to Figure 655 from Modern Pollution Control Technology (an attachment to the 1993 Texas Air Control Board guideline package [see Section 8, References for complete citation]), after 10 minutes, approximately 45 percent of the solvent in an acrylic coating will volatilize. After another 20 minutes, another 7 percent of the solvent will volatilize. The remaining 48 percent of the solvent will volatilize in the oven. Based on this figure, the solvent volatilization fraction (F) that should be used to estimate emissions from each step in this coating process is:

F       = 0.45 (spray booth)  
      = 0.07 (transport to drying oven)  
      = 0.48 (drying oven)

Example 7.4-2

This example shows how hourly and annual VOC emissions for a coating operation where both coating and drying occur under a laboratory hood can be calculated using Equations 7.4-1 through 7.4-3. The data are given below.

Given:

$$\begin{aligned} Q &= 10 \text{ gal/hr} \\ &= 1,000 \text{ gal/yr} \\ C_{\text{VOC}} &= 7 \text{ lb/gal} \\ F &= 1 \\ \text{Cap} &= 60\% \end{aligned}$$

Total VOC emissions from coating and drying are calculated using Equation 7.4-1:

$$\begin{aligned} E_{\text{VOC}} &= Q * C_{\text{VOC}} \\ &= 10 \text{ gal/hr} * 7 \text{ lb/gal} \\ &= 70 \text{ lb/hr} \end{aligned} \quad (7.4-1)$$

Hourly captured VOC emissions from coating and drying are calculated using Equation 7.4-2:

$$\begin{aligned} E_{\text{VOC,p}} &= E_{\text{VOC}} * \text{Cap}/100 * F \\ &= 70 \text{ lb/hr} * 60/100 * 1 \\ &= 42 \text{ lb/hr} \end{aligned} \quad (7.4-2)$$

Fugitive hourly VOC emissions from coating and drying are calculated using Equation 7.4-3:

$$\begin{aligned} E_{\text{VOC,f}} &= E_{\text{VOC}} - E_{\text{VOC,p}} \\ &= 70 \text{ lb/hr} - 42 \text{ lb/hr} \\ &= 28 \text{ lb/hr} \end{aligned} \quad (7.4-3)$$

Total annual VOC emissions from coating and drying are calculated using Equation 7.4-1 using annual material usage rates:

$$\begin{aligned} E_{\text{VOC}} &= Q * C_{\text{VOC}} \\ &= 1,000 \text{ gal/yr} * 7 \text{ lb/gal} \\ &= 7,000 \text{ lb/yr} * (1 \text{ ton}/2,000 \text{ lb}) \\ &= 3.5 \text{ ton/yr} \end{aligned} \quad (7.4-1)$$

Annual captured VOC emissions from coating and drying are calculated using Equation 7.4-2:

$$\begin{aligned} E_{\text{VOC,p}} &= E_{\text{VOC}} * \text{Cap}/100 * F \\ &= 3.5 \text{ ton/yr} * 60/100 * 1 \\ &= 2.1 \text{ ton/yr} \end{aligned} \quad (7.4-2)$$

Annual fugitive VOC emissions from coating and drying are calculated using Equation 7.4-3:

$$\begin{aligned} E_{\text{VOC,f}} &= E_{\text{VOC}} - E_{\text{VOC,p}} \\ &= 3.5 \text{ ton/yr} - 2.1 \text{ ton/yr} \\ &= 1.4 \text{ ton/yr} \end{aligned} \quad (7.4-3)$$

Example 7.4-3

This example shows how hourly and annual VOC emissions from a spray booth coating operation for which products are air dried outside the booth can be calculated using Equations 7.4-1 through 7.4-3 and the data given below.

Given:

$$\begin{aligned} Q &= 25 \text{ gal/hr} \\ &= 85,000 \text{ gal/yr} \\ C_{\text{VOC}} &= 7 \text{ lb/gal} \\ F &= 0.65 \text{ (spray booth)} \\ &= 0.35 \text{ (air drying)} \\ \text{Cap} &= 80\% \text{ (spray booth)} \\ &= 0\% \text{ (air drying)} \end{aligned}$$

Total VOC emissions from the spray booth and air drying are calculated using Equation 7.4-1:

$$\begin{aligned} E_{\text{VOC}} &= Q * C_{\text{VOC}} \\ &= 25 \text{ gal/hr} * 7 \text{ lb/gal} \\ &= 175 \text{ lb/hr} \end{aligned} \quad (7.4-1)$$

Hourly captured VOC emissions from the spray booth are calculated using Equation 7.4-2:

$$\begin{aligned} E_{\text{VOC,p}} &= E_{\text{VOC}} * \text{Cap}/100 * F \\ &= 175 \text{ lb/hr} * 80/100 * 0.65 \\ &= 91 \text{ lb/hr} \end{aligned} \quad (7.4-2)$$

Because the emissions from the air drying step are not vented, the capture efficiency (Cap) is 0 percent, and the emissions from air drying are all uncaptured emissions.

Fugitive hourly VOC emissions from the spray booth and air drying are calculated using Equation 7.4-3:

$$\begin{aligned} E_{\text{VOC,f}} &= E_{\text{VOC}} - E_{\text{VOC,p}} \\ &= 175 \text{ lb/hr} - 91 \text{ lb/hr} \\ &= 84 \text{ lb/hr} \end{aligned} \quad (7.4-3)$$

Total annual VOC emissions from the spray booth and air drying are calculated with Equation 7.4-1 using annual material usage rates:

$$\begin{aligned} E_{\text{VOC}} &= Q * C_{\text{VOC}} \\ &= 85,000 \text{ gal/yr} * 7 \text{ lb/gal} \\ &= 595,000 \text{ lb/yr} * (1 \text{ ton}/2,000 \text{ lb}) \\ &= 298 \text{ ton/yr} \end{aligned} \quad (7.4-1)$$

Annual captured VOC emissions from the spray booth are calculated using Equation 7.4-2:

$$\begin{aligned} E_{\text{VOC,p}} &= E_{\text{VOC}} * \text{Cap}/100 * F \\ &= 298 \text{ ton/yr} * 80/100 * 0.65 \\ &= 155 \text{ ton/yr} \end{aligned} \quad (7.4-2)$$

Example 7.4-3 (Continued)

Because the emissions from the air drying step are not vented, the capture efficiency (Cap) is 0 percent and the emissions from air drying are all uncaptured emissions.

Annual fugitive VOC emissions from the spray booth and air drying are calculated using Equation 7.4-3:

$$\begin{aligned} E_{\text{VOC},f} &= E_{\text{VOC}} - E_{\text{VOC},p} \\ &= 298 \text{ ton/yr} - 155 \text{ ton/yr} \\ &= 143 \text{ ton/yr} \end{aligned} \quad (7.4-3)$$

Example 7.4-4

This example shows how hourly and annual VOC emissions from a coating operation for which products are air dried outside the booth can be calculated using Equations 7.4-1 through 7.4-3 and the data given below.

Given:

$$\begin{aligned} Q &= 18 \text{ gal/hr} \\ &= 28,500 \text{ gal/yr} \\ C_{\text{VOC}} &= 7.6 \text{ lb/gal} \\ F &= 0.40 \text{ (coating)} \\ &= 0.20 \text{ (transport to dryer)} \\ &= 0.40 \text{ (drying)} \\ \text{Cap} &= 60\% \text{ (coating)} \\ &= 0\% \text{ (transport to dryer)} \\ &= 100\% \text{ (drying)} \end{aligned}$$

Total VOC emissions from all steps are calculated using Equation 7.4-1:

$$\begin{aligned} E_{\text{VOC}} &= Q * C_{\text{VOC}} \\ &= 18 \text{ gal/hr} * 7.6 \text{ lb/gal} \\ &= 136.8 \text{ lb/hr} \end{aligned} \quad (7.4-1)$$

Hourly captured VOC emissions from coating and drying are calculated using Equation 7.4-2:

$$\begin{aligned} E_{\text{VOC},p} &= E_{\text{VOC}} * \text{Cap}/100 * F \\ \text{Coating} &= 136.8 \text{ lb/hr} * 60/100 * 0.40 \\ &= 32.8 \text{ lb/hr} \\ \text{Drying} &= 136.8 \text{ lb/hr} * 100/100 * 0.40 \\ &= 54.7 \text{ lb/hr} \end{aligned} \quad (7.4-2)$$

Because the emissions from the transport to dryer step are not vented, the capture efficiency (Cap) is 0 percent, and the emissions from transport are all uncaptured emissions.

Example 7.4-4 (Continued)

Fugitive hourly VOC emissions from all steps are calculated using Equation 7.4-3:

$$\begin{aligned} E_{\text{VOC},f} &= E_{\text{VOC}} - E_{\text{VOC},p} & (7.4-3) \\ &= 136.8 \text{ lb/hr} - (32.8 \text{ lb/hr} + 54.7 \text{ lb/hr}) \\ &= 49.3 \text{ lb/hr} \end{aligned}$$

Total annual VOC emissions from all steps are calculated with Equation 7.4-1 using annual material usage rates:

$$\begin{aligned} E_{\text{VOC}} &= Q * C_{\text{VOC}} & (7.4-1) \\ &= 28,500 \text{ gal/yr} * 7.6 \text{ lb/gal} \\ &= 216,600 \text{ lb/yr} * (1 \text{ ton}/2,000 \text{ lb}) \\ &= 108 \text{ ton/yr} \end{aligned}$$

Annual captured VOC emissions from coating and drying are calculated using Equation 7.4-2:

$$\begin{aligned} E_{\text{VOC},p} &= E_{\text{VOC}} * \text{Cap}/100 * F & (7.4-2) \\ \text{Coating} &= 108 \text{ ton/yr} * 60/100 * 0.40 \\ &= 25.9 \text{ ton/yr} \\ \text{Drying} &= 108 \text{ ton/yr} * 100/100 * 0.40 \\ &= 43.2 \text{ ton/yr} \end{aligned}$$

Because the emissions from the transport to dryer step are not vented, the capture efficiency (Cap) is 0 percent and the emissions from transport are all uncaptured emissions.

Annual fugitive VOC emissions from all steps are calculated using Equation 7.4-3:

$$\begin{aligned} E_{\text{VOC},f} &= E_{\text{VOC}} - E_{\text{VOC},p} & (7.4-3) \\ &= 108 \text{ ton/yr} - (25.9 \text{ ton/yr} + 43.2 \text{ ton/yr}) \\ &= 38.9 \text{ ton/yr} \end{aligned}$$

## 4.2 CALCULATION OF SPECIATED VOC EMISSIONS USING MATERIAL BALANCE

Material balance can also be used to calculate speciated VOC emissions. Each VOC species emission rate can be determined using Equation 7.4-4:

$$E_x = Q * d * \frac{wt\%_x}{100} \quad (7.4-4)$$

where:

$E_x$	=	Emissions of VOC species "x" (lb/hr)
$Q$	=	Material usage rate (gal/hr)
$d$	=	Density of the material used (lb/gal)
$wt\%_x$	=	Weight percent of pollutant "x" in material (%)

The density ( $d$ ) and the weight percent of pollutant "x" ( $wt\%_x$ ) can be obtained from the manufacturer's technical specification sheet. The weight percent of pollutant "x" should consider any solvent or other material added to the coating.

The captured and uncaptured emissions of VOC species "x" can be estimated using the total VOC species "x" emissions calculated above and Equations 7.4-5 and 7.4-6.

Use Equation 7.4-5 to calculate captured emissions:

$$E_{x,p} = E_x * Cap/100 * F \quad (7.4-5)$$

where:

$E_{x,p}$	=	Captured emissions of pollutant x (lb/hr)
$E_x$	=	Total pollutant x emissions (lb/hr)
$Cap$	=	Capture efficiency (%)
$F$	=	Fraction of solvent volatilized at this step in the coating process (e.g., application area, drying area)

Capture efficiency ( $Cap$ ) is typically a design parameter that can be determined by reviewing equipment specifications or by contacting the equipment manufacturer. Equipment such as hoods, spray booths, and totally enclosed processes typically have a capture efficiency. Open coating operations are nonvented operations and, therefore, have no capture efficiency.

The fraction of solvent volatilized at any particular step in a coating process (F) can be estimated using available resources. Table 7.4-2 presents a distribution of emissions for selected coating industries. Coating manufacturers may also be able to provide solvent evaporation curves that can be used to distribute solvent losses. Reference books may also provide solvent evaporation curves. In cases where the coating application and drying steps are vented to the same capture system, the variable F in Equation 7.4-2 equals 1. Example 7.4-1 illustrates the use of solvent evaporation curves to distribute emissions from a coating operation.

In a material balance calculation, all unaccounted for emissions can be assumed to be uncaptured emissions. Use Equation 7.4-6 to estimate uncaptured emissions based on a material balance:

$$E_{x,f} = E_x - E_{x,p} \quad (7.4-6)$$

where:

$$\begin{aligned} E_{x,f} &= \text{Uncaptured emissions of pollutant } x \text{ (lb/hr)} \\ E_x &= \text{Total pollutant } x \text{ emissions (lb/hr)} \\ E_{x,p} &= \text{Captured emissions of pollutant } x \text{ (lb/hr)} \end{aligned}$$

For open coating operations, the captured emission component ( $E_{x,p}$ ) of Equation 7.4-6 is zero, therefore, uncaptured emissions ( $E_{x,f}$ ) are equal to total pollutant x emissions ( $E_x$ ).

Annual speciated emissions can be calculated by applying an annual rather than an hourly material usage rate in Equation 7.4-4.

Example 7.4-5 illustrates the use of Equations 7.4-4 through 7.4-6 to calculate both hourly and annual total, captured, and fugitive VOC species emissions.

### 4.3 CALCULATION OF EMISSIONS FOR MULTIPLE-PART COATINGS

Some coatings require the addition of a thinning solvent, a catalyst, or both resulting in a multiple-part coating. Material usage rates for these coatings must be determined for each part (the thinner, the catalyst, and the coating) based on the mixing ratio of the parts.



Example 7.4-5

This example shows how hourly and annual VOC speciated emissions from a spray booth coating operation for which products are air dried outside the booth can be calculated using Equations 7.4-4 through 7.4-6 and the data given below. Emissions from only one species ("x") are shown, as an example, however, typically more than one VOC species will be present and the following calculations would have to be completed for each species.

Given:

$$\begin{aligned}
 Q &= 10 \text{ gal/hr} \\
 &= 5,200 \text{ gal/yr} \\
 \text{wt}\%_x &= 38\% \\
 d &= 10 \text{ lb/gal} \\
 F &= 0.65 \text{ (spray booth)} \\
 &= 0.35 \text{ (air drying)} \\
 \text{Cap} &= 80\% \text{ (spray booth)} \\
 &= 0\% \text{ (air drying)}
 \end{aligned}$$

Calculate total hourly pollutant x emissions from the spray booth and air drying using Equation 7.4-4:

$$\begin{aligned}
 E_x &= Q * d * \text{wt}\%_x / 100 \\
 &= 10 \text{ gal/hr} * 10 \text{ lb/gal} * 38 / 100 \\
 &= 38 \text{ lb/hr}
 \end{aligned} \tag{7.4-4}$$

Hourly captured pollutant x emissions from the spray booth are calculated using Equation 7.4-5:

$$\begin{aligned}
 E_{x,p} &= E_x * \text{cap} / 100 * F \\
 &= 38 \text{ lb/hr} * 80 / 100 * 0.65 \\
 &= 19.76 \text{ lb/hr}
 \end{aligned} \tag{7.4-5}$$

Because the emissions from the air drying step are not vented, the capture efficiency (Cap) is 0 percent, and there are no captured emissions from air drying.

Hourly uncaptured emissions of pollutant x from the spray booth and air drying are calculated using Equation 7.4-6:

$$\begin{aligned}
 E_{x,f} &= E_x - E_{x,p} \\
 &= 38 \text{ lb/hr} - 19.76 \text{ lb/hr} \\
 &= 18.24 \text{ lb/hr}
 \end{aligned} \tag{7.4-6}$$

Total annual pollutant x emissions from the spray booth and air drying are calculated using Equation 7.4-4:

$$\begin{aligned}
 E_x &= Q * d * \text{wt}\%_x / 100 \\
 &= 5,200 \text{ gal/yr} * 10 \text{ lb/gal} * 38 / 100 \\
 &= 19,760 \text{ lb/yr}
 \end{aligned} \tag{7.4-4}$$

Annual captured emissions of pollutant x from the spray booth are calculated using Equation 7.4-5:

$$\begin{aligned}
 E_{x,p} &= E_x * \text{Cap} / 100 * F \\
 &= 19,760 \text{ lb/yr} * 80 / 100 * 0.65 \\
 &= 10,275 \text{ lb/yr}
 \end{aligned} \tag{7.4-5}$$

Example 7.4-5 (Continued)

Because the emissions from the air drying step are not vented, the capture efficiency (Cap) is 0 percent, and there are no captured emissions from air drying.

Annual fugitive pollutant x emissions from the spray booth and air drying are calculated using Equation 7.4-6:

$$\begin{aligned} E_{x,f} &= E_x - E_{x,p} \\ &= 19,760 \text{ lb/yr} - 10,275 \text{ lb/yr} \\ &= 9,485 \text{ lb/yr} \end{aligned} \quad (7.4-6)$$

The material usage rate for each part of a multiple-part coating can be calculated using mixing ratios and algebra, with Equation 7.4-7:

$$Q = Q_T * \frac{N_i}{\sum_{i=1}^n N_i} \quad (7.4-7)$$

where:

- Q = Material usage rate (gal/hr) of component (e.g., coating, thinner)
- Q<sub>T</sub> = Total multiple-part coating material usage rate (gal/hr)
- N<sub>i</sub> = Number of parts of component i in multiple-part coating
- n = Total number of components in multiple-part coating

For example, for a two-component coating with a thinner-to-coating mixing ratio of 1:6 (i.e., 1 part thinner to 6 parts coating), Equation 7.4-7 would be represented as:

For the thinner:

$$Q = Q_T * \frac{1}{1+6}$$

For the coating:

$$Q = Q_T * \frac{6}{1+6}$$

The material usage rates calculated for each component should be used in Equations 7.4-1 through 7.4-6 to estimate total, fugitive, and captured emissions from each component in the multiple-part coating. Examples 7.4-6 and 7.4-7 illustrate the use of Equation 7.4-7 to estimate emissions from two-component coatings.

When a multiple-part coating contains more than two components (e.g., coating, thinner, and catalyst), application of Equation 7.4-7 may require an iterative process depending on the known mixing ratio(s). For example, if the known mixing ratio is 1 part catalyst, 2 parts thinner, and 8 parts coating, no iterative process is required and the material usage rate of each component could be calculated directly from Equation 7.4-7 ( $n=3$ ). If, however, there are two mixing ratios (2 parts thinner to 8 parts catalyzed coating and 1 part catalyst to 8 parts coating), an iterative process would be required. The material usage rates for the thinner and catalyzed coating would be calculated first using Equation 7.4-7. The catalyzed coating usage rate calculated would then be factored back into Equation 7.4-7 along with the catalyst-to-coating mixing ratio (2:8) to estimate the usage rates of the catalyst and the coating. Example 7.4-8 illustrates this iterative process.

#### 4.4 CALCULATION OF PM/PM<sub>10</sub> EMISSIONS USING MATERIAL BALANCE (OPEN COATING OPERATIONS)

The preferred method for estimating PM/PM<sub>10</sub> emissions from open coating operations is material balance. Hourly PM/PM<sub>10</sub> emissions are calculated by material balance using Equation 7.4-8:

$$E_{PM} = Q * C_{PM} * (1 - T.E./100) \quad (7.4-8)$$

where:

- $E_{PM}$  = PM/PM<sub>10</sub> emissions (lb/hr)
- $Q$  = Material usage rate (gal/hr)
- $C_{PM}$  = PM/PM<sub>10</sub> or solids content of material (lb/gal)
- T.E. = Transfer efficiency of the application equipment (%)

The PM/PM<sub>10</sub> content of the material ( $C_{PM}$ ) can be determined from the manufacturer's technical specification sheet. The transfer efficiency for a particular product and application technique can be obtained from the application equipment manufacturer or from technical references such as *AP-42* (EPA, 1995a).

Annual PM/PM<sub>10</sub> emissions are calculated by using an annual rather than an hourly usage rate in Equation 7.4-8 and converting to ton/yr.

Example 7.4-6

Calculate emissions for thinner and coating given the following data:

Mixing ratio= 1:6 thinner to coating (i.e., 1 part thinner to 6 parts coating)

$Q_T$  = 50 gal/hr

$C_{VOC}$  = 7 lb/gal (thinner)

= 2.3 lb/gal (coating)

1. Calculate usage rate for each component using the mixing ratio and Equation 7.4-7:

$$Q = Q_T * N_i / (\sum_{i=1}^n N_i) \quad (7.4-7)$$

$$\begin{aligned} \text{A. Thinner, } Q &= 50 \text{ gal/hr} * 1/(1+6) \\ &= 7.14 \text{ gal/hr} \end{aligned}$$

$$\begin{aligned} \text{B. Coating, } Q &= 50 \text{ gal/hr} * 6/(1+6) \\ &= 42.86 \text{ gal/hr} \end{aligned}$$

2. Calculate VOC emissions for thinner using Equation 7.4-1:

$$Q = 7.14 \text{ gal/hr}$$

$$C_{VOC} = 7 \text{ lb/gal}$$

$$\begin{aligned} E_{VOC} &= Q * C_{VOC} \\ &= 7.14 \text{ gal/hr} * 7 \text{ lb/gal} \\ &= 50 \text{ lb/hr} \end{aligned} \quad (7.4-1)$$

3. Calculate VOC emissions for coating using Equation 7.4-1:

$$Q = 42.86 \text{ gal/hr}$$

$$C_{VOC} = 2.3 \text{ lb/gal}$$

$$\begin{aligned} E_{VOC} &= Q * C_{VOC} \\ &= 42.86 \text{ gal/hr} * 2.3 \text{ lb/gal} \\ &= 99 \text{ lb/hr} \end{aligned} \quad (7.4-1)$$

Note: Solvents common to the thinner and coating should be summed. For example, if both the coating and thinner contain methyl ethyl ketone (MEK), then total MEK should be summed.

Example 7.4-7

Calculate emissions from a catalyzed coating given the following data:

Mixing ratio = 1:8 catalyst to coating (i.e., 1 part catalyst to 8 parts coating)  
 $Q_T$  = 50 gal/hr  
 $C_{VOC}$  = 5.2 lb/gal (catalyst)  
 = 2.3 lb/gal (coating)

1. Calculate usage rate per component using Equation 7.4-7:

$$Q = Q_T * N_i / (\sum_{i=1}^n N_i) \quad (7.4-7)$$

A. Catalyst,  $Q$  = 50 gal/hr \* 1/(1+8)  
 = 5.6 gal/hr

B. Coating,  $Q$  = 50 gal/hr \* 8/(1+8)  
 = 44.4 gal/hr

2. Calculate VOC emissions for a catalyst using Equation 7.4-1:

$$\begin{aligned} Q &= 5.6 \text{ gal/hr} \\ C_{VOC} &= 5.2 \text{ lb/gal} \\ E_{VOC} &= Q * C_{VOC} \\ &= 5.6 \text{ gal/hr} * 5.2 \text{ lb/gal} \\ &= 29 \text{ lb/hr} \end{aligned} \quad (7.4-1)$$

3. Calculate VOC emissions for a coating using Equation 7.4-1:

$$\begin{aligned} Q &= 44.4 \text{ gal/hr} \\ C_{VOC} &= 2.3 \text{ lb/gal} \\ E_{VOC} &= Q * C_{VOC} \\ &= 44.4 \text{ gal/hr} * 2.3 \text{ lb/gal} \\ &= 102 \text{ lb/hr} \end{aligned} \quad (7.4-1)$$

Example 7.4-8

Calculate emissions from a thinned and catalyzed coating given the following data:

Mixing ratios:

2:8 thinner to catalyzed coating (i.e., 2 parts thinner to 8 parts catalyzed coating)

1:8 catalyst to coating (i.e., 1 part catalyst to 8 parts coating)

$C_{VOC}$  = 7 lb/gal (thinner)  
 = 5.2 lb/gal (catalyst)  
 = 2.3 lb/gal (coating)

Annual usage of the multiple-part coating = 50,000 gal/yr ( $Q_T = 50,000$  gal/yr)

1. Calculate usage rate per component using Equation 7.4-7:

$$Q = Q_T * N_i / (\sum_{i=1}^n N_i) \quad (7.4-7)$$

- A. Calculate usage rate for thinner and catalyzed coating:

Thinner,  $Q$  = 50,000 gal/yr \* 2/(2+8)  
 = 10,000 gal/yr

Catalyzed coating,  $Q$  = 50,000 gal/yr \* 8/(2+8)  
 = 40,000 gal/yr

- B. Calculate usage rate for catalyst and coating based on total usage rate of catalyzed coating calculated above ( $Q_T = 40,000$  gal/yr):

Catalyst,  $Q$  = 40,000 gal/yr \* 1/(1+8)  
 = 4,444 gal/yr

Coating,  $Q$  = 40,000 gal/yr \* 8/(1+8)  
 = 35,556 gal/yr

2. Calculate VOC emissions from thinner, catalyst, and coating using Equation 7.4-1 and the usage rates per part calculated above:

$$E_{VOC} = Q * C_{VOC} \quad (7.4-1)$$

$C_{VOC}$  = 7 lb/gal (thinner)  
 = 5.2 lb/gal (catalyst)  
 = 2.3 lb/gal (coating)

Example 7.4-8 (Continued)

- A. Thinner,  $E_{\text{VOC}} = 10,000 \text{ gal/yr} * 7 \text{ lb/gal}$   
 $= 70,000 \text{ lb/yr}$
- B. Catalyst,  $E_{\text{VOC}} = 4,444 \text{ gal/yr} * 5.2 \text{ lb/gal}$   
 $= 23,000 \text{ lb/yr}$
- C. Coating,  $E_{\text{VOC}} = 35,556 \text{ gal/yr} * 2.3 \text{ lb/gal}$   
 $= 82,000 \text{ lb/yr}$

Example 7.4-9 shows the use of Equation 7.4-8 to calculate both hourly and annual PM/PM<sub>10</sub> emissions. Example 7.4-9 also illustrates the conversion of annual emissions from lb/yr to ton/yr.

Hourly speciated PM/PM<sub>10</sub> emissions are calculated using Equation 7.4-9:

$$E_x = Q * d * \frac{\text{wt}\%_x}{100} * (1 - \text{T.E.}/100) \quad (7.4-9)$$

where:

- $E_x$  = Emissions of PM/PM<sub>10</sub> species x (lb/hr)  
 $Q$  = Material usage rate (gal/hr)  
 $d$  = Density of the material used (lb/gal)  
 $\text{wt}\%_x$  = Weight percent of the PM/PM<sub>10</sub> species x (%)  
 $\text{T.E.}$  = Transfer efficiency of the application equipment (%)

The weight percent of the PM/PM<sub>10</sub> species x ( $\text{wt}\%_x$ ) can be determined from the manufacturer's technical specification sheet. The transfer efficiency for a particular product and application technique can be obtained from the application equipment manufacturer or from technical references such as *AP-42* (EPA, 1995a).

Example 7.4-10 shows how speciated PM/PM<sub>10</sub> emissions can be calculated using Equation 7.4-9.

**Example 7.4-9**

This example shows how hourly and annual PM/PM<sub>10</sub> emissions can be calculated using Equation 7.4-8 and the data given below:

Given:

$$\begin{aligned} Q &= 10.0 \text{ gal/hr} \\ &= 3,250 \text{ gal/yr} \\ \text{T.E.} &= 45\% \\ C_{\text{PM}} &= 3.0 \text{ lb/gal} \end{aligned}$$

Hourly PM/PM<sub>10</sub> emissions are calculated using Equation 7.4-8:

$$\begin{aligned} E_{\text{PM}} &= Q * C_{\text{PM}} * (1 - \text{T.E.}/100) \\ &= 10.0 \text{ gal/hr} * 3.0 \text{ lb/gal} * (1 - 45/100) \\ &= 16.5 \text{ lb/hr} \end{aligned} \quad (7.4-8)$$

Annual PM/PM<sub>10</sub> emissions are calculated using annual usage rates and Equation 7.4-8:

$$\begin{aligned} E_{\text{PM}} &= Q * C_{\text{PM}} * (1 - \text{T.E.}/100) \\ &= 3,250 \text{ gal/yr} * 3.0 \text{ lb/gal} * (1 - 45/100) \\ &= 5,360 \text{ lb/yr} * \text{ton}/2,000 \text{ lb} \\ &= 2.68 \text{ ton/yr} \end{aligned} \quad (7.4-8)$$

## 4.5 CALCULATION OF PM/PM<sub>10</sub> EMISSIONS USING SOURCE TESTING DATA (VENTED COATING OPERATIONS)

The preferred method for estimating PM/PM<sub>10</sub> emissions from vented coating operations is stack sampling (e.g., EPA Reference Method 5 and Method 201). The methodology described in Chapter 2 of this series, *Preferred and Alternative Methods for Estimating Air Emissions from Boilers*, Section 4, "Estimating PM<sub>10</sub> Emissions using Raw Stack Sampling Data" shows how PM<sub>10</sub> emissions can be calculated using EPA Method 201.

Stack sampling test reports often provide particulate concentration data in grains per dry standard cubic feet (grain/dscf). An hourly emission rate can be determined based on this stack gas concentration using Equation 7.4-10:

$$E_x = (C_x * V * 60)/7,000 \quad (7.4-10)$$

where:

$$\begin{aligned} E_x &= \text{Speciated emissions of pollutant x (lb/hr)} \\ C_x &= \text{Stack gas concentration of pollutant x (grain/dscf)} \\ V &= \text{Stack gas volumetric flow rate (dscfm)} \\ 60 &= 60 \text{ min/hr} \\ 7,000 &= 7,000 \text{ grain/lb} \end{aligned}$$



Example 7.4-10

This example shows how to estimate hourly and annual PM/PM<sub>10</sub> species x emissions using Equation 7.4-9 and the data given below:

Given:

$$\begin{aligned} Q &= 10 \text{ gal/hr} \\ &= 23,000 \text{ gal/yr} \\ d &= 8.32 \text{ lb/gal H}_2\text{O} \\ \text{T.E.} &= 45\% \\ \text{wt}\%_x &= 15\% \end{aligned}$$

Calculate the hourly emissions of PM/PM<sub>10</sub> species x using Equation 7.4-9:

$$\begin{aligned} E_x &= Q * d * \text{wt}\%_x / 100 * (1 - \text{T.E.} / 100) \\ &= 10 \text{ gal/hr} * 8.32 \text{ lb/gal} * 15 / 100 * (1 - 45 / 100) \\ &= 6.9 \text{ lb/hr} \end{aligned} \quad (7.4-9)$$

Calculate annual emissions for PM/PM<sub>10</sub> species x using Equation 7.4-9 and convert to tons per year:

$$\begin{aligned} E_x &= Q * d * \text{wt}\%_x / 100 * (1 - \text{T.E.} / 100) \\ &= 23,000 \text{ gal/yr} * 8.32 \text{ lb/gal} * 15 / 100 * (1 - 45 / 100) \\ &= 15,800 \text{ lb/yr} * 1 \text{ ton} / 2,000 \text{ lb} \\ &= 7.9 \text{ ton/yr} \end{aligned} \quad (7.4-9)$$

Emissions in tons per year can be calculated by multiplying the average hourly emission rate (lb/hr) from Equation 7.4-10 by the number of operating hours (as in Equation 7.4-11 below).

$$A_x = E_x * \text{OH} * 1 \text{ ton} / 2,000 \text{ lb} \quad (7.4-11)$$

where:

$$\begin{aligned} A_x &= \text{Annual emissions of pollutant x (ton/yr)} \\ E_x &= \text{Speciated hourly emissions of pollutant x (lb/hr)} \\ \text{OH} &= \text{Operating hours (hr/yr)} \end{aligned}$$

Example 7.4-11 illustrates the use of stack test data to estimate PM/PM<sub>10</sub> emissions. This example also illustrates the conversion from lb/yr to ton/yr.

Example 7.4-11

This example shows how hourly and annual PM/PM<sub>10</sub> emissions can be calculated using the data obtained from a stack test. The PM/PM<sub>10</sub> concentration based on stack test results is 0.015 grain/dscf. Hourly emissions are calculated using Equation 7.4-10, and annual emissions are calculated using Equation 7.4-11.

Given:

$$\begin{aligned}C_x &= 0.015 \text{ grain/dscf} \\V &= 1,817 \text{ dscfm} \\OH &= 1,760 \text{ hr/yr}\end{aligned}$$

Hourly emissions are calculated using Equation 7.4-10:

$$\begin{aligned}E_x &= (C_x * V * 60)/7,000 \\&= \frac{0.015 \text{ grain/dscf} * 1,817 \text{ dscf/min} * 60 \text{ min/hr}}{7,000 \text{ grain/lb}} \\&= 0.23 \text{ lb/hr}\end{aligned} \tag{7.4-10}$$

Annual emissions are calculated using Equation 7.4-11:

$$\begin{aligned}A_x &= E_x * OH * 1 \text{ ton}/2,000 \text{ lb} \\&= 0.23 \text{ lb/hr} * 1,760 \text{ hr/yr} * 1 \text{ ton}/2,000 \text{ lb} \\&= 0.20 \text{ ton/yr}\end{aligned} \tag{7.4-11}$$

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# 5

## ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

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For open coating operations, PEM, emission factors, and source testing are the alternative methods for estimating VOC, PM/PM<sub>10</sub>, and HAP emissions. For vented coating operations, source testing, PEM, and emission factors are the alternative methods for estimating VOC and HAP emissions, and material balance, emission factors, and PEM are the alternative methods for estimating PM/PM<sub>10</sub> emissions.

Table 7.5-1 lists the variables and symbols used in the following discussions.

### 5.1 PREDICTIVE EMISSION MONITORING (PEM)

PEM is a predictive emission estimation method where emissions are correlated to process parameters based on demonstrated correlations. PEM develops a correlation between pollutant emissions and an easily measured process parameter. Amount of material used, the number of items coated, and hours of operation are quantifiable parameters that affect emissions and can be used to develop a correlation with emissions. When developing a PEM correlation, parameter data and corresponding emissions are collected for several tests. Table 7.5-2 illustrates data and emissions that can be used to develop a correlation.

### 5.2 EMISSION FACTOR CALCULATIONS

Emission factors can be used when site-specific monitoring data are unavailable. The EPA maintains *AP-42*, a compilation of approved emission factors for criteria pollutants and HAPs (EPA, 1995a). Another comprehensive source of available air pollutant emission factors from numerous sources is the FIRE system (EPA, 2000).

Much work has been done recently on developing emission factors for HAPs and recent *AP-42* revisions have included these factors (EPA, 1995a). In addition, many states have developed their own HAP emission factors for certain source categories and may require their use in any inventories that include HAPs. Refer to Chapter 1, *Introduction to Point Source Emission Inventory Development*, of this series for a complete discussion of available information sources for locating, developing, and using emission factors as an estimation technique.

**TABLE 7.5-1**  
**LIST OF VARIABLES AND SYMBOLS**

Variable	Symbol	Units
Emissions of pollutant x	$E_x$	typically lb/hr of pollutant x
Activity factor	AF	gal/hr, for example
Emission factor for pollutant x	$EF_x$	typically lb/gal of pollutant x
Density of material	d	lb/gal
Concentration of pollutant x at the source	$C_x$	parts per million volume dry (ppmvd)
Temperature correction for differences in temperature during test	$K_t$	dimensionless
Pressure correction for differences in pressure during test	$K_p$	dimensionless
Average concentration of pollutant x	$C_{a,x}$	ppmvd
Molecular weight of pollutant x	$MW_x$	lb/lb-mole of pollutant x
Molar volume	M	cubic feet (ft <sup>3</sup> )/lb-mole
Stack gas volumetric flow rate	V	dry standard cubic feet per minute (dscfm)
Annual emissions of pollutant x	$A_x$	ton/yr
Operating hours	OH	hr/yr
PM/PM <sub>10</sub> emissions	$E_{PM}$	lb/hr
Material usage rate	Q	typically gal/hr or gal/yr
PM/PM <sub>10</sub> or solids content of material	$C_{PM}$	lb/gal
Transfer efficiency of application equipment	T.E.	%
Weight percentage of pollutant x in material	wt% <sub>x</sub>	%

**TABLE 7.5-2**  
**PREDICTIVE EMISSION MONITORING ANALYSIS<sup>a</sup>**

Test Number	Amount of Material Used (gal)	No. of Items Coated	Hours of Operation	Emissions (lb)
1	20	5	2	40
2	35	7	3	70
3	10	3	1	22
4	8	3	1	16
5	22	5	2	43
6	20	5	2	42
7	10	3	1	21
8	30	7	3	62
9	18	5	2	35

<sup>a</sup> Data for this example may be used to develop a correlation between emissions and process parameters. In this example, the PEM correlation could be in terms of lb/gal, lb/item coated, or lb/hr.

Emission factors developed from measurements for a specific spray booth, dip tank, or open area may sometimes be used to estimate emissions at other sites. For example, a company may have several spray booths of a similar model and size that conduct a similar coating process; if emissions were measured from one spray booth, a factor can be developed and applied to the other spray booths. It is advisable to have the factor approved by state/local agencies or by the EPA before using it to calculate emissions.

The basic equation used to calculate emissions using an emission factor is shown in Equation 7.5-1:

$$E_x = EF_x * AF \quad (7.5-1)$$

where:

$E_x$  = Emissions of pollutant "x"  
 $EF_x$  = Emission factor of pollutant x  
 $AF$  = Activity factor

Example 7.5-1 shows how VOC and PM<sub>10</sub> emissions may be calculated for an industrial surface coating operation using an emission factor.

#### Example 7.5-1

This example shows how VOC and PM<sub>10</sub> emissions may be calculated for an uncontrolled industrial surface coating operation using a conventional enamel paint with a density (d) of 7.6 lb/gal and a VOC content of 45 percent by weight (wt%<sub>VOC</sub>). Assume that for this operation the paint usage rate or activity factor (AF) is 10 gal/hr. From AP-42, Table 4.2.2.1-1, for conventional paints, an emission factor is developed as follows:

$$\begin{aligned}EF_{VOC} &= d * wt\%_{VOC}/100 \\&= (7.6 \text{ lb/gal}) * 45 \text{ lb VOC}/100 \text{ lb coating} \\&= 3.42 \text{ lb VOC/gal coating}\end{aligned}$$

Thus,

$$\begin{aligned}E_{VOC} &= EF_{VOC} * AF \\&= 3.42 \text{ lb VOC/gal coating} * 10 \text{ gal coating/hr} \\&= 34.2 \text{ lb VOC/hr}\end{aligned} \tag{7.5-1}$$

Using above information and the FIRE emission factor of 4.52 lb PM<sub>10</sub>/ton of solvent in the coating (assume that the solvent content equals the VOC content):

$$\begin{aligned}EF_{PM_{10}} &= (4.52 \text{ lb PM}_{10}/\text{ton VOC}) * (3.42 \text{ lb VOC/gal coating}) * (1 \text{ ton}/2,000 \text{ lb}) \\&= 0.0077 \text{ lb PM}_{10}/\text{gal coating}\end{aligned}$$

Thus,

$$\begin{aligned}E_{PM_{10}} &= EF_{PM_{10}} * AF \\&= (0.0077 \text{ lb PM}_{10}/\text{gal coating}) * 10 \text{ gal coating/hr} \\&= 0.077 \text{ lb PM}_{10}/\text{hr}\end{aligned}$$

## 5.3 EMISSIONS CALCULATIONS USING SOURCE TESTING DATA

Various stack sampling test methods can be used to estimate VOC emissions and speciated organic emission rates from surface coating operations (e.g., EPA Method 25). Air flow rates can be determined from flow rate meters or from pressure drops across a critical orifice (e.g., EPA Reference Method 2).

Stack sampling test reports often provide chemical concentration data in parts per million by volume dry (ppmvd). For gaseous pollutants, the concentration of a pollutant ( $C_x$ ) can be determined from the Equation 7.5-2:

$$C_x = K_t * K_p * C_{a,x} \quad (7.5-2)$$

where:

- $C_x$  = Concentration of pollutant x (ppmvd) at the source
- $K_t$  = Temperature correction for differences in temperature during test
- $K_p$  = Pressure correction for differences in pressure during test
- $C_{a,x}$  = Average concentration of pollutant x for all analyzed samples (ppmvd)

If the concentration is known, an hourly emission rate can be determined using Equation 7.5-3:

$$E_x = (C_x * MW_x * V * 60) / (M * 10^6) \quad (7.5-3)$$

where:

- $E_x$  = Hourly emissions of pollutant x (lb/hr)
- $C_x$  = Concentration of pollutant x (ppmvd)
- $MW_x$  = Molecular weight of pollutant x (lb/lb-mole)
- $V$  = Stack gas volumetric flow rate (dscfm)
- 60 = 60 min/hr
- $M$  = Volume occupied by 1 mole of ideal gas at standard temperature and pressure (385.5 ft<sup>3</sup>/lb-mole at 68°F and 1 atm)

Emissions in tons per year can be calculated by multiplying the average hourly emission rate (lb/hr) from Equation 7.5-3 by the number of operating hours (as in Equation 7.5-4 below) or by multiplying an average emission factor (lb/gal) by the total annual amount of material used (gal).

$$A_x = E_x * OH * 1 \text{ ton}/2,000 \text{ lb} \quad (7.5-4)$$

where:

- $A_x$  = Annual emissions of pollutant x (ton/yr)
- $E_x$  = Hourly emissions of pollutant x (lb/hr)
- OH = Operating hours (hr/yr)

Example 7.5-2 illustrates the use of Equations 7.5-2 through 7.5-4.



**Example 7.5-2**

This example shows how annual VOC emissions can be calculated using the data obtained from a stack test. The concentration of pollutant x is calculated using Equation 7.5-2, hourly emissions are calculated using Equation 7.5-3, and annual emissions are calculated using Equation 7.5-4.

Given:

$$\begin{aligned} K_t &= 1.0 \\ K_p &= 0.8 \\ C_{a,x} &= 15.4 \text{ ppmvd} \\ MW_x &= 12.0 \text{ lb/lb-mole} \\ V &= 1,817 \text{ dscfm} \\ OH &= 1,760 \text{ hr/yr} \end{aligned}$$

The concentration of pollutant x is calculated using Equation 7.5-2:

$$\begin{aligned} C_x &= K_t * K_p * C_{a,x} \\ &= 1.0 * 0.8 * 15.4 \\ &= 12.32 \text{ ppmvd} \end{aligned} \quad (7.5-2)$$

Hourly emissions are calculated using Equation 7.5-3:

$$\begin{aligned} E_x &= (C_x * MW_x * V * 60) / (M * 10^6) \\ &= 12.3 * 12.0 * 1,817 * 60 / (385.5 * 10^6) \\ &= 0.0418 \text{ lb/hr} \end{aligned} \quad (7.5-3)$$

Annual emissions are calculated using Equation 7.5-4:

$$\begin{aligned} A_x &= E_x * OH * 1 \text{ ton}/2,000 \text{ lb} \\ &= 0.0418 * (1,760/2,000) \end{aligned} \quad (7.5-4)$$

## 5.4 CALCULATION OF PM/PM<sub>10</sub> EMISSIONS FROM VENTED COATING OPERATIONS USING MATERIAL BALANCE

Hourly controlled PM/PM<sub>10</sub> emissions are calculated by material balance using Equation 7.5-5:

$$E_{PM} = Q * C_{PM} * (1 - T.E./100) * (1 - F.E./100) \quad (7.5-5)$$

where:

$$\begin{aligned} E_{PM} &= \text{PM/PM}_{10} \text{ emissions (lb/hr)} \\ Q &= \text{Material usage rate (gal/hr)} \\ C_{PM} &= \text{PM/PM}_{10} \text{ or solids content of material (lb/gal)} \end{aligned}$$

T.E. = Transfer efficiency of the application equipment (%)

F.E. = Filter efficiency of the PM/PM<sub>10</sub> control equipment (%)

The PM/PM<sub>10</sub> content of the material ( $C_{PM}$ ) can be determined from the manufacturer's technical specification sheet. The transfer efficiency for a particular product and application technique can be obtained from the application equipment manufacturer or from technical references such as *AP-42* (EPA, 1995a).

Control efficiencies (which can be acquired from the equipment vendor or manufacturer) for PM/PM<sub>10</sub> control devices are frequently in excess of 90% for PM, but there can be considerable variation in the control efficiency for PM<sub>10</sub>. It is important to make sure that an appropriate filter efficiency is used for calculating emissions (i.e., do not assume that a device's PM<sub>10</sub> filter efficiency is identical to its PM filter efficiency).

If detailed filter efficiencies are not available, additional guidance is available in documents such as EPA's *Fractional Penetration of Paint Overspray Arrestors* (EPA-600/R-97-011, May 1997).

Note that the use of Equation 7.5-5 assumes that 100% of the PM/PM<sub>10</sub> emissions are vented through the control device (i.e., that there are no uncaptured emissions).

Annual PM/PM<sub>10</sub> emissions are calculated by using an annual rather than an hourly usage rate in Equation 7.5-5 and converting to ton/yr.

Example 7.5-3 shows the use of Equation 7.5-5 to calculate both controlled hourly and annual PM/PM<sub>10</sub> emissions. Example 7.5-3 also illustrates the conversion of annual emissions from lb/yr to ton/yr.

Example 7.5-3

This example shows how hourly and annual PM/PM<sub>10</sub> emissions can be calculated using Equation 7.5-5 and the data given below:

Given:

$$\begin{aligned} Q &= 10.0 \text{ gal/hr} \\ &= 3,250 \text{ gal/yr} \\ \text{T.E.} &= 45\% \\ C_{\text{PM}} &= 3.0 \text{ lb/gal} \\ \text{F.E.} &= 99\% \end{aligned}$$

Hourly PM/PM<sub>10</sub> emissions are calculated using Equation 7.5-5:

$$\begin{aligned} E_{\text{PM}} &= Q * C_{\text{PM}} * (1 - \text{T.E.}/100) * (1 - \text{F.E.}/100) \\ &= 10.0 \text{ gal/hr} * 3.0 \text{ lb/gal} * (1 - 45/100) * (1 - 99/100) \\ &= 0.165 \text{ lb/hr} \end{aligned} \quad (7.5-5)$$

Annual PM/PM<sub>10</sub> emissions are calculated using annual usage rates and Equation 7.5-5:

$$\begin{aligned} E_{\text{PM}} &= Q * C_{\text{PM}} * (1 - \text{T.E.}/100) * (1 - \text{F.E.}/100) \\ &= 3,250 \text{ gal/yr} * 3.0 \text{ lb/gal} * (1 - 99/100) \\ &= 53.6 \text{ lb/yr} * \text{ton}/2,000 \text{ lb} \\ &= 0.027 \text{ ton/yr} \end{aligned} \quad (7.5-5)$$

Hourly uncontrolled speciated PM/PM<sub>10</sub> emissions are calculated using Equation 7.5-6:

$$E_x = Q * d * \frac{\text{wt}\%_x}{100} * (1 - \text{T.E.}/100) \quad (7.5-6)$$

where:

$$\begin{aligned} E_x &= \text{Emissions of PM/PM}_{10} \text{ species } x \text{ (lb/hr)} \\ Q &= \text{Material usage rate (gal/hr)} \\ d &= \text{Density of the material used (lb/gal)} \\ \text{wt}\%_x &= \text{Weight percent of the PM/PM}_{10} \text{ species } x \text{ (\%)} \\ \text{T.E.} &= \text{Transfer efficiency of the application equipment (\%)} \end{aligned}$$

Example 7.5-4

This example shows how to estimate hourly and annual PM/PM<sub>10</sub> species x emissions using Equation 7.5-6.

Given:

$$\begin{aligned} Q &= 10 \text{ gal/hr} \\ &= 23,000 \text{ gal/yr} \\ d &= 8.32 \text{ lb/gal} \\ \text{T.E.} &= 45\% \\ \text{wt}\%_x &= 15\% \end{aligned}$$

Calculate the hourly emissions of PM/PM<sub>10</sub> species x using Equation 7.5-6:

$$\begin{aligned} E_x &= Q * d * \text{wt}\%_x / 100 * (1 - \text{T.E.}/100) \\ &= 10 \text{ gal/hr} * 8.32 \text{ lb/gal} * 15/100 * (1 - 45/100) \\ &= 6.9 \text{ lb/hr} \end{aligned} \quad (7.5-6)$$

Calculate annual emissions for PM/PM<sub>10</sub> species x using Equation 7.5-6 and convert to tons per year:

$$\begin{aligned} E_x &= Q * d * \text{wt}\%_x / 100 * (1 - \text{T.E.}/100) \\ &= 23,000 \text{ gal/yr} * 8.32 \text{ lb/gal} * 15/100 * (1 - 45/100) \\ &= 15,800 \text{ lb/yr} * 1 \text{ ton}/2,000 \text{ lb} \\ &= 7.9 \text{ ton/yr} \end{aligned} \quad (7.5-6)$$

The weight percent of the PM/PM<sub>10</sub> species x (wt%<sub>x</sub>) can be determined from the manufacturer's technical specification sheet. The transfer efficiency for a particular product and application technique can be obtained from the application equipment manufacturer or from technical references such as *AP-42* (EPA, 1995a).

Example 7.5-4 shows how speciated PM/PM<sub>10</sub> emissions can be calculated using Equation 7.5-6.

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# 6

## QUALITY ASSURANCE/QUALITY CONTROL

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The consistent use of standardized methods and procedures is essential in the compilation of reliable emission inventories. Quality assurance (QA) and quality control (QC) of an inventory is accomplished through a set of procedures that ensure the quality and reliability of data collection and analysis. These procedures include the use of appropriate emission estimation techniques, applicable and reasonable assumptions, accuracy/logic checks of computer models, checks of calculations, and data reliability checks. Figure 7.6-1 provides an example checklist that could aid in the preparation of an inventory where surface coating operations must be considered. Volume VI of this series, *Quality Assurance Procedures*, describes additional QA/QC methods and tools for performing these procedures.

Volume II, Chapter 1, *Introduction to Point Source Emission Inventory Development*, presents recommended standard procedures to follow to ensure that the reported inventory data are complete and accurate. Chapter 1 discusses preparation of a QA plan, development and use of QC checklists, and QA/QC procedures for specific emission estimation methods (e.g., emission factors).

Another useful document, *Guidelines for Determining Capture Efficiency*, can be found at [www.epa.gov/ttn/emc/guidlnd.html](http://www.epa.gov/ttn/emc/guidlnd.html) (EPA, 1995b). This document presents details of the EPA approved test methods for determining capture efficiency, which is critical to determining the effectiveness of VOC emission control systems. The document provides technical details, including the data quality objective (DQO) and lower confidence limit (LCL) test methods. The DQO and LCL methods are sets of approval criteria which, when met by the data obtained with any given protocol of process parameter measurement procedures, may be used to determine VOC capture system compliance with a capture efficiency (CE) standard.

### 6.1 GENERAL QA/QC CONSIDERATIONS INVOLVED IN EMISSION ESTIMATION TECHNIQUES

#### 6.1.1 MATERIAL BALANCE

The accuracy and reliability of emission values calculated using the material balance approach are related to the quality of material usage and speciation data. The quantity of material used in a

Item	Y/N	Corrective Action (Complete if "N"; Describe, Sign, and Date)
<p>If the material balance method is being used for emission calculations, have the necessary data been collected, including:</p> <ul style="list-style-type: none"> <li>• Material usage rates;</li> <li>• Fugitive flashoff estimates;</li> <li>• Material speciation data;</li> <li>• Material densities;</li> <li>• Transfer efficiencies of application equipment; and</li> <li>• Filter efficiencies of spray booth filters?</li> </ul>		
If toxic emissions are to be calculated using test data, are the test methods approved?		
If the toxic emissions are to be calculated using emission factors, are the emission factors from AP-42 or FIRE?		
Have stack parameters been provided for each stack or vent that emits criteria or toxic pollutants?		
If required by the state, has a site diagram been included with the emission inventory? This should be a detailed plant drawing showing the location of sources/stacks with ID numbers for all processes, control equipment, and exhaust points.		
Have examples of all calculations been included?		
Have all assumptions been documented?		
Have references for all calculation methods been included?		
Have all conversions and units been reviewed and checked for accuracy?		

FIGURE 7.6-1

## EXAMPLE EMISSION INVENTORY CHECKLIST FOR SURFACE COATING OPERATIONS

coating operation is often "eye-balled," a procedure that can easily result in an error of as great as 25 percent. This level of uncertainty can be reduced by using a standardized method of measuring quantities such as a gravimetric procedure (e.g., weighing a container before and after using the material) or use of a stick or gauge to measure the level of liquid in a container. For certain applications (e.g., those where very small quantities of materials are used), it may be more accurate to make these types of measurements monthly or annually, rather than after each application event. Another technique for determining usage quantities would be to use purchase and inventory records.

Uncertainty of emissions using the material balance approach is also related to the quality of material speciation data, which is typically extracted from Technical Specification Sheets. If speciation data are not available on these sheets, the material manufacturer should be contacted.

### **6.1.2 SOURCE TESTING AND PEM**

Data collected via source testing or PEM must meet quality objectives. Source test data must be reviewed to ensure that the test was conducted under normal operating conditions, or under maximum operating conditions in some states, and that the results were generated according to an acceptable method for each pollutant of interest. Calculation and interpretation of accuracy for stack testing methods and PEM are described in detail in the *Quality Assurance Handbook for Air Pollution Measurements Systems: Volume III. Stationary Source Specific Methods (Interim Edition)*.

The acceptance criteria, limits, and values for each control parameter associated with manual sampling methods, such as dry gas meter calibration, are summarized in Chapter 1 of this volume. The magnitudes of concentration and emission rate errors caused by a +10 percent error in various types of measurements (e.g., stack diameter and temperature) are also presented in Chapter 1 of this volume.

### **6.1.3 EMISSION FACTORS**

The use of emission factors is straightforward when the relationship between process data and emissions is direct and relatively uncomplicated. When using emission factors, the user should be aware of the quality indicator associated with the value. Emission factors published within EPA documents and electronic tools have a quality rating applied to them. The lower the quality rating, the more likely that a given emission factor may not be representative of the source type. The reliability and uncertainty of using emission factors as an emission estimation technique are discussed in detail in the QA/QC section of Chapter 1 of this volume.



## 6.2 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

One measure of emission inventory data quality is the DARS score. Four examples are given here to illustrate DARS scoring using the preferred and alternative methods. DARS provides a numerical ranking on a scale of 0 to 1.0 for individual attributes of the emission factor and the activity data. Each score is based on what is known about the factor and the activity data, such as the specificity to the source category and the measurement technique employed. The composite attribute score for the emissions estimate can be viewed as a statement of the confidence that can be placed in the data. For a complete discussion of DARS and other rating systems, see *Quality Assurance Procedures* (Volume VI, Chapter 4) and Volume II, Chapter 1, *Introduction to Point Source Emission Inventory Development*.

Table 7.6-1 gives a set of scores for an estimate based on material balance data. Tables 7.6-2 and 7.6-3 give a set of scores for estimates based on source sampling and PEM data, respectively. Table 7.6-4 gives an example for an estimate prepared with an emission factor.

Each of the examples below is hypothetical. A range is given where appropriate to cover different situations. Maximum scores of 1.0 are automatic for the source specificity and spatial congruity attributes. Likewise, the temporal congruity attribute receives a 1.0 if data capture is greater than 90 percent; this assumes that data are sampled adequately throughout the year. The measurement/method attribute score of 1.0 assumes that the pollutants of interest were measured directly. A lower score is given if the emissions are speciated using a profile or if the emissions are used as a surrogate for another pollutant. Also, the measurement/method score can be less than 1.0 if the relative accuracy is poor (e.g., >10 percent), if the data are biased, or if data capture is closer to 90 percent than to 100 percent.

These examples are given as an illustration of the relative quality of each method. If the sample analysis was done for a real site, the scores could be different but the relative ranking of methods should stay the same. Note, however, that if the source is not truly a member of the population used to develop the EPA correlation equations or the emission factors, these approaches are less appropriate and the DARS scores will probably drop.

If sufficient data are available, the uncertainty in the estimate should be evaluated. Qualitative and quantitative methods for conducting uncertainty analyses are described in *Quality Assurance Procedures* (Volume VI, Chapter 4).

**TABLE 7.6-1**  
**DARS SCORES: MATERIAL BALANCE**

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/ Method	0.50	0.90 - 1.0	0.45 - 0.5	Based on material balance, all/most end-points accounted for.	Lower scores reflects direct, intermittent measurement of activity; upper score reflects direct, continuous measurement of activity.
Source Specificity	1.0	1.0	1.0	Factor is developed specifically for the intended source.	Activity data represents the emission process exactly.
Spatial Congruity	1.0	1.0	1.0	Factor is developed for and specific to the given spatial scale.	Activity data are developed for and specific to the inventory.
Temporal Congruity	1.0	1.0	1.0	Factor is developed for and is applicable to the temporal period represented in inventory	Activity data are specific for the temporal period represented in the inventory.
Composite Scores	0.88	0.98	0.86 - 0.88		

**TABLE 7.6-2**  
**DARS SCORES: SOURCE SAMPLING**

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/ Method	0.70 - 0.90	0.80	0.56 - 0.72	Lower score reflects a small number of tests at typical loads; upper score represents numerous tests over a range of loads.	Activity rate is derived from a surrogate that is indirectly related to the activity data (rather than a surrogate that has been directly related and measured).
Source Specificity	1.0	1.0	1.0	Factor is developed specifically for the intended source.	Activity data represents the emission process exactly.
Spatial Congruity	1.0	1.0	1.0	Factor is developed for and is specific to the given spatial scale.	Activity data is developed for and specific to the inventory.
Temporal Congruity	0.70 - 1.0	0.70 - 1.0	0.49 - 1.0	Lower score reflects a factor developed for a shorter time period with moderate to low temporal variability; upper score reflects a factor developed for an applicable to the same temporal scale.	Lower score reflects activity data representative of a short period of time; upper score represents activity data specific for the temporal period represented in the inventory.
Composite Scores	0.85 - 0.98	0.88 - 0.95	0.76 - 0.93		

TABLE 7.6-3

**DARS SCORES: PREDICTIVE EMISSIONS MONITORING (PEM)**

<b>Attribute</b>	<b>Factor Score</b>	<b>Activity Score</b>	<b>Emissions Score</b>	<b>Factor Assumptions</b>	<b>Activity Assumptions</b>
Measurement/ Method	0.50	0.10	0.50	The factor is based on study data representative of the process.	Activity data are a direct continuous measurement of the activity of the source.
Source Specificity	1.0	0.90	0.90	The factor is developed specifically for the intended source.	Activity is very closely correlated to the emissions activity.
Spatial Congruity	1.0	1.0	1.0	The factor is developed for and specific to the given spatial scale.	Activity data are developed for and specific to the inventory.
Temporal Congruity	1.0	1.0	1.0	The factor is developed for and applicable to the same temporal scale.	Activity data are specific to the temporal period represented in the inventory.
Composite Scores	0.88	0.98	0.85		

TABLE 7.6-4

## DARS SCORES: EMISSION FACTORS

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/ Method	0.60	0.80 - 1.0	0.48 - 0.60	Factor is based on speciation profile applied to measurement of other pollutant.	Lower score reflects an activity rate derived from a surrogate that is indirectly related to the activity data (rather than a surrogate that has been directly related and measured); upper score reflects direct continuous measurement of activity.
Source Specificity	0.40 - 0.60	0.70 - 0.90	0.28 - 0.54	Lower score reflects a factor developed for a similar source category and it is not known if it is a subset or superset of the source of interest; upper score reflects a factor for a similar, subset or superset source category.	Lower score reflects activity that was developed for a similar process that is highly correlated to the category or process; upper score reflects activity data that is very closely related to the emissions activity.
Spatial Congruity	0.90	1.0	0.90	The factor is developed for a similar source; spatial variability is low.	Activity data are developed for and specific to the source being inventoried.

TABLE 7.6-4

(CONTINUED)

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Temporal Congruity	0.50 - 0.70	0.50 - 0.90	0.25 - 0.63	Lower score reflects a factor developed for a different period, where the temporal variability is expected to be moderate to high; upper score reflects a factor developed for a different period where the temporal variability is expected to be moderate to low.	Lower score reflects activity data developed for a different period, where the temporal variability is expected to be moderate to high; upper score reflects activity data that are representative of the same temporal period as the inventory, but is based on an average of several repeated periods (activity data are an average of three years, inventory is for one year).
Composite Scores	0.60 - 0.70	0.75 - 0.95	0.48 - 0.67		

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# 7

## DATA CODING PROCEDURES

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This section describes the methods and codes available for characterizing emissions from industries with surface coating operations. Using the EPA's Source Classification Codes (SCCs) and the Aeromatic Information Retrieval System (AIRS) control device codes will assure consistent categorization and coding and result in greater uniformity among inventories. The SCCs are the building blocks on which point source emissions data are structured. Each SCC represents a unique process or function within a source category that is logically associated with an emission point. The procedures described here will assist the reader when preparing data for input to the AIRS or a similar database management system. For example, the use of the SCCs provided in Table 7.7-1 are recommended for describing the various surface coating operations. The codes presented here are currently in use, but may change based on further refinement of the codes. Refer to the EPA's Technology Transfer Network (TTN) internet site for the most recent list of SCCs for surface coating operations. This data is accessible at <http://www.epa.gov/ttn/chief/scccodes.html>.

### 7.1 SOURCE CLASSIFICATION CODES

SCCs for the various surface coating categories listed below are presented in Table 7.7-1. These include the following:

- Surface Coating Application (refers to types of coatings used);
- Coating Oven;
- Thinning Solvents;
- Fabric Coating and Printing;
- Paper Coating;
- Large Appliances;
- Magnet Wire Surface Coating;
- Automobiles and Light-duty Trucks;



- Metal Can Coating;
- Metal Coil Coating;
- Wood Furniture Surface Coating;
- Metal Furniture Operations;
- Flat Wood Products;
- Plastic Parts;
- Large Ships;
- Large Aircraft;
- Steel Drums; and
- Miscellaneous Metal Parts.

The individual surface coating categories may also include the following components:

- Prime Coating Operation;
- Cleaning/Pretreatment;
- Coating Mixing;
- Coating Storage;
- Equipment Cleanup;
- Degreasing and Cold Solvent Cleaning and Stripping;
- Topcoat Operation;
- Uncaptured emissions; and
- Wastewater Emissions.

## 7.2 AIRS CONTROL DEVICE CODES

Control device codes applicable to surface coating operations are presented in Table 7.7-2. These should be used to enter the type of applicable emission control device into the AIRS Facility Subsystem (AFS). The "099" control code may be used for miscellaneous control devices that do not have a unique identification code.

Note: At the time of publication, these control device codes were under review by the EPA. The reader should consult the EPA for the most current list of codes.

TABLE 7.7-1

## SOURCE CLASSIFICATION CODES FOR SURFACE COATING OPERATIONS

Process Description	SCC	Units
<b>Process Emissions: General</b>		
Surface Coating Application - General: Paint: Solvent-base	40200101	Tons Coating Mix Applied
Surface Coating Application - General: Paint: Solvent-base	40200110	Gallons of Coating Processed
Surface Coating Application - General: Paint: Water-base	40200201	Tons Coating Mix Applied
Surface Coating Application - General: Paint: Water-base	40200210	Gallons of Coating Processed
Surface Coating Application - General: Varnish/Shellac	40200301	Tons Coating Mix Applied
Surface Coating Application - General: Varnish/Shellac	40200310	Gallons of Coating Processed
Surface Coating Application - General: Lacquer	40200401	Tons Coating Mix Applied
Surface Coating Application - General: Lacquer	40200410	Gallons of Coating Processed
Surface Coating Application - General: Enamel	40200501	Tons Coating Mix Applied
Surface Coating Application - General: Enamel	40200510	Gallons of Coating Processed
Surface Coating Application - General: Primer	40200601	Tons Coating Mix Applied
Surface Coating Application - General: Primer	40200610	Gallons of Coating Processed
Surface Coating Application - General: Adhesive Application	40200701	Tons Coating Mix Applied
Surface Coating Application - General: Adhesive: Roll-on	40200712	Gallons Adhesive Applied
Surface Coating Application - General: Adhesive: Solvent Mixing	40200706	Tons of Solvent Mixed
Surface Coating Application - General: Adhesive: Solvent Storage	40200707	Tons of Solvent Stored
Surface Coating Application - General: Adhesive: General	40200710	Gallons of Coatings Processed

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Surface Coating Application - General: Adhesive: Spray	40200711	Gallons of Adhesive Applied
Coating Oven - General	40200801	Tons of Coating Processed
Coating Oven - General: Dried < 175°F	40200802	Tons of Coating Processed
Coating Oven - General: Baked > 175°F	40200803	Tons of Coating Processed
Coating Oven - General: General	40200810	Gallons of Coating
Coating Oven - General: Prime/Base Coat Oven	40200820	Tons of Coating Processed
Coating Oven - General: Topcoat Oven	40200830	Tons of Coating Processed
Coating Oven - General: Two Piece Can Curing Ovens: General (Includes Codes 41, 42, and 43)	40200840	Tons of Coating Processed
Coating Oven - General: Two Piece Can Base Coat Oven	40200841	Tons of Coating Processed
Coating Oven - General: Two Piece Can Over Varnish Oven	40200842	Tons of Coating Processed
Coating Oven - General: Two Piece Can Interior Body Coat Oven	40200843	Tons of Coating Processed
Coating Oven - General: Three Piece Can Curing Ovens (Includes Codes 46, 47, 48, and 49)	40200845	Tons of Coating Processed
Coating Oven - General: Three Piece Can Sheet Base Coat (Interior) Oven	40200846	Tons of Coating Processed
Coating Oven - General: Three Piece Can Sheet Base Coat (Exterior) Oven	40200847	Tons of Coating Processed
Coating Oven - General: Three Piece Can Sheet Lithographic Coating Oven	40200848	Tons of Coating Processed
Coating Oven - General: Three Piece Can Interior Body Coat Oven	40200849	Tons of Coating Processed
Coating Oven - General: Filler Oven	40200855	Tons of Coating Processed
Coating Oven - General: Sealer Oven	40200856	Tons of Coating Processed
Coating Oven - General: Single Coat Application: Oven	40200861	Tons of Coating Processed

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Coating Oven - General: Color Coat Oven	40200870	Tons of Coating Processed
Coating Oven - General: Topcoat/Texture Coat Oven	40200871	Tons of Coating Processed
Coating Oven - General: EMI/RFI <sup>a</sup> Shielding Coat Oven	40200872	Tons of Coating Processed
Coating Oven - General: General	40200898	1000 Feet Material Processed
Coating Oven - General	40200899	Tons Coating Processed
<b>Process Emissions: Solvents</b>		
Thinning Solvents - General: General: Specify in Comments	40200901	Tons Solvent Used
Thinning Solvents - General: Acetone	40200902	Tons Solvent Used
Thinning Solvents - General: Butyl Acetate	40200903	Tons Solvent Used
Thinning Solvents - General: Butyl Alcohol	40200904	Tons Solvent Used
Thinning Solvents - General: Carbitol	40200905	Tons Solvent Used
Thinning Solvents - General: Cellosolve	40200906	Tons Solvent Used
Thinning Solvents - General: Cellosolve Acetate	40200907	Tons Solvent Used
Thinning Solvents - General: Dimethyl Formamide	40200908	Tons Solvent Used
Thinning Solvents - General: Ethyl Acetate	40200909	Tons Solvent Used
Thinning Solvents - General: Ethyl Alcohol	40200910	Tons Solvent Used
Thinning Solvents - General: Gasoline	40200911	Tons Solvent Used
Thinning Solvents - General: Isopropyl Alcohol	40200912	Tons Solvent Used
Thinning Solvents - General: Isopropyl Acetate	40200913	Tons Solvent Used
Thinning Solvents - General: Kerosene	40200914	Tons Solvent Used
Thinning Solvents - General: Lactol Spirits	40200915	Tons Solvent Used
Thinning Solvents - General: Methyl Acetate	40200916	Tons Solvent Used

<sup>a</sup>EMI/RFI = electromagnetic interference/radio frequency interference.

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Thinning Solvents - General: Methyl Alcohol	40200917	Tons Solvent Used
Thinning Solvents - General: Methyl Ethyl Ketone	40200918	Tons Solvent Used
Thinning Solvents - General: Methyl Isobutyl Ketone	40200919	Tons Solvent Used
Thinning Solvents - General: Mineral Spirits	40200920	Tons Solvent Used
Thinning Solvents - General: Naphtha	40200921	Tons Solvent Used
Thinning Solvents - General: Toluene	40200922	Tons Solvent Used
Thinning Solvents - General: Varsol	40200923	Tons Solvent Used
Thinning Solvents - General: Xylene	40200924	Tons Solvent Used
Thinning Solvents - General: Benzene	40200925	Tons Solvent Used
Thinning Solvents - General: Turpentine	40200926	Tons Solvent Used
Thinning Solvents - General: Hexylene Glycol	40200927	Tons Solvent Used
Thinning Solvents - General: Ethylene Oxide	40200928	Tons Solvent Used
Thinning Solvents - General: 1,1,1-Trichloroethane (Methyl Chloroform)	40200929	Tons Solvent Used
Thinning Solvents - General: Methylene Chloride	40200930	Tons Solvent Used
Thinning Solvents - General: Perchloroethylene	40200931	Tons Solvent Used
Thinning Solvents - General: General: Specify in Comments	40200998	Gallons Solvent Used
<b>Process Emissions - Fabric Coating/Printing</b>		
Fabric Coating/Printing: Coating Oven Heater: Natural Gas	40201001	Million Cubic Feet Burned
Fabric Coating/Printing: Coating Oven Heater: Distillate Oil	40201002	1000 Gallons Burned
Fabric Coating/Printing: Coating Oven Heater: Residual Oil	40201003	1000 Gallons Burned
Fabric Coating/Printing: Coating Oven Heater, Liquified Petroleum Gas (LPG)	40201004	1000 Gallons Burned

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Fabric Coating/Printing: Coating Operation (Also See Specific Coating Method Codes 4-02-04X)	40201101	Tons Solvent in Coating
Fabric Coating/Printing: Coating Mixing (Also See Specific Coating Method Codes 4-02-04X)	40201103	Tons Solvent in Coating
Fabric Coating/Printing: Coating Storage (Also See Specific Coating Method Codes 4-02-04X)	40201104	Tons Solvent in Coating
Fabric Coating/Printing: Fabric Coating: Equipment Cleanup (Also See Specific Coating Method Codes 4-02-04X)	40201105	Tons Solvent in Coating
Fabric Coating/Printing: Fabric Printing: Roller (Also See New Codes Under 4-02-040-XX)	40201111	Tons of Fabric Processed
Fabric Coating/Printing: Fabric Printing: Roller (Also See New Codes Under 4-02-040-XX)	40201112	Printing Lines Operating Each Year
Fabric Coating/Printing: Fabric Printing: Rotary Screen (Also See New Codes Under 4-02-040-XX)	40201113	Tons of Fabric Processed
Fabric Coating/Printing: Fabric Printing: Rotary Screen (Also See New Codes Under 4-02-040-XX)	40201114	Printing Lines Operating Each Year
Fabric Coating/Printing: Printing: Flat Screen (Also See New Codes Under 4-02-040-XX)	40201115	Tons of Fabric
Fabric Coating/Printing: Printing: Flat Screen (Also See New Codes Under 4-02-040-XX)	40201116	Printing Lines Operating Each Year
Fabric Coating/Printing: Printing: Dryer: Steam Coil (Also See New Codes Under 4-02-040-XX)	40201121	Tons of Fabric Processed
Fabric Coating/Printing: Printing: Dryer: Fuel-fired (Also See New Codes Under 4-02-040-XX)	40201122	Tons of Fabric Processed
Fabric Coating/Printing: Misc. Fugitives: Specify in Comments (Also New Codes 4-02-040-XX)	40201197	Tons Solvent Used
Fabric Coating/Printing: Misc. Fugitives: Specify in Comments (Also New Codes 4-02-040-XX)	40201198	Tons Fabric Printed/Coated
Fabric Coating/Printing: Other Not Classified (Also See New Codes Under 4-02-040-XX)	40201199	Tons Solvent in Coating

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Fabric Printing: Roller: Print Paste	40204001	Tons of Fabric Processed
Fabric Printing: Roller: Application	40204002	Tons of Fabric Processed
Fabric Printing: Roller: Transfer	40204003	Tons of Fabric Processed
Fabric Printing: Roller: Steam Cans/Drying	40204004	Tons of Fabric Processed
Fabric Printing: Rotary Screen: Print Paste	40204010	Tons of Fabric Processed
Fabric Printing: Rotary Screen: Application	40204011	Tons of Fabric Processed
Fabric Printing: Rotary Screen: Transfer	40204012	Tons of Fabric Processed
Fabric Printing: Rotary Screen: Drying/Curing	40204013	Tons of Fabric Processed
Fabric Printing: Flat Screen: Print Paste	40204020	Tons of Fabric Processed
Fabric Printing: Flat Screen: Application	40204021	Tons of Fabric Processed
Fabric Printing: Flat Screen: Transfer	40204022	Tons of Fabric Processed
Fabric Printing: Flat Screen: Drying/Curing	40204023	Tons of Fabric Processed
Fabric Coating: Knife Coating: Mixing Tanks	40204121	Tons of Fabric Coated
Fabric Coating: Knife Coating: Coating Application	40204130	Tons of Fabric Coated
Fabric Coating: Knife Coating: Drying/Curing	40204140	Tons of Fabric Coated
Fabric Coating: Knife Coating: Cleanup	40204150	Tons of Fabric Coated
Fabric Coating: Knife Coating: Cleanup: Coating Application Equipment	40204151	Tons of Fabric Coated
Fabric Coating: Knife Coating: Cleanup: Empty Coating Drums	40204152	Tons of Fabric Coated
Fabric Coating: Knife Coating: Waste	40204160	Tons of Fabric Coated
Fabric Coating: Knife Coating: Waste: Cleaning Rags	40204161	Tons of Fabric Coated
Fabric Coating: Knife Coating: Waste Ink Disposal	40204162	Tons of Fabric Coated
Fabric Coating: Roller Coating: Mixing Tanks	40204221	Tons of Fabric Coated
Fabric Coating: Roller Coating: Coating Application	40204230	Tons of Fabric Coated



TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Fabric Coating: Roller Coating: Drying/Curing	40204240	Tons of Fabric Coated
Fabric Coating: Roller Coating: Cleanup	40204250	Tons of Fabric Coated
Fabric Coating: Roller Coating: Cleanup: Coating Application Equipment	40204251	Tons of Fabric Coated
Fabric Coating: Roller Coating: Cleanup: Empty Coating Drums	40204252	Tons of Fabric Coated
Fabric Coating: Roller Coating: Waste	40204260	Tons of Fabric Coated
Fabric Coating: Roller Coating: Waste: Cleaning Rags	40204261	Tons of Fabric Coated
Fabric Coating: Roller Coating: Waste: Waste Ink Disposal	40204262	Tons of Fabric Coated
Fabric Coating: Dip Coating: Mixing Tanks	40204321	Tons of Fabric Coated
Fabric Coating: Dip Coating: Coating Application	40204330	Tons of Fabric Coated
Fabric Coating: Dip Coating: Drying/Curing	40204340	Tons of Fabric Coated
Fabric Coating: Dip Coating: Cleanup	40204350	Tons of Fabric Coated
Fabric Coating: Dip Coating: Cleanup: Coating Application Equipment	40204351	Tons of Fabric Coated
Fabric Coating: Dip Coating: Cleanup: Empty Coating Drums	40204352	Tons of Fabric Coated
Fabric Coating: Dip Coating: Waste	40204360	Tons of Fabric Coated
Fabric Coating: Dip Coating: Waste: Cleaning Rags	40204361	Tons of Fabric Coated
Fabric Coating: Dip Coating: Waste: Waste Ink Disposal	40204362	Tons of Fabric Coated
Fabric Coating: Transfer Coating: Mixing Tanks	40204421	Tons of Fabric Coated
Fabric Coating: Transfer Coating: Coating Application	40204430	Tons of Fabric Coated
Fabric Coating: Transfer Coating: Coating Application: First Roll Applicator	40204431	Tons of Fabric Coated
Fabric Coating: Transfer Coating: Coating Application: Second Roll Applicator	40204432	Tons of Fabric Coated

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Fabric Coating: Transfer Coating: Lamination: Laminating Device	40204435	Tons of Fabric Coated
Fabric Coating: Transfer Coating: Drying/Curing	40204440	Tons of Fabric Coated
Fabric Coating: Transfer Coating: Drying/Curing: First Predrier	40204441	Tons of Fabric Coated
Fabric Coating: Transfer Coating: Drying/Curing: Second Predrier	40204442	Tons of Fabric Coated
Fabric Coating: Transfer Coating: Drying/Curing: Main Drying Tunnel	40204443	Tons of Fabric Coated
Fabric Coating: Transfer Coating: Cooler	40204450	Tons of Fabric Coated
Fabric Coating: Transfer Coating: Winding	40204455	Tons of Fabric Coated
Fabric Coating: Transfer Coating: Cleanup	40204460	Tons of Fabric Coated
Fabric Coating: Transfer Coating: Cleanup: Coating Application Equipment	40204461	Tons of Fabric Coated
Fabric Coating: Transfer Coating: Cleanup: Empty Coating Drums	40204462	Tons of Fabric Coated
Fabric Coating: Transfer Coating: Waste	40204470	Tons of Fabric Coated
Fabric Coating: Transfer Coating: Waste: Cleaning Rags	40204471	Tons of Fabric Coated
Fabric Coating: Transfer Coating: Waste: Waste Ink Disposal	40204472	Tons of Fabric Coated
Fabric Coating: Extrusion Coating: Mixing Tanks	40204521	Tons of Fabric Coated
Fabric Coating: Extrusion Coating: Coating Application	40204530	Tons of Fabric Coated
Fabric Coating: Extrusion Coating: Coating Application: Extruder	40204531	Tons of Fabric Coated
Fabric Coating: Extrusion Coating: Coating Application: Coating Die	40204532	Tons of Fabric Coated
Fabric Coating: Extrusion Coating: Cooling Cylinder	40204550	Tons of Fabric Coated
Fabric Coating: Extrusion Coating: Winding	40204555	Tons of Fabric Coated

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Fabric Coating: Extrusion Coating: Cleanup	40204560	Tons of Fabric Coated
Fabric Coating: Extrusion Coating: Cleanup: Coating Application Equipment	40204561	Tons of Fabric Coated
Fabric Coating: Extrusion Coating: Cleanup: Empty Coating Drums	40204562	Tons of Fabric Coated
Fabric Coating: Extrusion Coating: Waste	40204570	Tons of Fabric Coated
Fabric Coating: Extrusion Coating: Waste: Cleaning Rags	40204571	Tons of Fabric Coated
Fabric Coating: Extrusion Coating: Waste: Waste Ink Disposal	40204572	Tons of Fabric Coated
Fabric Coating: Melt Roll Coating: Mixing Tanks	40204621	Tons of Fabric Coated
Fabric Coating: Melt Roll Coating: Coating Application	40204630	Tons of Fabric Coated
Fabric Coating: Melt Roll Coating: Coating Application: Calendar Rolls	40204631	Tons of Fabric Coated
Fabric Coating: Melt Roll Coating: Coating Application: Pick Up Roll	40204632	Tons of Fabric Coated
Fabric Coating: Melt Roll Coating: Cooling Rolls	40204650	Tons of Fabric Coated
Fabric Coating: Melt Roll Coating: Winding	40204655	Tons of Fabric Coated
Fabric Coating: Melt Roll Coating: Cleanup	40204660	Tons of Fabric Coated
Fabric Coating: Melt Roll Coating: Cleanup: Coating Application Equipment	40204661	Tons of Fabric Coated
Fabric Coating: Melt Roll Coating: Cleanup: Empty Coating Drums	40204662	Tons of Fabric Coated
Fabric Coating: Melt Roll Coating: Waste	40204670	Tons of Fabric Coated
Fabric Coating: Melt Roll Coating: Waste: Cleaning Rags	40204671	Tons of Fabric Coated
Fabric Coating: Melt Roll Coating: Waste: Waste Ink Disposal	40204672	Tons of Fabric Coated
Fabric Coating: Coagulation: Mixing Tanks	40204721	Tons of Fabric Coated
Fabric Coating: Coagulation: Coating Application	40204730	Tons of Fabric Coated

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Fabric Coating: Coagulation: Coagulation Baths and Solvent Separation	40204735	Tons of Fabric Coated
Fabric Coating: Coagulation: Solvent Recovery	40204740	Tons of Fabric Coated
Fabric Coating: Coagulation: Drying	40204750	Tons of Fabric Coated
Fabric Coating: Coagulation: Winding	40204755	Tons of Fabric Coated
Fabric Coating: Coagulation: Cleanup	40204760	Tons of Fabric Coated
Fabric Coating: Coagulation: Cleanup: Coating Application Equipment	40204761	Tons of Fabric Coated
Fabric Coating: Coagulation: Cleanup: Empty Coating Drums	40204762	Tons of Fabric Coated
Fabric Coating: Coagulation: Waste	40204770	Tons of Fabric Coated
Fabric Coating: Coagulation: Waste: Cleaning Rags	40204771	Tons of Fabric Coated
Fabric Coating: Coagulation: Waste Ink Disposal	40204772	Tons of Fabric Coated
<b>Process Emissions: Paper Coating</b>		
Paper Coating: Coating Operation	40201301	Tons Solvent in Coating Used
Paper Coating: Coating Mixing	40201303	Tons Solvent in Coating Used
Paper Coating: Coating Storage	40201304	Tons Solvent in Coating Used
Paper Coating: Equipment Cleanup	40201305	Tons Solvent in Coating Used
Paper Coating: Coating Application: Knife Coater	40201310	1000 Sq. Ft. Product Surface Area Coated
Paper Coating: Coating Application: Reverse Roll Coater	40201320	1000 Sq. Ft. Product Surface Area Coated
Paper Coating: Coating Application: Rotogravure Printer	40201330	1000 Sq. Ft. Product Surface Area Coated
Paper Coating: Other Not Classified	40201399	Tons Solvent in Coating Used

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
<b>Process Emissions: Large Appliances</b>		
Large Appliances: Prime Coating Operation	40201401	Tons Solvent in Coating Used
Large Appliances: Cleaning/Pretreatment	40201402	Tons Solvent in Coating Used
Large Appliances: Coating Mixing	40201403	Tons Solvent in Coating Used
Large Appliances: Coating Storage	40201404	Tons Solvent in Coating Used
Large Appliances: Equipment Cleanup	40201405	Tons Solvent in Coating Used
Large Appliances: Topcoat Spray	40201406	Tons Solvent in Coating Used
Large Appliances: Prime Coat Flashoff	40201410	1000 Sq. Ft. Product Surface Area Coated
Large Appliances: Topcoat Flashoff	40201411	1000 Sq. Ft. Product Surface Area Coated
Large Appliances: Coating Line: General	40201431	Appliances Produced
Large Appliances: Prime Air Spray	40201432	1000 Sq. Ft. Product Surface Area Coated
Large Appliances: Prime Electrostatic Spray	40201433	1000 Sq. Ft. Product Surface Area Coated
Large Appliances: Prime Flow Coat	40201434	1000 Sq. Ft. Product Surface Area Coated
Large Appliances: Prime Dip Coat	40201435	1000 Sq. Ft. Product Surface Area Coated
Large Appliances: Prime Electrodeposition	40201436	1000 Sq. Ft. Product Surface Area Coated
Large Appliances: Top Air Spray	40201437	1000 Sq. Ft. Product Surface Area Coated
Large Appliances: Top Electrostatic Spray	40201438	1000 Sq. Ft. Product Surface Area Coated Used
Large Appliances: Other Not Classified	40201499	Tons Solvent in Coating Used

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
<b>Process Emissions: Magnet Wire</b>		
Magnet Wire Surface Coating: Coating/Application/Curing	40201501	Tons Solvent in Coating Used
Magnet Wire Surface Coating: Cleaning/Pretreatment	40201502	Tons Solvent in Coating Used
Magnet Wire Surface Coating: Coating Mixing	40201503	Tons Solvent in Coating Used
Magnet Wire Surface Coating: Coating Storage	40201504	Tons Solvent in Coating Used
Magnet Wire Surface Coating: Equipment Cleanup	40201505	Tons Solvent in Coating Used
Magnet Wire Surface Coating: Coating Line: General	40201531	Coating Line Operating Each Year
Magnet Wire Surface Coating: Other Not Classified	40201599	Tons Solvent in Coating Used
<b>Process Emissions: Automobiles and Light Duty Trucks</b>		
Automobiles and Light Trucks: Prime Application/Electrodeposition/Dip/Spray	40201601	Tons Solvent in Coating Used
Automobiles and Light Trucks: Cleaning/Pretreatment	40201602	Tons Solvent in Coating Used
Automobiles and Light Trucks: Coating Mixing	40201603	Tons Solvent in Coating Used
Automobiles and Light Trucks: Coating Storage	40201604	Tons Solvent in Coating Used
Automobiles and Light Trucks: Equipment Cleanup	40201605	Tons Solvent in Coating Used
Automobiles and Light Trucks: Topcoat Operation	40201606	Tons Solvent in Coating Used
Automobiles and Light Trucks: Sealers	40201607	Gallons Sealer Used
Automobiles and Light Trucks: Deadeners	40201608	Gallons Deadener Used
Automobiles and Light Trucks: Anti-corrosion Priming	40201609	Gallons Primer Used
Automobiles and Light Trucks: Prime Surfacing Operation	40201619	Tons Solvent in Coating Used
Automobiles and Light Trucks: Repair Topcoat Application Area	40201620	Tons Solvent in Coating Used
Automobiles and Light Trucks: Prime Coating: Solvent-borne - Automobiles	40201621	Vehicle Produced

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Automobiles and Light Trucks: Prime Coating: Electro-deposition - Automobiles	40201622	Vehicle Produced
Automobiles and Light Trucks: Guide Coating: Solvent-borne - Automobiles	40201623	Vehicle Produced
Automobiles and Light Trucks: Guide Coating: Water-borne - Automobiles	40201624	Vehicle Produced
Automobiles and Light Trucks: Topcoat: Solvent-borne - Automobiles	40201625	Vehicle Produced
Automobiles and Light Trucks: Topcoat: Water-borne - Automobiles	40201626	Vehicle Produced
Automobiles and Light Trucks: Prime Coating: Solvent-borne - Light Trucks	40201627	Vehicle Produced
Automobiles and Light Trucks: Prime Coating: Electrodeposition - Light Trucks	40201628	Vehicle Produced
Automobiles and Light Trucks: Guide Coating: Solvent-borne - Light Trucks	40201629	Vehicle Produced
Automobiles and Light Trucks: Guide Coating: Water-borne - Light Trucks	40201630	Vehicle Produced
Automobiles and Light Trucks: Topcoat: Solvent-borne - Light Trucks	40201631	Vehicle Produced
Automobiles and Light Trucks: Topcoat: Water-borne - Light Trucks	40201632	Vehicle Produced
Automobiles and Light Trucks: Other Not Classified	40201699	Tons Solvent in Coating Used
<b>Process Emissions: Metal Can Coating</b>		
Metal Can Coating: Cleaning/Pretreatment	40201702	Tons Solvent in Coating Used
Metal Can Coating: Coating Mixing	40201703	Tons Solvent in Coating Used
Metal Can Coating: Coating Storage	40201704	Tons Solvent in Coating Used
Metal Can Coating: Equipment Cleanup	40201705	Tons Solvent in Coating Used

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Metal Can Coating: Solvent Storage	40201706	1000 Gallons Storage Capacity Each Year
Metal Can Coating: Two-piece Exterior Base Coating	40201721	Tons Solvent in Coating Used
Metal Can Coating: Interior Spray Coating	40201722	Tons Solvent in Coating Used
Metal Can Coating: Interior Sheet Base Coating	40201723	Tons Solvent in Coating Used
Metal Can Coating: Exterior Sheet Base Coating	40201724	Tons Solvent in Coating Used
Metal Can Coating: Side Seam Spray Coating	40201725	Tons Solvent in Coating Used
Metal Can Coating: End Sealing Compound (Also See 4-02-017-36 & -37)	40201726	Tons Solvent in Coating Used
Metal Can Coating: Lithography	40201727	Tons Solvent in Coating Used
Metal Can Coating: Over Varnish	40201728	Tons Solvent in Coating Used
Metal Can Coating: Exterior End Coating	40201729	Coating Lines Operating Each Year
Metal Can Coating: Three-piece Can Sheet Base Coating	40201731	Coating Lines Operating Each Year
Metal Can Coating: Three-piece Can Sheet Lithographic Coating Line	40201732	Coating Lines Operating Each Year
Metal Can Coating: Three-piece Can Side Seam Spray Coating	40201733	Coating Lines Operating Each Year
Metal Can Coating: Three-piece Can Interior Body Spray Coat	40201734	Coating Lines Operating Each Year
Metal Can Coating: Two-piece Can Coating Line	40201735	Coating Lines Operating Each Year
Metal Can Coating: Two-piece Can End Sealing Compound	40201736	Coating Lines Operating Each Year
Metal Can Coating: Three-piece Can End Sealing Compound	40201737	Coating Lines Operating Each Year
Metal Can Coating: Two-piece Can Lithographic Coating Line	40201738	Coating Lines Operating Each Year



TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Metal Can Coating: Three-piece Can Coating Line (All Coating Solvent Emission Points)	40201739	Coating Lines Operating Each Year
Metal Can Coating: Other Not Classified	40201799	Tons Solvent in Coating Used
<b>Process Emissions - Metal Coil Coating</b>		
Metal Coil Coating: Prime Coating Application	40201801	Tons Solvent in Coating Used
Metal Coil Coating: Cleaning/Pretreatment	40201802	Tons Solvent in Coating Used
Metal Coil Coating: Solvent Mixing	40201803	Tons Solvent in Coating Used
Metal Coil Coating: Solvent Storage (Use 4-07-004-01 through 4-07-999-98 if possible)	40201804	Tons Solvent in Coating Used
Metal Coil Coating: Equipment Cleanup	40201805	Tons Solvent in Coating Used
Metal Coil Coating: Finish Coating	40201806	Tons Solvent in Coating Used
Metal Coil Coating: Coating Storage	40201807	Tons Solvent in Coating Used
Metal Coil Coating: Other Not Classified	40201899	Tons Solvent in Coating Used
<b>Process Emissions - Wood and Metal Furniture Coating</b>		
Wood Furniture Surface Coating: Coating Operation	40201901	Tons Solvent in Coating Used
Wood Furniture Surface Coating: Coating Mixing	40201903	Tons Solvent in Coating Used
Wood Furniture Surface Coating: Coating Storage	40201904	Tons Solvent in Coating Used
Wood Furniture Surface Coating: Other Not Classified	40201999	Tons Solvent in Coating Used
Metal Furniture Operations: Coating Operation	40202001	Tons Solvent in Coating Used
Metal Furniture Operations: Cleaning/Pretreatment	40202002	Tons Solvent in Coating Used
Metal Furniture Operations: Coating Mixing	40202003	Tons Solvent in Coating Used

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Metal Furniture Operations: Coating Storage	40202004	Tons Solvent in Coating Used
Metal Furniture Operations: Equipment Cleanup	40202005	Tons Solvent in Coating Used
Metal Furniture Operations: Prime Coat Application	40202010	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Prime Coat Application: Spray, High Solids	40202011	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Prime Coat Application: Spray, Water-borne	40202012	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Prime Coat Application: Dip	40202013	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Prime Coat Application: Flow Coat	40202014	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Prime Coat Application: Flashoff	40202015	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Topcoat Application	40202020	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Topcoat Application: Spray, High Solids	40202021	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Topcoat Application: Spray, Water-borne	40202022	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Topcoat Application: Dip	40202023	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Topcoat Application: Flow Coat	40202024	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Topcoat Application: Flashoff	40202025	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Single Spray Line: General	40202031	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Spray Dip Line: General (Use 4-01-20-37)	40202032	1000 Sq. Ft. Product Surface Area Coated

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Metal Furniture Operations: Spray High Solids Coating (Use 4-02-020-35)	40202033	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Spray Water-borne Coating (Use 4-02-020-36)	40202034	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Single Coat Application: Spray, High Solids	40202035	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Single Coat Application: Spray, Water-borne	40202036	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Single Coat Application: Dip	40202037	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Single Coat Application: Flow Coat	40202038	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Single Coat Application: Flashoff	40202039	1000 Sq. Ft. Product Surface Area Coated
Metal Furniture Operations: Other Not Classified	40202099	Tons Solvent in Coating Used
<b>Process Emissions: Flatwood Products</b>		
Flatwood Products: Base Coat	40202101	Tons Solvent in Coating Used
Flatwood Products: Coating Mixing	40202103	Tons Solvent in Coating Used
Flatwood Products: Coating Storage	40202104	Tons Solvent in Coating Used
Flatwood Products: Equipment Cleanup	40202105	Tons Solvent in Coating Used
Flatwood Products: Topcoat	40202106	Tons Solvent in Coating Used
Flatwood Products: Filler	40202107	Tons Solvent in Coating Used
Flatwood Products: Sealer	40202108	Tons Solvent in Coating Used
Flatwood Products: Inks	40202109	Tons Solvent in Coating Used

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Flatwood Products: Grove Coat Application	40202110	Tons Solvent in Coating Used
Flatwood Products: Stain Application	40202111	Tons Solvent in Coating Used
Flatwood Products: Filler Sander	40202117	1000 Sq. Ft. Product Produced
Flatwood Products: Sealer Sander	40202118	1000 Sq. Ft. Product Produced
Flatwood Products: Water-borne Coating	40202131	1000 Sq. Ft. Product Surface Area Coated
Flatwood Products: Solvent-borne Coating	40202132	1000 Sq. Ft. Product Surface Area Coated
Flatwood Products: Ultraviolet Coating	40202133	1000 Sq. Ft. Product Surface Area Coated
Flatwood Products: Surface Preparation (Includes Tempering, Sanding, Brushing, and Grove Cut)	40202140	1000 Sq. Ft. Product Produced
Flatwood Products: Other Not Classified	40202199	Tons Solvent in Coating Used
<b>Process Emissions: Plastic Parts</b>		
Plastic Parts: Coating Operation	40202201	Tons Solvent in Coating Used
Plastic Parts: Cleaning/Pretreatment	40202202	Tons Solvent in Coating Used
Plastic Parts: Coating Mixing	40202203	Tons Solvent in Coating Used
Plastic Parts: Coating Storage	40202204	Tons Solvent in Coating Used
Plastic Parts: Equipment Cleanup	40202205	Tons Solvent in Coating Used
Plastic Parts: Business: Baseline Coating Mix	40202206	Square Feet Surface Area Coated
Plastic Parts: Business: Low Solids Solvent-borne Coating	40202207	Square Feet Surface Area Coated
Plastic Parts: Business: Medium Solids Solvent-borne Coating	40202208	Square Feet Surface Area Coated
Plastic Parts: Business: High Solids Coating (25% Efficiency)	40202209	Square Feet Surface Area Coated

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Plastic Parts: Business: High Solids Solvent-borne Coating (40% Efficiency)	40202210	Square Feet Surface Area Coated
Plastic Parts: Business: Water-borne Coating	40202211	Square Feet Surface Area Coated
Plastic Parts: Business: Low Solids Solvent-borne EMI/RFI <sup>a</sup> Shielding Coating	40202212	Square Feet Surface Area Coated
Plastic Parts: Business: Higher Solids Solvent-borne EMI/RFI Shielding Coating	40202213	Square Feet Surface Area Coated
Plastic Parts: Business: High Solids Solvent-borne EMI/RFI <sup>a</sup> Shielding Coating	40202214	Square Feet Surface Area Coated
Plastic Parts: Business: Zinc Arc Spray	40202215	Square Feet Surface Area Coated
Plastic Parts: Prime Coat Application	40202220	Square Feet Surface Area Coated
Plastic Parts: Prime Coat Flashoff	40202229	Square Feet Surface Area Coated
Plastic Parts: Color Coat Application	40202230	Square Feet Surface Area Coated
Plastic Parts: Color Coat Flashoff	40202239	Square Feet Surface Area Coated
Plastic Parts: Topcoat/Texture Coat Application	40202240	Square Feet Surface Area Coated
Plastic Parts: Topcoat/Texture Coat Flashoff	40202249	Square Feet Surface Area Coated
Plastic Parts: EMI/RFI <sup>a</sup> Shielding Coat Application	40202250	Square Feet Surface Area Coated
Plastic Parts: EMI/RFI <sup>a</sup> Shielding Coat Flashoff	40202259	Square Feet Surface Area Coated
Plastic Parts: Sanding/Grit Blasting Prior to EMI/RFI Shielding Coat Application	40202270	Square Feet Surface Area Coated
Plastic Parts: Maskant Application	40202280	Square Feet Surface Area Coated

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Plastic Parts: Other Not Classified	40202299	Tons Solvent in Coating Used
<b>Process Emissions - Large Ships and Aircraft</b>		
Large Ships: Prime Coating Operation	40202301	Tons Solvent in Coating Used
Large Ships: Cleaning/Pretreatment	40202302	Tons Solvent in Coating Used
Large Ships: Coating Mixing	40202303	Tons Solvent in Coating Used
Large Ships: Coating Storage	40202304	Tons Solvent in Coating Used
Large Ships: Equipment Cleanup	40202305	Tons Solvent in Coating Used
Large Ships: Topcoat Operation	40202306	Tons Solvent in Coating Used
Large Ships: Other Not Classified	40202399	Tons Solvent in Coating Used
Large Aircraft: Prime Coating Operation	40202401	Tons Solvent in Coating Used
Large Aircraft: Cleaning/Pretreatment	40202402	Tons Solvent in Coating Used
Large Aircraft: Coating Mixing	40202403	Tons Solvent in Coating Used
Large Aircraft: Coating Storage	40202404	Tons Solvent in Coating Used
Large Aircraft: Equipment Cleanup	40202405	Tons Solvent in Coating Used
Large Aircraft: Topcoat Operation	40202406	Tons Solvent in Coating Used
Large Aircraft: Other Not Classified	40202499	Tons Solvent in Coating Used
<b>Process Emissions - Steel Drums</b>		
Steel Drums: Coating Operation	40202601	Gallons Paint Consumed
Steel Drums: Cleaning/Pretreatment	40202602	Gallons Paint Consumed
Steel Drums: Coating Mixing	40202603	Gallons Paint Consumed
Steel Drums: Coating Storage	40202604	Gallons Paint Consumed
Steel Drums: Equipment Cleanup	40202605	Gallons Paint Consumed
Steel Drums: Interior Coating	40202606	Gallons Paint Consumed
Steel Drums: Exterior Coating	40202607	Gallons Paint Consumed

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Steel Drums: Specify in Comments Field	40202699	Gallons Paint Consumed
<b>Process Emissions: Miscellaneous Metal Parts</b>		
Miscellaneous Metal Parts: Coating Operation	40202501	Tons Solvent in Coating Used
Miscellaneous Metal Parts: Cleaning/Pretreatment	40202502	Tons Solvent in Coating Used
Miscellaneous Metal Parts: Coating Mixing	40202503	Tons Solvent in Coating Used
Miscellaneous Metal Parts: Coating Storage	40202504	Tons Solvent in Coating Used
Miscellaneous Metal Parts: Equipment Cleanup	40202505	Tons Solvent in Coating Used
Miscellaneous Metal Parts: Prime Coat Application	40202510	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Prime Coat Application: Spray, High Solids	40202511	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Prime Coat Application: Spray, Water-borne	40202512	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Prime Coat Application: Flashoff	40202515	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Topcoat Application	40202520	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Topcoat Application: Spray, High Solids	40202521	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Topcoat Application: Spray, High Solids	40202522	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Topcoat Application: Dip	40202523	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Topcoat Application: Flow Coat	40202524	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Topcoat Application: Flashoff	40202525	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Conveyor Single Flow	40202531	1000 Sq. Ft. Product Surface Area Coated

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Miscellaneous Metal Parts: Conveyor Single Dip	40202532	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Conveyor Single Spray	40202533	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Conveyor Two Coat, Flow and Spray	40202534	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Conveyor Two Coat, Dip and Spray	40202535	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Conveyor Two Coat, Spray	40202536	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Manual Two Coat, Spray and Air Dry	40202537	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Single Coat Application: Spray, High Solids	40202542	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Single Coat Application: Spray, Water-borne	40202543	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Single Coat Application: Dip	40202544	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Single Coat Application: Flow Coat	40202545	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Single Coat Application: Flashoff	40202546	1000 Sq. Ft. Product Surface Area Coated
Miscellaneous Metal Parts: Other Not Classified	40202599	Tons Solvent in Coating
<b>Degreasing</b>		
Stoddard (Petroleum) Solvent: Open-top Vapor Degreasing	40100201	Tons make-up solvent used
1,1,1-Trichloroethane (Methyl Chloroform): Open-top Vapor Degreasing	40100202	Tons make-up solvent used
Perchloroethylene: Open-top Vapor Degreasing	40100203	Tons make-up solvent used
Methylene Chloride: Open top Vapor Degreasing	40100204	Tons make-up solvent used
Trichloroethylene: Open-top Vapor Degreasing	40100205	Tons make-up solvent used



TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Toluene: Open-top Vapor Degreasing	40100206	Tons make-up solvent used
Trichlorotrifluoroethane (Freon®): Open-top Vapor Degreasing	40100207	Tons make-up solvent used
Chlorosolve: Open-top Vapor Degreasing	40100208	Tons make-up solvent used
Butyl Acetate	40100209	Tons make-up solvent used
Entire Unit: Open-top Vapor Degreasing	40100215	Degreasing units in operation
Degreaser: Entire Unit	40100216	1,000 sq. ft. product surface area
Entire Unit	40100217	Sq. ft. surface area x hours operated
Stoddard (Petroleum) Solvent: Conveyorized Vapor Degreasing	40100221	Tons make-up solvent used
1,1,1-Trichloroethane (Methyl Chloroform): Conveyorized Vapor Degreasing	40100222	Tons make-up solvent used
Perchloroethylene: Conveyorized Vapor Degreasing	40100223	Tons make-up solvent used
Methylene Chloride: Conveyorized Vapor Degreasing	40100224	Tons make-up solvent used
Trichloroethylene: Conveyorized Vapor Degreasing	40100225	Tons make-up solvent used
Entire Unit: with Vaporized Solvent: Conveyorized Vapor Degreasing	40100235	Degreasing units in operation
Entire Unit: with Non-boiling Solvent: Conveyorized Vapor Degreasing	40100236	Degreasing units in operation
Stoddard (Petroleum) Solvent: General Degreasing Units	40100251	Gallons solvent consumed
1,1,1-Trichloroethane (Methyl Chloroform): General Degreasing Units	40100252	Gallons solvent consumed
Perchloroethylene: General Degreasing Units	40100253	Gallons solvent consumed
Methylene Chloride: General Degreasing Units	40100254	Gallons solvent consumed
Trichloroethylene: General Degreasing Units	40100255	Gallons solvent consumed
Toluene: General Degreasing Units	40100256	Gallons solvent consumed
Trichlorotrifluoroethane (Freon®): General Degreasing Units	40100257	Gallons solvent consumed
Trichlorofluoromethane: General Degreasing Units	40100258	Gallons solvent consumed

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
1,1,1-Trichloroethane (Methyl Chloroform): General Degreasing Units	40100259	Gallons solvent consumed
Other Not Classified: General Degreasing Units	40100295	Gallons solvent consumed
Other Not Classified: General Degreasing Units	40100296	Gallons solvent consumed
Other Not Classified: Open-top Vapor Degreasing	40100297	Gallons solvent consumed
Other Not Classified: Conveyorized Vapor Degreasing	40100298	Tons make-up solvent used
Other Not Classified: Open-top Vapor Degreasing	40100299	Tons make-up solvent used
<b>Cold Solvent Cleaning and Stripping</b>		
Methanol	40100301	Tons solvent consumed
Methylene Chloride	40100302	Tons solvent consumed
Stoddard (Petroleum) Solvent	40100303	Tons solvent consumed
Perchloroethylene	40100304	Tons solvent consumed
1,1,1-Trichloroethane (Methyl Chloroform)	40100305	Tons solvent consumed
Trichloroethylene	40100306	Tons solvent consumed
Isopropyl Alcohol	40100307	Tons solvent consumed
Methyl Ethyl Ketone	40100308	Tons solvent consumed
Freon®	40100309	Tons solvent consumed
Acetone	40100310	Tons solvent consumed
Glycol Ethers	40100311	Tons solvent consumed
Entire Unit	40100335	Cold cleaners in operation
Degreaser: Entire Unit	40100336	1,000 sq. ft. product surface area
Other Not Classified	40100398	Gallons solvent consumed
Other Not Classified	40100399	Tons solvent consumed
<b>Miscellaneous Operations</b>		
Glass Mirrors: Mirror Backing Coating Operation	40202701	Tons Solvent in Coating Applied
Glass Mirrors: Mirror Backing Coating Operation	40202710	Gallons of Coating Applied

TABLE 7.7-1

(CONTINUED)

Process Description	SCC	Units
Semiconductor Coating: Specify Solvent	40203001	Tons of Solvent in Coating
Paper Coating and Glazing: Extrusion Coating Line with Solvent Free Resin/Wax	3-07-011-99	Tons of Resin or Wax Consumed
<b>Fuel Fired Equipment</b>		
Distillate Oil: Incinerator/Afterburner	40290011	1000 Gallons Burned
Residual Oil: Incinerator/Afterburner	40390012	1000 Gallons Burned
Natural Gas: Incinerator/Afterburner	40290013	Million Cubic Feet Burned
Natural Gas: Flares	40290023	Million Cubic Feet Burned

**TABLE 7.7-2**  
**AIRS CONTROL DEVICE CODES<sup>a</sup>**

<b>Control Device</b>	<b>Code</b>
Wet Scrubber-High Efficiency	001
Wet Scrubber-Medium Efficiency	002
Wet Scrubber-Low Efficiency	003
Mist Eliminators-High Velocity	014
Mist Eliminators-Low Velocity	015
Catalytic Afterburners	019
Catalytic Afterburners with Heat Exchanges	020
Direct-Flame Afterburners	021
Direct-Flame Afterburners with Heat Exchanges	022
Flares	023
Activated Carbon Adsorption	048
Packed-Gas Absorption Column	050
Tray-Type Gas Adsorption Column	051
Impingement Plate Scrubber	055
Mat or Panel Filter	058
Dust Suppression by Water Sprays	061
Process Modifications-Electrostatic Spraying	105
Refrigerated Condenser	073
Barometric Condenser	074
Process Modification-Water-borne Coatings	101
Process Modification-Low Solvent Coatings	102
Process Modification-Power Coatings	103
Miscellaneous Control Device	099

<sup>a</sup> At the time of publication, these control device codes were under review by the EPA. The reader should consult the EPA for the most current list of codes.

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<sup>1</sup> The Texas Air Control Board (TACB) has since been renamed the Texas Natural Resource Conservation Commission (TNRCC).



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## **APPENDIX A**

# **EXAMPLE DATA COLLECTION FORM INSTRUCTIONS FOR SURFACE COATING OPERATIONS**

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## EXAMPLE DATA COLLECTION FORM INSTRUCTIONS FOR SURFACE COATING OPERATIONS

1. This form may be used as a work sheet to aid the plant engineer in collecting the information necessary to calculate emissions from each surface coating operation. The information requested on the form relates to the methods (described in Sections 3 and 4) for quantifying emissions. This form may also be used by the regulatory agency to assist in area-wide inventory preparation.
2. The completed forms should be maintained in a reference file by the plant engineer with other supporting documentation.
3. If the information requested is unknown, write "unknown" in the blank. If the information requested does not apply to a particular unit or process, write "NA" in the blank.
4. If you want to modify the form to better serve your needs, an electronic copy of the form may be obtained through the EIIP on the CHIEF Web Site (<http://www.epa.gov/ttn/chief/eiip>).
5. If hourly or monthly material use information is not available, enter the information in another unit (quarterly or yearly). Be sure to indicate the unit of measure on the form.
6. Use the comments field on the form to record all useful information that will allow your work to be reviewed and reconstructed.
7. Collect all Manufacturer's Technical Specification (Data) Sheets for all materials containing potential air contaminants that are used at the facility.
8. For each material used, determine maximum hourly usage rates and annual usage rates.
9. The plant engineer should maintain all material usage information and Technical Specification (Data) Sheets in a reference file.
10. Revisions should be made as appropriate and necessary to make data collection consistent with permit categorization.

**EXAMPLE DATA COLLECTION FORM - SURFACE COATING OPERATIONS****GENERAL INFORMATION**

Facility/Plant Name: \_\_\_\_\_

SIC Code: \_\_\_\_\_

SCC: \_\_\_\_\_

SCC Description: \_\_\_\_\_

Location: \_\_\_\_\_

County: \_\_\_\_\_

City: \_\_\_\_\_

State: \_\_\_\_\_

Plant Geographical Coordinates:

Latitude: \_\_\_\_\_

Longitude: \_\_\_\_\_

UTM Zone: \_\_\_\_\_

UTM Easting: \_\_\_\_\_

UTM Northing: \_\_\_\_\_

Contact Name: \_\_\_\_\_

Title: \_\_\_\_\_

Telephone Number: \_\_\_\_\_

Unit ID Number: \_\_\_\_\_

Permit Number: \_\_\_\_\_

**EXAMPLE DATA COLLECTION FORM - SURFACE COATING OPERATIONS**

<b>EQUIPMENT AND PROCESS INFORMATION</b>	<b>COMMENTS</b>
Name or description of equipment:	
Make:	
Model:	
Rated capacity of equipment:	
Type of operation:	
Surface coater:	
Dryer:	
Printing press:	
Other:	
Type of equipment for this operation:	
Dip coater:	
Letter press:	
Other:	
Application/Dryer evaporation split (%):	
Typical use:	
Hours/day:	
Days/week:	
Weeks/year:	
Seasonal variations (%):	
January:              February:              March:	
April:                May:                      June:	
July:                 August:                  September:	
October:             November:              December:	

**EXAMPLE DATA COLLECTION FORM - SURFACE COATING OPERATIONS****MATERIAL INFORMATION****MATERIAL COMPOSITION**

Name of Material:

VOC Content (lb/gal or wt.%):

Solids Content (wt. %):

Density of Material:

Composition (lb<sub>x</sub>/lb material) \* 100%:

- Name of component \_\_\_\_\_

- Wt. % of component \_\_\_\_\_

**MATERIAL USAGE**

Hourly throughput:

Monthly throughput:

Annual throughput:

Maximum throughput:

**SURFACE COATING OPERATIONS**

Type of Coating (ink, primer, paint, etc.):

Substrate Coated (wood, metal, etc.):

Mixture Name (for multipart coatings):

Brand/Product Name (for each part of coating mixture):

Mix Ratio for Coating Mixtures:

% VOC Evaporated as Fugitive:

Particulate Emission Factor:

- Reference:

## WORKSHEET A SOLVENT DESCRIPTION

Solvent Composition	Annual Usage (gal/yr)	Percent of Total Solvents Listed	Molecular Weight (lb/lb-mole)	Liquid Density (lb/gal)
Total				
Solvent Molecular Weight (weighted average), (MW <sub>i</sub> )			lb/lb-mole	
Solvent Liquid Density (weighted average), (d <sub>i</sub> )			lb/lb-mole	

$$Y = \sum_{i=1}^n (x_i * y_i)$$

where:

- Y = Weighted average molecular weight (M<sub>i</sub>) or liquid density (d<sub>i</sub>)
- n = Number of VOC species in the solvent(s)
- y<sub>i</sub> = Molecular weight (MW<sub>i</sub>) or liquid density (d<sub>i</sub>) for VOC<sub>i</sub>
- x<sub>i</sub> = Fraction of total solvent for VOC<sub>i</sub>



Booth ID No.:							
Annual Hours of Operation of this Booth:							
EXHAUST GAS STREAM CHARACTERISTICS							
Flow Rate (acfm)		Exhaust Stack			Building Height (ft)	Abatement Device Particulate Loading (lb/hr)	
Design Maximum	Average Expected	Temperature (°F)	Height (ft)	Diameter (ft)		Inlet	Outlet
TYPE OF COATING AND MAXIMUM RATE OF USE							
Type	Max. Rate of Use (lb/hr)		Max. Rate of Use (ton/yr)		Volatile Portion (%weight)		
Lacquer							
Varnish							
Enamel							
Metal Primer							
Metal Spray							
Resin							
Sealer							
Shellac							
Stain							
Zinc Chromate							
Epoxy							
Polyurethane							
Other							
SOLVENT COMPOSITION AND RATE OF USE (INCLUDE THAT SUPPLIED WITH COATING)							
Chemical Composition of Volatiles & Wt. (%)		Max. Rate of Use (lb/hr)		Max. Rate of Use(ton/yr)			
TYPE OF PM ABATEMENT DEVICE							
<input type="checkbox"/> Spray Chamber (water use gal/hr) _____ <input type="checkbox"/> Dry _____ <input type="checkbox"/> Water Curtain (water use gal/hr) _____ <input type="checkbox"/> Other _____							
Filter Pads (total number in all layers)____ (size)____ (explain) _____ <input type="checkbox"/> Manufacturer's _____							
Rating for PM Control Efficiency _____							
TYPE OF VOC ABATEMENT DEVICE							
Type _____				Rated Control Efficiency _____			

**WORKSHEET B  
(CONTINUED)**

METHOD OF SPRAYING	DESCRIPTION OF ITEMS TO BE COATED (SHAPE AND SIZE)
<input type="checkbox"/> Air Atomization <input type="checkbox"/> Airless Electrostatic <input type="checkbox"/> Disc <input type="checkbox"/> Airless <input type="checkbox"/> Air-Atomized <input type="checkbox"/> Other _____	

## EMISSION ESTIMATION RESULTS

Pollutant	Coating Operation ID <sup>a</sup>	Emission Estimation Method <sup>b</sup>	Emissions	Emissions Units	Emission Factor <sup>c</sup>	Emission Factor Units	Gallons of Coating Applied	Comments
VOC								
THC								
PM <sub>10</sub>								
Total Particulate								
Hazardous Air Pollutants (list individually)								

<sup>a</sup> Use the following codes to indicate which type of operation was used:

SC = Surface Coater  
 DR = Dryer  
 PP = Printing Press  
 O = Other

<sup>b</sup> Use the following codes to indicate which emission estimation method is used for each pollutant:

Material Balance = MB      Emission Factor = EF  
 Stack Test Data = ST      Other indicate = O

<sup>c</sup> Where applicable, enter the emission factor and provide the full citation of the reference or source of information from where the emission factor came. Include edition, version, table, and page number if *AP-42* is used.

Volume II: Chapter 8

# **Methods for Estimating Air Emissions from Paint, Ink, and Other Coating Manufacturing Facilities**

February 2005



## **Disclaimer**

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

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## **1.0 Introduction**

The purpose of this guideline is to describe emission estimation techniques for point sources in an organized manner and to provide concise example calculations to aid in the preparation of emission inventories. While emissions estimates are not provided, the information presented in this document may be used to select an emission estimation technique best suited to a particular application. This chapter describes the procedures and recommended approaches for estimating emissions from paint, ink, and other coating manufacturing operations, and it is intended to assist industry as well as regulatory agency personnel.

As EPA has indicated in this and other EIIP documents, the choice of methods to be used to estimate emissions depends on how the estimate will be used and the degree of accuracy required and methods using site-specific data are preferred over other methods. Because this document provides non-binding guidance and is not a rule, EPA, the States, and others retain the discretion to employ or require other approaches that meet the specific requirements of the applicable regulations in individual circumstances.

Section 2 of this chapter provides a brief overview of the types of coating manufacturing processes, emission sources, and factors that affect emissions. Section 3 of this chapter provides an overview of available emission estimation methods and an example showing the application of different techniques to estimate emissions for a paint manufacturing facility. Note that the use of site-specific emissions data is always preferred over the use of default values developed through use of industry emission averages.

Section 4 of this chapter presents mathematical models and equations for estimating emissions from several paint, ink, and other coating manufacturing operations. Section 5 of this chapter describes other techniques for estimating emissions such as the use of emission factors and material balances. Section 6 of this chapter presents references.

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## 2.0 Source Category Description

### 2.1 Process Description

This section provides a brief overview of paint, ink, and other coating manufacturing operations. The reader is referred to Control of VOC Emissions from Ink and Paint Manufacturing Processes, April 1992, for additional background information. Paint and ink are suspensions of finely separated pigment particles in a liquid that when spread over a surface in a thin layer will form a solid, cohesive, and adherent film. Types of paints that are currently manufactured include architectural coatings, product finishes (e.g., finishes for automobiles, machinery, metal and wood furniture, and appliances), and special purpose coatings (e.g., industrial new construction and maintenance paints, traffic marking paints, and marine paints). Approximately 80 percent of architectural coatings are water-based (Census Bureau, 1997). However, solvent-based paint is still predominantly used for product finishes and special-purpose coatings. Inks that are currently manufactured include letterpress, lithographic and offset, gravure, and flexographic inks. Letterpress and lithographic inks are typically classified as paste inks. Gravure and flexographic inks are typically water- or solvent-based and are classified as liquid inks (NAPIM, 1996). Specialty ink products include textile and silk screen ink, invisible inks, powder inks, carbon paper, typewriter, and duplicating inks. Paint, ink, and other coating manufacturing can be classified as a batch process and generally involves the blending/mixing of resins, pigments, solvents, and additives. Traditional paint, ink, and other coating manufacturing consists of four major steps:

- Preassembly and premix;
- Pigment grinding/milling/dispersing;
- Product finishing/blending; and
- Product filling/packaging.

These steps are described in more detail in the sections below.

#### 2.1.1 Preassembly and Premix

In the preassembly and premix step, liquid raw materials are assembled and then mixed in containers to form a viscous material to which pigments are added. For solvent-based paints, the raw ingredients include resins, organic solvents, plasticizers, dry pigment, and pigment extenders. Raw materials used in the preassembly and premix step for water-based paints include water, ammonia, dispersant, pigment, and pigment extenders. Raw materials for ink manufacturing include pigments, oils, resins, solvents, and driers. The premix stage results in the formation of an intermediate product that is referred to as the base or mill base. The type of equipment used in the premix step depends on the batch size and the type of coating being

produced. Drums equipped with a portable mixer may be used for drum-sized batches. These mixers normally have an impeller with three or four blades. Other materials made in portable mix tanks may be blended using larger, permanent high-speed dispersers or variable-speed mixers fitted with paddle, propeller, turbine, or disc-type agitators. Coating manufacturing facilities may use typical grinding equipment to accomplish the premix operations. This approach, common with water-based paints and inks, eliminates the need to transfer the material to another type of equipment for the grinding/milling step described below.

### **2.1.2 Pigment Grinding or Milling**

Pigment grinding or milling entails the incorporation of the pigment into the liquid base of the coating to yield a fine particle dispersion. The three stages of this process include wetting, grinding, and dispersion, which may overlap in any grinding operation. The wetting agent, normally a surfactant, wets the pigment particles by displacing air, moisture, and gases that are adsorbed on the surface of the pigment particles. Grinding is the mechanical breakup and separation of pigment clusters into isolated particles and may be facilitated by the use of grinding media such as pebbles, balls, or beads. Finally, dispersion is the movement of wetted particles into the body of the liquid vehicle to produce a particle suspension. There is a wide array of milling equipment. The type of equipment used depends on the types of pigments being handled (Noyes, 1993). More commonly used equipment include the following: roller mills, ball and pebble mills, attritors, sand mills, bead and shot mills, high-speed stone and colloid mills, high-speed dispersers, high-speed impingement mills, and horizontal media mills. However, it should be noted that roller and ball mills are somewhat outdated methods in current pigment base manufacturing technology. Additionally, these types of equipment are usually associated with elevated levels of volatile organic compound (VOC) emissions due to their more open design. Roller mills may have from one to five rolls that grind pigments into vehicles. Most coating manufacturing facilities that use roller mills operate with conventional three-roll mills. Roller mills are labor intensive, requiring highly skilled operators. Their lack of speed and high operating cost make them unsuitable for large-volume production. The use of roller mills is confined to the manufacture of very high quality paint and inks and viscous pigmented products that require fine dispersion and clean color (EPA, 1992a).

High-speed dispersion is the most universally used method of mixing in the paint, ink, and other coating manufacturing industry. Some paint and ink blends are manufactured entirely in one piece of equipment using high-speed, disk-type impellers. Because no grinding media are present in the mixing vat, pigment disperses on itself and against the surfaces of the rotor. While high-speed disk dispersion may work well for some products such as undercoats and primers, it may not be appropriate for high-quality paints and inks. It can, however, be used for premix operations of high-quality paints and inks, thus reducing the number of passes in a media mill or reducing the amount of time spent in a ball mill.

### **2.1.3 Product Finishing**

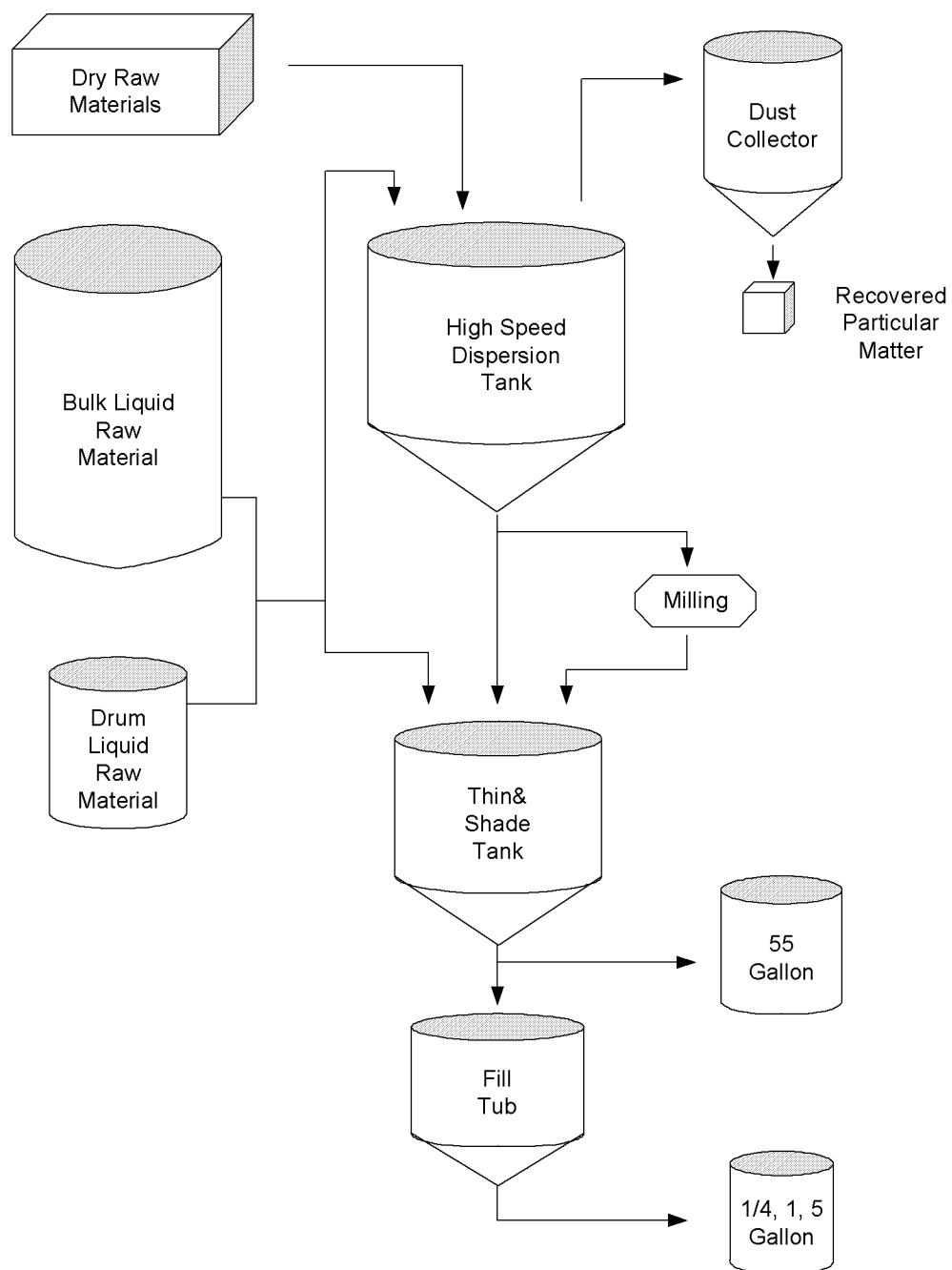
Final product specifications for color, viscosity, and other coating characteristics are achieved in the product finishing step. This process generally consists of thinning, tinting, and blending. Most of the solvents, tints, and shades are added during this operation (Fisher et al., 1993). Product finishing activities for solvent-based paints and inks involve adding various combinations of pigments, organic solvents, and resins. For water-based coatings, a preservative, an antifoaming agent, a polyvinyl acetate emulsion, and water are added at this step of the manufacturing process. Blending is the process of mixing the added ingredients to meet product specifications. Blending may consist of additional milling in a ball mill or added mixing and dispersing in a portable mix tank/high-speed disperser setup.

### **2.1.4 Product Filling**

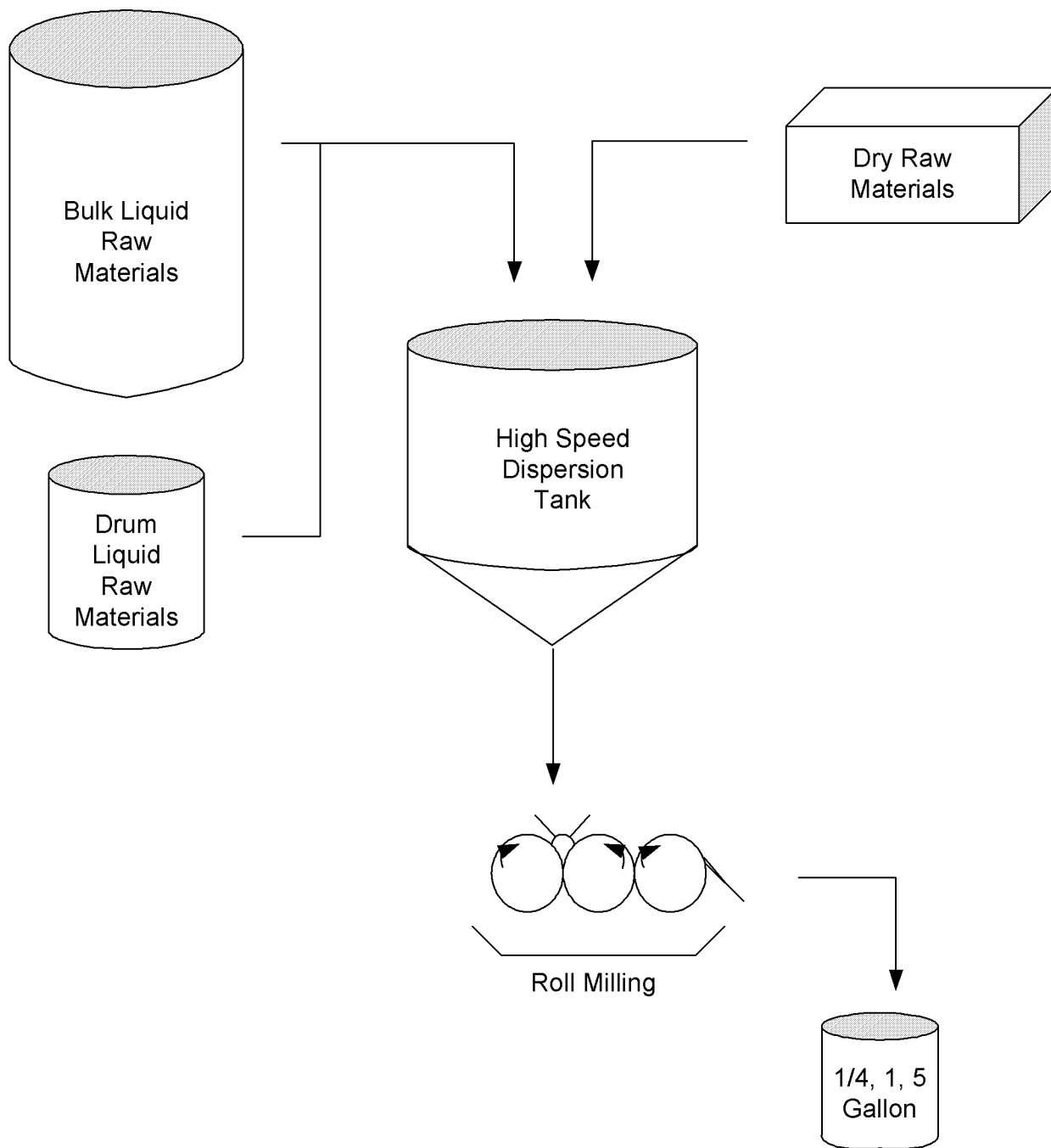
The final step in the paint, ink, and other coating manufacturing process is the product filling operation. During the filling step, filtration is performed to remove impurities and to catch small particles of grinding media. Coatings may be filtered in a variety of ways and the end use of the product determines the type of filtration required. Some products require only a cloth bag filter; other products require filtering equipment such as strainers or sieves (Fisher et al, 1993). Once the material has been filtered, it can be transferred into pails, drums, totes, tank wagons, or other containers for shipment. Filling may be accomplished either manually or mechanically depending on the number and size of the containers to be filled.

### **2.1.5 Basic Flow Sheets for Coating Manufacturing Processes**

Figures 8.2.1 and 8.2.2 present basic paint and ink manufacturing process diagrams.



**Figure 8.2-1. Basic paint manufacturing process flow diagram.**



**Figure 8.2-2. Basic Inks manufacturing process flow diagram.**



## 2.2 Emission Sources

The majority of emissions that occur from paint, ink, and other coating manufacturing operations are from volatile organic compounds (VOCs) that evaporate during manufacturing. Particulate matter emissions may also occur from the handling of solid powders that are used in manufacturing.

Several air emission sources have been identified for paint, ink, and other coating manufacturing operations; they are as follows:

- Process operations
- Related miscellaneous operations
- Material storage
- Equipment leaks
- Spills and other abnormalities

### 2.2.1 Process Operations

Process operations cover emissions from mixing, grinding, blending, and filling activities. Emissions from these operations can generally be classified in one of the following four categories.

**Material Loading Emissions.** VOC emissions may occur during material loading of mixing and grinding equipment due to the displacement of organic vapors. VOCs may be emitted from a mixing tank when the device is uncovered or when a lid is open. For certain grinding equipment, VOCs may be released from the chute through which ingredients are added.

Particulate matter (PM) and PM equal to or less than 10 micrometers in diameter (PM<sub>10</sub>) emissions may also occur during the material loading process from handling of pigments and other solids. VOC and PM emissions during material loading emissions may occur as point source or fugitive, depending on whether a PM emissions collection system is in place.

**Heat-Up Losses.** Heat-up losses occur during the operation of high-speed dispersers, ball and pebble mills, and similar types of dispersing equipment. During the grinding/dispersing process, there is a rise in temperature as some of the kinetic mixing energy is converted to thermal energy. This rise in temperature in many cases is controlled through the use of cold water jackets on the process vessel. As the VOCs in the mixers heat up, the vapor in the headspace expands and leads to solvent emissions from the equipment. Emissions that escape the process equipment through loose fittings or duct connections and enter the room air are considered to be fugitive emissions. Emissions that exit the process equipment through the vent duct to the emissions handling system are considered to be process emissions. (Fisher et al, 1993)

**Surface Evaporation.** Surface evaporation may occur during mixing, dispersing, and blending operations if the vessel contents are exposed to the atmosphere. For certain types of mixing and

grinding equipment, VOCs may be emitted through agitator shaft openings or around the edges of a vessel lid. VOC emissions from older vertical media mills (e.g., sand mills, bead mills, and shot mills) may occur from the exposed filtering screen.

**Filling Losses.** Emissions from product filling occur during transfer and free-fall into the receiving container.

### 2.2.2 Miscellaneous Operations

In addition to typical process operations associated with paint, ink, and other coating manufacturing, miscellaneous operations can generate emissions (primarily in the form of VOCs). These operations are discussed below:

**Solvent Reclamation.** Solvent reclamation refers to the purification of dirty or spent solvent through use of a distillation device. VOC emissions occur from loading solvent into the distillation equipment, operation of the distillation equipment, and spillage. Emissions from loading and spilling are classified as fugitive, while emissions from operation of the equipment are generally discharged through a condenser vent and are thus classified as point source.

**Cleaning.** Cleaning is an important ancillary part of paint, ink, and other coating manufacturing processes. Process equipment may be cleaned with solvent as often as after each batch. VOC emissions result from charging the mixer or disperser with solvent and can be characterized as fugitive. In addition to this type of cleaning, small items used in the process may be cleaned by washing with solvents in a cold cleaner or open-top vapor degreaser. Of the two technologies, the use of a cold cleaner is more common. VOC emissions from this type of cleaning are classified as fugitive.

**Wastewater Treatment.** A paint, ink, or other coating manufacturing facility may use a wastewater treatment system to treat contaminated water generated during the process (e.g., water that has been used to clean equipment used in the production of water-based coating). Wastewater treatment systems generally consist of a series of surface impoundments that are used for equalization, neutralization, aeration, and clarification of the waste stream. Fugitive VOC emissions may occur from each type of basin. Procedures used to estimate emissions from wastewater treatment facilities are described in detail in Volume II, Chapter 5, Preferred and Alternative Methods for Estimating Air Emissions from Wastewater Collection and Treatment.

### 2.2.3 Material Storage

Various types and sizes of storage tanks are used to store solvents and resins used in the paint, ink, and other coating manufacturing processes. Most of these tanks have a fixed-roof design (Fisher et al., 1993). The two significant types of emissions from fixed-roof tanks are breathing and working losses. Breathing loss is the expulsion of vapor from a tank through vapor expansion and contraction that result from changes in ambient temperature and barometric pressure. This loss occurs without any liquid level change in the tank. The combined loss from

filling and emptying tanks is called working loss. Evaporation during filling operations results from an increase in the liquid level in the tank. As the liquid level increases, the pressure inside the tank exceeds the relief pressure and vapors are expelled from the tank. Evaporative emissions during emptying occur when air drawn into the tank during liquid removal becomes saturated with organic vapor and expands, expelling vapor through the vapor relief valve (EPA, 1995a). Emissions from tanks are characterized as a point source because VOCs are released through a vent.

#### **2.2.4 Equipment Leaks**

In order to transport stored materials (e.g., organic solvents and resins) from storage tanks to the paint, ink, or other coating manufacturing operation, a network of pipes, pumps, valves, and flanges is employed. As liquid material is pumped from the storage tanks to the particular process area, the pipes and supporting hardware (process line components) may develop leaks over time. When leaks occur, volatile components in the transported material are released to the atmosphere. This generally occurs from the following process line components:

- Pump seals
- Valves
- Compressor seals
- Safety relief valves
- Flanges
- Open-ended lines
- Sampling connections.

Emissions from equipment leaks can be characterized as fugitive and are described in detail in Volume II, Chapter 4, Preferred and Alternative Methods for Estimating Fugitive Emissions from Equipment Leaks. Emission factors for pumps, valves, and connectors at coating manufacturing facilities are also discussed in section 5.1.6 of this chapter.

#### **2.2.5 Spills**

Solvents, resins, or product may be accidentally spilled during manufacturing or cleaning activities. Materials that are spilled onto the ground may spread over an area, vaporize, and thus result in an air emission (EPA, 1987). Such an emission would be characterized as fugitive.

### **2.3 Process Design and Operating Factors Influencing Emissions**

VOC and PM emissions from paint, ink, and other coating manufacturing may be reduced through the use of add-on control systems or through equipment and process modifications.

### 2.3.1 VOC Control Systems

A VOC control system typically consists of a capture device and a removal device. The capture device (such as a hood or enclosure) captures the VOC-laden air from the emission area and ducts the exhaust air stream to removal equipment such as a recovery device or a destructive control device. In either case, the purpose of the control device is to remove VOCs from the exhaust air stream. The overall efficiency of a control system is a function of the specific removal efficiency for each device in the system.

Example recovery devices:

1. Condensers are one of the most frequently used control devices in industry. They work by reducing the temperature of the emission exhaust gas to a cold enough temperature so that VOC vapors are recovered through condensation. One problem that is frequently encountered in the coating manufacturing industries is that the solvent vapors in the emission exhaust gas may have a fairly low dew point temperature. This is because normal processing temperatures are generally low and many exhaust systems provide a high level of dilution from outside air that further reduces the dew point temperature of the gas.
2. Adsorption Devices that incorporate activated carbon are capable of removing VOC vapors from exhaust emission streams to very low levels in the final gas stream. Large scale adsorption based recovery systems normally have two or more activated carbon adsorption chambers. One carbon chamber is being used to remove VOCs from an emission stream while the spent carbon chamber is being regenerated. VOCs are recovered from the system during the regeneration phase. Steam is routed into the saturated carbon bed to cause the VOCs to desorb from the carbon and condense at the condenser. Once VOC liquids have been collected then they may be recycled or further purified prior to reuse in the manufacturing operation.
3. Dust collectors are used to collect particulate matter from the emission stream. Dust collectors are constructed in many different designs. However, one style that is commonly used in the coating manufacturing industry is a bag house design. A bag house consists of a large rectangular housing with many internal banks of vertically mounted filter bags. The emission stream enters the bag house through the side inlet, passes through the bag filter media, and exits the unit through the discharge port at the top. Particulate matter builds up on the filter media until it is shaken off by pulses of compressed air from within each bag. The dust that falls from the bags during the pulsing process is collected at the lower section of the bag house and finally discharged through the solids outlet to a drum or other container. When designing a bag house for an installation it is important to select the appropriate filter media and surface area for the particulate matter to be collected. The pore size of the filter cloth will determine the removal efficiency of the overall unit.

4. A floating roof on a storage tank helps to reduce solvent emissions by eliminating the headspace that is present in conventional storage tanks. For the conventional storage tank, air that is saturated with solvent vapors exits the vessel as the surrounding temperature increases during the day. Outside air then reenters the vessel during the evening hours as the surrounding temperature decreases and the daily cycle prepares to be repeated. Additionally, when a conventional storage tank is filled periodically then emissions occur by way of displacement. A floating roof moves up and down the vessel vertical walls as the level of the storage tank changes. Since the vessel contains no headspace all breathing and filling losses are avoided.

Example destructive control devices:

1. Catalytic Incinerators are used to reduce VOCs from process exhaust gases from paint spray booths, ovens, and other process operations. The catalyst section operates at between 315°C to 400°C to convert VOC to CO<sub>2</sub> and H<sub>2</sub>O. A properly designed and installed system can achieve a VOC destruction efficiency of greater than 95%.
2. Thermal Incinerators control VOC levels in a gas stream by passing the stream through a combustion chamber where the VOCs are burned in air at temperatures between 700°C to 1,300°C. Fuel is burned in the unit to supply the necessary heat for decomposition of the VOC's. Heat exchangers may also be installed as part of the unit to conserve energy by warming the inlet air stream with the hot exhaust gases.
3. Venturi Scrubbers are used to remove particulate material from vent exhaust streams. These units normally incorporate a spray nozzle section where liquid is discharged at a high velocity, a mixing section where liquid droplets contact the incoming emission gas stream, and a settling/separation section where scrubber fluid is recycled to the inlet spray nozzle and the exit gas is discharged to the atmosphere or to a secondary control device.
4. Enclosed Oxidizing Flares convert VOCs into CO<sub>2</sub> and H<sub>2</sub>O by way of direct combustion. Normally an enclosed oxidizing flare is used when the waste gas is rich enough in organic content to be its own fuel source. If the process gas stream does not contain an adequate level of combustible VOCs then additional fuel must be supplied for effective operation.

The removal efficiency for each control device is a function of the specific design of the unit and how well its capability matches the intended application. Before selecting pollution equipment one should consult different manufacturers and/or engineering firms to determine the most appropriate control device solution for a given application.

### 2.3.2 PM/PM10 Control Systems

PM/PM10 control systems for the paint, ink, and other coatings manufacturing industry consist of a capture device paired with a control device that is typically a fabric filter (bag house). These systems are typically employed to reduce PM emissions from charging pigments and other solids into mixing and grinding devices. The captured dust may be recycled or sent for off-site disposal or treatment.

Bag houses remove particulate material from an emission gas stream by passing the emission stream through engineered fabric filter tubes, envelopes, or cartridges. Particulate material is retained on the filter media as the clean air is discharged to the atmosphere. Vibrators or timed air blast are used for removing and discharging the dust that has been collected in the unit. When identifying a bag house for an application it is important to consider the particle size in the emission stream, the particle size control requirements, the air flow rate of the emission stream, and the bag filter surface area requirements. Additionally, it is important to identify the appropriate chemical resistance requirements for the materials of construction in the unit.

Fabric filters are least efficient with particles 0.1 to 0.3  $\mu\text{m}$  in diameter and with emission streams of high moisture content. When operated under optimum conditions, they can generally achieve control efficiencies of up to 99+ percent (EIIP, 2000). However, typical control efficiencies range from 95 to 99 percent.

### 2.3.3 Equipment or Process Modifications

Most coatings manufacturing facilities reduce VOC emissions through equipment or process modifications. Some of these techniques will also reduce PM emissions. Modifications include those discussed below.

**Tank Lids.** Tank lids are the most common equipment modification used during paint, ink, and other coating manufacturing activities to control VOC emissions.

**Modified Milling Equipment.** VOC and PM emissions may be reduced by converting older milling equipment to closed systems.

**Use of Pigments in Paste Form.** PM emissions may be reduced by using pigments that have been wetted or mixed with resins. Since these pigments are wet, dust is not generated when the package is opened and as pigment is dumped into mixing vessels (Noyes, 1993).

**Product Reformulation.** Production of coatings that contain reduced or no VOCs will reduce VOC emissions from coatings manufacturing facilities. High-solids and water-based coatings contain less VOCs than traditional solvent-based products. Powder coatings and the majority of radiation-curable paints and inks contain no VOCs.

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## 3.0 Overview of Available Methods

### 3.1 Emission Estimation Methods

Several methods are available for calculating emissions from paint, ink, and other coating manufacturing operations. The best method to use depends upon the emission source being evaluated, available data, how the estimates will be used, and the degree of accuracy required in the estimate. Although multiple methods are identified for some operations, this document does not mandate any emission estimation method. Industry personnel using this manual should contact the appropriate state or local air pollution control agency regarding suggested methods prior to their use.

This section discusses the methods available for calculating emissions from paint, ink, and other coating manufacturing operations. A discussion of the sampling and analytical methods available for monitoring each pollutant is provided in Chapter 1 of this volume, *Introduction to Point Source Emission Inventory Development*.

Estimation techniques for storage tank emissions are discussed in Chapter 1 of this volume, and procedures for estimating emissions from wastewater are described in Chapter 5. This chapter focuses on estimating emissions from process operations, miscellaneous operations, and spills. This chapter also presents equipment leak emission factors for coating manufacturing; additional equations and factors for calculating emissions from equipment leaks are discussed in Chapter 4.

#### 3.1.1 Emission Factors

An emission factor can be defined as a pollutant emission rate relative to a level of source activity. Emission factors are typically based on the results of source tests performed at an individual plant or at one or more facilities within an industry. Chapter 1 of this volume contains a detailed discussion of the reliability/quality of available emission factors.

Emission factors may be used to calculate total VOC and PM emissions from a paint and ink manufacturing facility, as well as emissions from specific types of equipment typically found at such a facility. These types of equipment include the following:

- Process equipment;
- Solvent reclamation systems;
- Parts washing equipment; and
- Process piping.



EPA-approved emission factors for these sources may be found in *AP-42*, the *Locating and Estimating* series of documents, the Factor Information and REtrieval (FIRE) System, and/or *Protocol for Equipment Leak Emission Estimates* (EPA, 1995g). Emission factors may also be available through trade associations such as the National Association of Printing Ink Manufacturers, Inc. (NAPIM).

Use of paint manufacturing emission factors from Section 6.4 of *AP-42* and ink manufacturing emission factors from Section 6.7 of *AP-42* is generally accepted by regulatory agencies, and their use in calculating total facility or process-specific emissions is more cost-effective than collection and analysis of air samples or use of emission models. Additionally, there are potentially significant limitations with the material balance approach.

### 3.1.2 Source-Specific Models

Theoretical, more complex “models” or equations can be used for estimating emissions. Use of emission models/equations to estimate emissions from paint, ink, and other coating manufacturing facilities is a more complex and time-consuming process than the use of emission factors. Emission models/equations require more detailed inputs than use of emission factors; however, they provide emission estimates based on site-specific conditions.

Emission estimating models/equations are available for the following types of emissions found at paint, ink, or other coating manufacturing facilities:

- Material loading
- Heat-up losses from dispersion/grinding activities
- Surface evaporation during mixing/blending operations
- Filling
- Gas sweep or purge
- Cleaning solvent loading
- Solvent reclamation
- Material storage
- Spills
- Wastewater treatment.

Inputs for theoretical models/equations generally fall into the following categories: chemical/physical properties of the material(s) involved (e.g., vapor pressure, vapor molecular weight), operating data (e.g., amount of material processed, operating hours) and physical characteristics/properties of the source (e.g., tank color, tank diameter).

### 3.1.3 Material (Mass) Balance Calculations

The material balance approach to emissions estimation considers the given facility as a sort of “black box,” where one compares the total quantity of raw materials consumed versus amounts of materials leaving the facility as product or waste. Waste can consist of used filter bags or

cartridges, spent solvent or still bottoms, dust collector material, pigment bags and/or drum residue, and wastewater (NPCA, 1995).

Calculating emissions from a paint or ink manufacturing facility using material balance appears to represent a straightforward approach to emissions estimations. However, few facilities track material usage and waste generation with the overall accuracy needed for application of this method, and inaccuracies associated with individual material tracking or other activities inherent to each material handling step often accumulate into large deviations. Because emissions from specific materials are typically below 1.5 percent of gross consumption, an error of only  $\pm 5.0$  percent in any one step of the operation can significantly skew emissions calculations. Potential sources of error in the material balance calculation method include the following:

- The delivery of bulk raw materials at a paint or ink manufacturing facility is often tracked by volume, not by weight. Since density will vary with temperatures, the actual mass per unit volume of materials delivered in the summer may be less than that received in the winter.
- Raw materials received by paint or ink manufacturing facilities may potentially be used in hundreds or thousands of finished products. In order to complete the material balance, it is crucial that the exact quantity and speciation of each material shipped off-site in the product be known. For many facilities, it is extremely difficult, to accurately track the distribution of specific raw materials across their entire product line.
- The amount of raw material contained in waste must also be considered. This may involve precise analysis of the concentration of the material of interest in each waste stream.
- Batch production of paint or ink often requires the manual addition of raw materials. Sometimes these additions are not accurately measured or recorded (NPCA, 1995).

### 3.1.4 Test Data

Testing can be performed to quantify point source or fugitive emissions. In point source testing, effluent gas samples are usually collected from a stack using probes inserted through a port in the stack wall. Pollutants in the gas sample are collected in or on various media that are subsequently sent to a laboratory for analysis. Pollutant concentrations are obtained by dividing the amount of pollutant collected during the test by the volume of gas sampled. Emission rates are then determined by multiplying the pollutant concentration by the volumetric stack gas flow rate. Because there are many steps in the stack sampling procedures where errors can occur, only experienced stack testers should perform such tests.

Industrial hygiene data (concentrations) can be used in conjunction with exhaust system flow rates to calculate fugitive emissions from a room, floor, or building. Direct-reading instruments

that may be used to obtain an instantaneous reading of vapor concentrations include photoionization detectors, portable infrared spectrophotometers, and portable gas chromatographs (NPCA, 1995).

Use of stack and/or industrial hygiene test data is likely to be the most accurate method of quantifying air emissions from paint, ink, and other coating manufacturing operations. However, collection and analysis of air samples from manufacturing facilities can be very expensive and especially complicated for coating manufacturing facilities where a variety of VOCs are emitted and where most of the emissions may be fugitive in nature. Test data from one specific process may not be representative of the entire manufacturing operation and may provide only one example (a snapshot) of the facility's emissions.

To be representative, test data would need to be collected over a period of time that covers production of multiple coating formulations. It may be necessary to sample multiple production areas. In addition, these methods do not address fugitive emissions that occur outside of a building. If testing is performed, care should be taken to ensure that a representative operational cycle has been selected. If possible, full cycles should be monitored as opposed to portions of cycles.

VOC losses from certain operations (e.g., filling of containers) may also be measured by performing a study using a gravimetric analysis such as American Society for Testing and Materials (ASTM) Standard D2369: *Test Method for Volatile Content of Coatings*.

Chapter 1 of Volume II in this series provide information regarding test data quality.

### **3.2 Comparison of Available Emission Estimation Methodologies**

The best method to use depends upon the emission source being evaluated, available data, how the estimates will be used, and the degree of accuracy required in the estimate. In general, a more accurate method will require greater resources than a less accurate method. Case study 8.3-1 presents estimates for all of the operation at a paint manufacturing facility. For some operations, multiple estimates are provided showing the impact of different techniques on the results.

Case Study 8.3-1: The Bright Blue Paint CompanyDescription

The Bright Blue Paint Company produces a variety of related paint products that can be considered to have similar formulations. The total production rate is about 2,500,000 gal/yr.

The four main manufacturing operations at the Bright Blue Paint Company are:

- Preassembly and premix;
- Pigment grinding/milling;
- Product finishing/blending; and
- Product filling/packaging.

The batch begins with mixing of raw materials in a high speed disperser. The material from the disperser is then transformed to a thindown tank where additional solvent is added. The final product is then transferred to shipping containers. Total batch size is about 1,700 gallons.

Liquid storage of paint ingredients and cleaning compounds is in bulk tanks ranging from 2,500 to 10,000 gallons and in 55-gallon drums. Powder ingredients are stored in paper sacks or fiber drums ranging from 10 to 200 pounds.

Equipment is cleaned after each batch. Approximately 75,000 gallons of cleaning solvents are used for equipment cleaning each year. Small parts are also cleaned as necessary using an open-top vapor degreaser.

Emission Sources

Emission sources for this facility include:

- Mixing (material loading, heat-up, gas sweep, and surface evaporation);
- Filling losses;
- Cleaning (parts, mixers/tanks);
- Solvent reclamation;
- Material storage;
- Equipment leaks; and
- Spills.

Emissions

Emissions, the emission estimation method selected, and supporting data for this facility are summarized in Table 8.3-1.

**Table 8.3-1. Estimated VOC Emissions Summary for the Bright Blue Paint Company**

Emission Event	VOC Emissions, lb/yr			Data and Assumptions
	A	B	C	
Filling dispersion vessels  A: Saturation factor = 0.6 B: Saturation factor = 1.0 C: Saturation factor = 1.45 (Equation 8.4-1)	2683	4472	6485	<ul style="list-style-type: none"> <li>1,008,000 gal toluene</li> <li>564,000 gal MEK</li> <li>2,200,000 gal mixture of solvents and solids</li> <li>All materials added simultaneously</li> <li>T = 77°F (537°R)</li> <li>VP (toluene) = 0.58 psia</li> <li>VP (MEK) = 1.93 psia</li> <li>MW (toluene) = 92.1</li> <li>MW (MEK) = 72.1</li> </ul>
Gas sweep through dispersion vessels while loading solids  A: Option 2 S=0.774 for toluene S=0.788 for MEK (Equation 8.4-32) C: Option 1 (Equation 8.4-23)	11600		14814	<ul style="list-style-type: none"> <li>Average liquid mole fractions are same as for filling the vessels</li> <li>Sweep rate = 10 ft<sup>3</sup>/min</li> <li>Diameter of vessels = 7 ft</li> <li>T = 77°F (537°R)</li> <li>Sweep time = 1 hr/batch</li> <li>1,500 batches/yr</li> </ul>
Heat up in dispersion vessels due to mixing  A: Option 2 (Equation 8.4-15) C: Option 1 (Equation 8.4-10)	412		417	<ul style="list-style-type: none"> <li>Initial T = 77°F (537°R)</li> <li>Final T = 105°F (565°R)</li> <li>Average liquid mole fractions are same as for filling the vessels</li> <li>VP<sub>T<sub>2</sub></sub> (toluene) = 1.16 psia</li> <li>VP<sub>T<sub>2</sub></sub> (MEK) = 3.75 psia</li> <li>Sum of partial pressure for toluene and MEK at 105°F = 2.195 psia</li> </ul>
Mixing in dispersion vessels after sweep is turned off (surface evaporation)  B: K based on gas velocity (Equations 8.4-21 and 8.4-22)		2089		<ul style="list-style-type: none"> <li>batch time after sweep is turned off = 5 hours</li> <li>final temperature has been reached by the time the gas sweep is turned off (thus, T = 105°F [565°R])</li> <li>gas velocity above the vessel is determined to be 0.25 mph</li> <li>area of annulus in cover around the agitator shaft = 3 ft<sup>2</sup>.</li> </ul>

**Table 8.3-1. (continued)**

Emission Event	VOC Emissions, lb/yr			Data and Assumptions
	A	B	C	
Transfer contents of dispersion vessels to thindown tanks  A: Saturation factor = 0.6 B: Saturation factor = 1.0 C: Saturation factor = 1.45 (Equation 8.4-1)	5011	8352	12111	<ul style="list-style-type: none"> <li>T = 105°F (565°R)</li> <li>quantity transferred = 2,200,000 gal</li> </ul>
Add Toluene to thindown tanks  A: saturation factor = 0.6 B: saturation factor = 1.0 C: saturation factor = 1.45 (Equation 8.4-1)	355	592	859	<ul style="list-style-type: none"> <li>T = 77°F (537°R)</li> <li>quantity added = 200 gal/batch</li> </ul>
Holding/mixing in thindown tank  B: K based as gas velocity (Equations 8.4-21 and 8.4-22)		1048		<ul style="list-style-type: none"> <li>hold for 5 hours</li> <li>T = 77°F (537°R)</li> <li>gas velocity above vessel estimated to be 0.25 mph</li> <li>area of annulus in cover around the agitator shaft = 3ft<sup>2</sup></li> </ul>
Product loading  A: saturation factor = 0.6 B: saturation factor = 1.0 C: saturation factor = 1.45 (Equation 8.4-1)	2870	4784	6937	<ul style="list-style-type: none"> <li>total volume loaded = 2,500,000 gal/yr</li> <li>T = 77°F (537°R)</li> <li>sum of partial pressures from VOC's at 77°F = 1.0375 psia</li> </ul>
Cleaning (solvent flush)  A: saturation factor = 0.6 B: saturation factor = 1.0 C: saturation factor = 1.45 (Equation 8.4-1)	56	93	135	<ul style="list-style-type: none"> <li>total amount of solvent used = 75,000 gal/yr</li> <li>solvent is toluene</li> <li>T = 77°F (537°R)</li> </ul>
Small parts cleaning  B: AP-42 emission factor (Equation 8.5-13)		660		<ul style="list-style-type: none"> <li>one open top vapor degreaser</li> <li>AP-42 emission factor = 0.33 ton/yr/unit</li> </ul>

**Table 8.3-1. (continued)**

Emission Event	VOC Emissions, lb/yr			Data and Assumptions
	A	B	C	
Solvent reclamation  A: Modeling (Equations 8.4-1 and 8.4-34) C: AP-42 emission factor (Equation 8.4-8)	319		990	<ul style="list-style-type: none"> <li>• 300 tons of waste toluene cleaning solvent processed annually</li> <li>• see example 8.4-10</li> </ul>
Material storage  B: using TANKS program		6000		
Equipment leaks  B: Emission factors in section 5.1.6		949		<ul style="list-style-type: none"> <li>• 15 valves</li> <li>• 10 pumps</li> <li>• 50 connectors</li> <li>• 8760 hr/yr</li> <li>• see example 8.5-8</li> </ul>
Spills  B: Equation 8.4-19		18		<ul style="list-style-type: none"> <li>• One MEK spill outdoors</li> <li>• T = 77°F (537°R)</li> <li>• Area of spill = 15 ft<sup>2</sup></li> <li>• windspeed at 10 m above the surface = 8 mph</li> <li>• cleanup time = 1 hr</li> </ul>
Totals	34,070 to 53,512			

## 4.0 Modeling Methods for Estimating Emissions

Models/equations for estimating VOC emissions, including HAP, from paint, ink, and other coating manufacturing operations are presented in this section. This section describes these methodologies and provides examples to illustrate the use of each calculation technique.

Source-specific emission models/equations are presented for estimating VOC emissions from:

- Mixing operations (material loading, heat-up losses, and surface evaporation),
- Product filling,
- Vessel cleaning operations,
- Gas sweep or purge,
- Wastewater treatment processes,
- Solvent reclamation,
- Material storage, and
- Spills.

Models for these operations are discussed with examples given below. For additional guidance on estimating emissions from wastewater collection and treatment, see Chapter 5 of this volume. See also Chapter 1 of this volume for additional guidance on material storage.

It is not recommended that paint, ink, and other coating manufacturing facilities apply these models to each of the hundreds or even thousands of different formulations. Rather, formulations should be grouped based on composition and production rate, and a representative recipe and composition should be defined for each group. The emission calculations are then performed for each of the group representatives. In general, there are no specific guidelines for defining product groups except that each product group composition should be fairly characteristic of its components (Fisher et al., 1993).

Table 8.4-1 lists the variables used in Equations 8.4-1 through 8.4-27.



**Table 8.4-1. List of Variables and Symbols**

Variable	Symbol	Units
Total VOC emissions	$E_{\text{VOC}}$	lb/yr
Saturation factor	$S$	dimensionless
Vapor pressure of the material loaded	$P$	pounds per square inch absolute (psia)
Vapor molecular weight	$M$	lb/lb-mole
Volume of material loaded	$Q$	1,000 gal/yr
Temperature	$T$	°R
Partial vapor pressure of VOC species x	$P_x$	psia
Liquid mole fraction of VOC species x	$m_x$	mole/mole
True vapor pressure of VOC species x	$VP_x$	psia
Henry's Law constant for VOC species x	$H_x$	psia
Liquid mass fraction of VOC species x	$z_x$	lb/lb
Molecular weight of VOC species x	$M_x$	lb/lb-mole
Vapor mole fraction of VOC species x	$y_x$	mole/mole
Loading emissions of VOC species x	$E_x$	lb/yr
Vapor mass fraction of VOC species x	$x_x$	lb/lb
Initial partial pressure of VOC species x	$(P_x)_{T1}$	psia
Final partial pressure of VOC species x	$(P_x)_{T2}$	psia
Number of pound-moles of gas displaced	$\Delta n$	lb-mole/cycle
Vapor molecular weight, average	$M_a$	lb/lb-mole
Number of cycles/year	CYC	cycles/yr
Volume of free space in vessel	$V$	ft <sup>3</sup>
Universal gas constant at 1 atmosphere of pressure	$R$	10.73 psia- ft <sup>3</sup> /°R-lb mole
Initial noncondensable gas partial pressure in vessel	$Pa_1$	psia
Final noncondensable gas partial pressure in vessel	$Pa_2$	psia
Initial temperature of vessel	$T1$	°R
Final temperature of vessel	$T2$	°R
Moles of VOC species x leaving vessel per batch	$N_{x,\text{out}}$	lb-mole

**Table 8.4-1. (continued)**

Variable	Symbol	Units
Average molar volume in gas space during heating	$N_{avg}$	lb-mole
Initial moles of VOC species x in gas space	$n_{x,1}$	lb-mole
Final moles of VOC species x in gas space	$n_{x,2}$	lb-mole
Initial system pressure	$P_1$	psia
Final system pressure	$P_2$	psia
Initial total moles in gas space	$n_1$	lb-mole
Final total moles in gas space	$n_2$	lb-mole
Gas-phase mass transfer coefficient for VOC species x	$K_x$	ft/sec
Surface area (of spill or tank)	$A$	ft <sup>2</sup>
Duration of spill	HR	hr/event
Wind speed	$U$	mile/hr
Diffusion coefficient for VOC species x in air	$D_x$	ft <sup>2</sup> /sec
Batch time	$H$	hr/batch
Number of batches per year	$B$	batches/yr
Flow rate of noncondensable gas into vessel	$F_{nc}$	ft <sup>3</sup> /min
Total system pressure	$P_T$	psia
Flow rate of VOC species x out of vessel at saturated vapor pressure	$F_x^{sat}$	ft <sup>3</sup> /min
Partial pressure of VOC species x in a saturated gas stream	$P_x^{sat}$	psia
Mass transfer coefficient for a reference compound	$K_o$	cm/s
Mass transfer coefficient for VOC species x	$K_x$	cm/s
Molecular weight of reference compound	$M_o$	lb/lb-mole
Operating Hours	OH	hr/yr

#### 4.1 Emission Model for Material Loading

VOC emissions resulting from the addition of materials to mixers, grinding equipment, and thindown tanks may be calculated using a modification of the loading loss equation (which is presented in Section 5.2 of *AP-42*; EPA, 1995c). This equation, shown below as Equation 8.4-1, is related to tank car or tank truck loading, but can be applied to any tank or vessel loading (NPCA, 1995). This equation may also be applied to estimate product filling losses.

$$E_{\text{VOC}} = 12.46 \times \frac{S \times P \times M \times Q}{T} \quad (8.4-1)$$

where

$E_{\text{VOC}}$	=	total VOC loading emissions (lb/yr)
$S$	=	saturation factor (dimensionless; see Table 5.2-1 in <i>AP-42</i> )
$P$	=	vapor pressure of the material loaded at temperature $T$ (psia)
$M$	=	vapor molecular weight (lb/lb-mole)
$Q$	=	volume of material loaded (1,000 gal/yr)
$T$	=	temperature of liquid loaded ( $^{\circ}\text{R}$ ).

The constant in equation 8.4-1 is a function of the units used for other variables in the equation. The table below shows the constant that would apply if some of the variables are available in other units.

Constant	P	M	Q	T
12.46	psia	lb/lb-mole	1,000 gal	$^{\circ}\text{R}$
0.241	mm Hg	lb/lb-mole	1,000 gal	$^{\circ}\text{R}$
6.92	psia	lb/lb-mole	1,000 gal	$^{\circ}\text{K}$

Calculation of VOC emissions using Equation 8.4-1 is based on the following assumptions:

- The vapors displaced from the process vessel are identical to the vapors from the materials being loaded;
- The volume of vapor displaced is equal to the volume of material loaded into the vessel; and
- All solvent additions are coincident at a constant temperature (in reality, solvent additions may be phased) (Fisher et al., 1993).

An alternative to using the AP-42 saturation factor when material is added by submerged loading is to assume the vapor space in the vessel is saturated with the solvent vapors (i.e., equivalent to  $S = 1$ ). This assumption is a conservative approach that would ensure that emissions are not underestimated.

If multiple solvents are used, the vapor pressure ( $P$ ) will need to be calculated using Equation 8.4-2:

$$P = \sum P_x \quad (8.4-2)$$

where

$$\begin{aligned} P &= \text{vapor pressure of material loaded (psia)} \\ P_x &= \text{partial pressure of VOC species } x \text{ (psia).} \end{aligned}$$

$P_x$  may be calculated using Raoult's Law (for ideal solutions) or using Henry's Law constants (when gases are dissolved at low concentrations in water). Raoult's Law is given in Equation 8.4-3:

$$P_x = m_x \times VP_x \quad (8.4-3)$$

where

$$\begin{aligned} P_x &= \text{partial vapor pressure of VOC species } x \text{ (psia)} \\ m_x &= \text{liquid mole fraction of VOC species } x \text{ (mole/mole)} \\ VP_x &= \text{true vapor pressure of VOC species } x \text{ (psia).} \end{aligned}$$

$P_x$  may be calculated using Henry's Law constants and Equation 8.4-4:

$$P_x = m_x \times H_x \quad (8.4-4)$$

where

$$\begin{aligned} P_x &= \text{partial vapor pressure of VOC species } x \text{ (psia)} \\ m_x &= \text{liquid mole fraction of VOC species } x \text{ (mole/mole)} \\ H_x &= \text{Henry's Law constant for VOC species } x. \end{aligned}$$

The liquid mole fraction of VOC species  $x$  ( $m_x$ ) may be calculated if the liquid weight fractions of all species are known. Equation 8.4-5 is used:

$$m_x = \frac{z_x/M_x}{\Sigma(z_x/M_x)} \quad (8.4-5)$$

where

$$\begin{aligned} m_x &= \text{liquid mole fraction of VOC species } x \text{ (mole/mole)} \\ z_x &= \text{liquid mass fraction of VOC species } x \text{ (lb/lb)} \\ M_x &= \text{molecular weight of VOC species } x \text{ (lb/lb-mole).} \end{aligned}$$

The vapor molecular weight ( $M$ ) will also need to be calculated if multiple solvents are used for a single cleaning event. Equation 8.4-6 may be used:

$$M = \Sigma(y_x \times M_x) \quad (8.4-6)$$

where

$M$	=	vapor molecular weight (lb/lb-mole)
$y_x$	=	vapor mole fraction of VOC species x (mole/mole)
$M_x$	=	molecular weight of VOC species x (lb/lb-mole).

The vapor mole fraction ( $y_x$ ) is calculated using Equation 8.4-7:

$$y_x = \frac{P_x}{P} \quad (8.4-7)$$

where

$y_x$	=	vapor mole fraction of VOC species x (mole/mole)
$P_x$	=	partial pressure of VOC species x (calculated using Equation 8.4-3 or 8.4-4) (psia)
$P$	=	vapor pressure of the material loaded (calculated using Equation 8.4-2).

Speciated VOC emissions are calculated using Equation 8.4-8:

$$E_x = E_{\text{VOC}} \times x_x \quad (8.4-8)$$

where

$E_x$	=	loading emissions of VOC species x (lb/yr)
$E_{\text{VOC}}$	=	total VOC loading emissions, calculated using Equation 8.4-1 (lb/yr)
$x_x$	=	vapor mass fraction of VOC species x (lb/lb).

The vapor mass fraction of VOC species x ( $x_x$ ) is calculated using Equation 8.4-9:

$$x_x = \frac{y_x \times M_x}{M} \quad (8.4-9)$$

where

$x_x$	=	vapor mass fraction of VOC species x (lb/lb)
$y_x$	=	vapor mole fraction of VOC species x, calculated using Equation 8.4-7 (mole/mole)
$M_x$	=	molecular weight of VOC species x (lb/lb-mole)
$M$	=	vapor molecular weight, calculated using Equation 8.4-6 (lb/lb-mole).

**Example 8.4-1**

A mixing vessel is cleaned with a solvent mixture at the end of each day. The following data are given:

- The yearly consumption of the solvent mixture (Q) is 600,000 gal;
- The cleaning solvent is a 50/50 mixture (by weight) of toluene and heptane;
- The solvent mixture is splash loaded into the vessel ( $S = 1.45$ ); and
- The temperature of the solvent is 77°F or 537°R  
(°R = °F + 460).

Example 8.4-1 illustrates the use of the loading equation (Equation 8.4-1) and the supplemental equations (Equations 8.4-2 through 8.4-9).

Emissions are calculated by following Steps 1 through 8 below.

**Step 1: Apply Equation 8.4-5 - Calculation of Liquid Mole Fraction ( $m_x$ )**

Component	Liquid Mass Fraction, $z_x$ (lb of x/lb of liquid)	Molecular Weight, $M_x$ (lb of x/lb-mole of x)	Liquid Mole Fraction, $m_x$ (mole of x/mole of liquid)
Toluene	0.5	92	$\frac{z_x/M_x}{\sum(z_x/M_x)} = \frac{(0.5 / 92)}{[(0.5/92) + (0.5/100)]}$ $= 0.52$
Heptane	0.5	100	$\frac{z_x/M_x}{\sum(z_x/M_x)} = \frac{(0.5 / 100)}{[(0.5/92) + (0.5/100)]}$ $= 0.48$

**Step 2: Apply Equation 8.4-3 - Calculation of Partial Vapor Pressure ( $P_x$ )**

Component	Liquid Mole Fraction, $m_x$ (mole of x/mole of liquid)	Vapor Pressure, $VP_x$ (psia)	Partial Vapor Pressure, $P_x$ (psia)
Toluene	0.52	0.58	$m_x \times VP_x = 0.52 \times 0.58$ $= 0.30$
Heptane	0.48	0.9	$m_x \times VP_x = 0.48 \times 0.90$ $= 0.43$

**Step 3: Apply Equation 8.4-2 - Calculation of Vapor Pressure (P)**

$$\begin{aligned}
 P &= \Sigma P_x \\
 &= 0.30 + 0.43 \\
 &= 0.73 \text{ psia}
 \end{aligned}$$

**Step 4: Apply Equation 8.4-7 - Calculation of Vapor Mole Fraction ( $y_x$ )**

Component	Partial Vapor Pressure, $P_x$ (psia)	Total Vapor Pressure, P (psia)	Vapor Mole Fraction, $y_x$ (mole of x/mole of vapor)
Toluene	0.3	0.73	$\frac{P_x}{P} = \frac{0.30}{0.73}$ $= 0.41$
Heptane	0.43	0.73	$\frac{P_x}{P} = \frac{0.43}{0.73}$ $= 0.59$

**Step 5: Apply Equation 8.4-6 - Calculation of Vapor Molecular Weight (M)**

$$\begin{aligned}
 M &= \Sigma(y_x \times M_x) \\
 &= (0.41 \times 92) + (0.59 \times 100) \\
 &= 97 \text{ lb/lb-mole}
 \end{aligned}$$

**Step 6: Apply Equation 8.4-9 - Calculation of Vapor Mass Fraction ( $x_x$ )**

Component	Vapor Mole Fraction, $y_x$ (mole of x/mole of vapor)	Molecular Weight, $M_x$ (lb of x/lb-mole of x)	Vapor Molecular Weight, $M$ (lb of vapor/lb-mole of vapor)	Vapor Mass Fraction, $x_x$ (lb of x/lb of vapor)
Toluene	0.41	92	97	$\frac{y_x \times M_x}{M} = \frac{0.41 \times 92}{97}$ $= 0.39$
Heptane	0.59	100	97	$\frac{y_x \times M_x}{M} = \frac{0.59 \times 100}{97}$ $= 0.61$

**Step 7: Apply Equation 8.4-1 - Calculate Total VOC Emissions ( $E_{\text{VOC}}$ )**

$$\begin{aligned}
 E_{\text{VOC}} &= 12.46 \times \frac{S \times P \times M \times Q}{T} \\
 &= 12.46 \times \frac{1.45 \times 0.73 \times 97 \times 600}{537} \\
 &= 1,429 \text{ lb VOCs/yr}
 \end{aligned}$$

**Step 8: Apply Equation 8.4-8 - Calculate Speciated VOC Emissions ( $E_x$ )**

Component	VOC Emissions, $E_{\text{VOC}}$ (lb VOCs)	Vapor Mass Fraction, $x_x$ (lb of x/lb of VOCs)	Speciated VOC Emissions, $E_x$ (lb x)
Toluene	1,429	0.39	$E_{\text{VOC}} \times x_x = 1,429 \times 0.39$ $= 557$
Heptane	1,429	0.61	$E_{\text{VOC}} \times x_x = 1,429 \times 0.61$ $= 872$

**4.2 Heat-Up Losses**

Heat-up losses that occur during the operation of high-speed dispersers, bead and ball mills, and similar types of dispersing equipment may be estimated by application of the Ideal Gas Law and vapor-liquid equilibria principles. Emissions are calculated using the following assumptions:



- Covers are closed during operation, but it is possible for vapors to be vented during operation;
- No material is added during heat-up;
- The displaced gas is always saturated with VOC vapor in equilibrium with the liquid mixture;
- The moles of gas displaced from the vessel result from the expansion of gases during heat-up and an increase in VOC vapor pressure; and
- The vapor pressure of the mixers never rises above 1 atmosphere (Fisher et al., 1993).

This section presents two equations for estimating heatup emissions. The first is from *Control of Volatile Organic Compound Emissions from Batch Processes* (EPA, 1994c). The second was derived by performing moderate balances around the vessel headspace for the noncondensable component and for condensable component  $x$  during the heating (Hatfield, 1998a).

The two approaches yield similar results when the amount of heat-up is small, and the final temperature is well below the boiling point of the liquid mixture. However, the disparity between the results from the two options increases as the final temperature approaches the boiling point. Under these conditions Option 1 gives unrealistically high estimates, and Option 2 is the better choice.

#### 4.2.1 Option 1

The equation for calculating heat-up emissions that is in *Control of Volatile Organic Compound Emissions from Batch Processes* is shown in Equation 8.4-10 (EPA, 1994c).

$$E_{\text{VOC}} = \frac{\left( \frac{\sum (P_x)_{T1}}{14.7 - \sum (P_x)_{T1}} \right) + \left( \frac{\sum (P_x)_{T2}}{14.7 - \sum (P_x)_{T2}} \right)}{2} \times \Delta n \times M_a \times \text{CYC} \quad (8.4-10)$$

where

- $E_{\text{VOC}}$  = VOC emissions from material heat-up in the process equipment (lb/yr)
- $(P_x)_{T1}$  = initial partial pressure of each VOC species  $x$  in the vessel headspace at the initial temperature  $T1$  (psia); see Equations 8.4-3 and 8.4-4
- $(P_x)_{T2}$  = final partial pressure of each VOC species  $x$  in the vessel headspace at the final temperature  $T2$  (psia); see Equations 8.4-3 and 8.4-4
- $\Delta n$  = number of pound-moles of gas displaced (lb-mole/cycle)
- $M_a$  = average vapor molecular weight (lb/lb-mole)
- CYC = number of cycles per year (cycles/yr).

The term  $\Delta n$  may be calculated using Equation 8.4-11:

$$\Delta n = \frac{V}{R} \times \left( \frac{Pa_1}{T1} - \frac{Pa_2}{T2} \right) \quad (8.4-11)$$

where

$\Delta n$	=	number of pound-moles of gas displaced (lb-mole/cycle)
$V$	=	volume of free space in the vessel (ft <sup>3</sup> )
$R$	=	universal gas constant at 1 atmosphere of pressure, 10.73 psia · ft <sup>3</sup> /lb-mole · °R
$Pa_1$	=	initial gas pressure in vessel (psia)
$Pa_2$	=	final gas pressure in vessel (psia)
$T1$	=	initial temperature of vessel (°R)
$T2$	=	final temperature of vessel (°R).

$Pa_1$  and  $Pa_2$  may be calculated using Equations 8.4-12 and 8.4-13:

$$Pa_1 = 14.7 - \Sigma(P_x)_{T1} \quad (8.4-12)$$

$$Pa_2 = 14.7 - \Sigma(P_x)_{T2} \quad (8.4-13)$$

where

$Pa_1$	=	initial gas pressure in vessel (psia)
$Pa_2$	=	final gas pressure in vessel (psia)
$(P_x)_{T1}$	=	partial pressure of each VOC <sub>x</sub> in the vessel headspace (psia) at the initial temperature T1; see Equations 8.4-3 and 8.4-4
$(P_x)_{T2}$	=	partial pressure of each VOC <sub>x</sub> in the vessel headspace (psia) at the final temperature T2; see Equations 8.4-3 and 8.4-4.

Speciated VOC emissions would be calculated using a modified version of Equation 8.4-10 as shown in Equation 8.4-14:

$$E_x = \frac{\left( \frac{(P_x)_{T1}}{14.7 - \Sigma(P_x)_{T1}} \right) + \left( \frac{(P_x)_{T2}}{14.7 - \Sigma(P_x)_{T2}} \right)}{2} \times \Delta n \times M_a \times CYC \quad (8.4-14)$$

where

$E_x$	=	VOC species x emissions from material heat-up in the process equipment (lb/yr)
$(P_x)_{T1}$	=	partial pressure of VOC species x in the vessel headspace at the initial temperature T1 (psia); see Equations 8.4-3 and 8.4-4
$(P_x)_{T2}$	=	partial pressure of VOC species x in the vessel headspace at the final temperature T2 (psia); see Equations 8.4-3 and 8.4-4
$\Delta n$	=	number of pound-moles of gas displaced (lb-mole/cycle); see Equation 8.4-11
$M_a$	=	average vapor molecular weight (lb/lb-mole)
CYC	=	Number of cycles/year.

Example 8.4-2 illustrates the use of Equations 8.4-10 through 8.4-13. Emissions are calculated by following Steps 1 through 6 presented on the next few pages.

#### Example 8.4-2

This example shows how heat-up losses from a disperser are calculated using Equations 8.4-10 through 8.4-13. Supporting equations from Section 4.1.1 (Equations 8.4-3 and 8.4-5) are also used in this example.

A 3,000-gallon, high-speed disperser contains 2,000 gallons of paint. The following data are given:

- The paint consists of 30 percent by weight toluene, 20 percent by weight methyl ethyl ketone (MEK), and 50 percent by weight insoluble pigments and nonvolatile resins;
- The initial temperature (T1) of the mixture is 77°F or 537°R (°R = °F + 460);
- The final temperature (T2) is 105°F (565°R);
- The average vapor molecular weight ( $M_a$ ) is 77 lb/lb-mole (calculated using Equation 8.4-6); and
- The mixer goes through the given temperature cycle with this paint formulation 25 times/yr (CYC).
- The volume of free space in the vessel is 3,000 - 2,000 gal = 1,000 gal or 133.68 ft<sup>3</sup>.

**Step 1: Apply Equation 8.4-5, Calculation of Liquid Mole Fraction ( $m_x$ )**

Component x	Liquid Mass Fraction, $z_x$ (lb of x/lb of liquid)	Molecular Weight, $M_x$ (lb of x/lb-mole of x)	Liquid Mole Fraction, $m_x$ (mole of x/mole of liquid)
Toluene	0.3	92	$\frac{z_x/M_x}{\sum(z_x/M_x)} = \frac{0.3/92}{(0.3/92 + 0.2/72)} = 0.54$
MEK	0.2	72	$\frac{z_x/M_x}{\sum(z_x/M_x)} = \frac{0.2/72}{(0.3/92 + 0.2/72)} = 0.46$

**Step 2: Apply Equation 8.4-3, Calculation of Partial Vapor Pressure at Initial Temperature [ $(P_x)_{T1}$ ]**

Component x	Liquid Mole Fraction, $m_x$ (mole of x/mole of liquid)	Vapor Pressure, $VP_x$ @ 77°F (psia)	Partial Pressure at T1, $(P_x)_{T1}$ (psia)
Toluene	0.54	0.58	$m_x \times VP_x = 0.54 \times 0.58 = 0.313$
MEK	0.46	1.93	$m_x \times VP_x = 0.46 \times 1.93 = 0.888$

**Step 3: Apply Equation 8.4-3, Calculation of Partial Pressure at Final Temperature [ $(P_x)_{T2}$ ]**

Component x	Liquid Mole Fraction, $m_x$ (mole/mole)	Vapor Pressure, $VP_x$ @ 105°F (psia)	Partial Pressure at T2, $(P_x)_{T2}$ (psia)
Toluene	0.54	1.16	$m_x \times VP_x = 0.54 \times 1.16 = 0.626$
MEK	0.46	3.75	$m_x \times VP_x = 0.46 \times 3.75 = 1.73$

**Step 4: Apply Equations 8.4-12 and 8.4-13, Calculation of Initial Pressure (Pa<sub>1</sub>) and Final Pressure (Pa<sub>2</sub>)**

$$\begin{aligned}
 Pa_1 &= 14.7 - \Sigma(P_x)_{T1} \\
 &= 14.7 - (0.313 + 0.888) \\
 &= 13.5 \text{ psia}
 \end{aligned}$$

$$\begin{aligned}
 Pa_2 &= 14.7 - \Sigma(P_x)_{T2} \\
 &= 14.7 - (0.626 + 1.73) \\
 &= 12.34 \text{ psia}
 \end{aligned}$$

**Step 5: Apply Equation 8.4-11, Calculation of lb-moles Gas Displaced ( $\Delta n$ )**

The volume of free space in the vessel (V) is 3,000 gal - 2,000 gal = 1,000 gal or 133.68 ft<sup>3</sup>.

$$\begin{aligned}
 \Delta n &= \frac{V}{R} \times \left( \frac{Pa_1}{T_1} - \frac{Pa_2}{T_2} \right) \\
 &= \frac{133.68}{10.73} \times \left( \frac{13.5}{537} - \frac{12.3}{565} \right) \\
 &= 0.042 \text{ lb-moles/CYC}
 \end{aligned}$$

**Step 6: Apply Equation 8.4-10, Calculation of Total VOC Emissions (E<sub>VOC</sub>)**

$$\begin{aligned}
 E_{VOC} &= \frac{\left( \frac{\Sigma(P_x)_{T1}}{14.7 - \Sigma(P_x)_{T1}} \right) + \left( \frac{\Sigma(P_x)_{T2}}{14.7 - \Sigma(P_x)_{T2}} \right)}{2} \times \Delta n \times M \times \text{CYC} \\
 &= \frac{\left( \frac{(0.313 + 0.888)}{14.7 - (0.313 + 0.888)} \right) + \left( \frac{(0.626 + 1.73)}{14.7 - (0.626 + 1.73)} \right)}{2} \times 0.042 \times 77 \times 2 \\
 &= 11.3 \text{ lb VOCs/yr}
 \end{aligned}$$

**Step 7: Apply Equation 8.4-14, Calculation of Toluene Emissions ( $E_{\text{VOC}}$ )**

$$\begin{aligned}
 E_{\text{VOC}} &= \frac{\left( \frac{(P_x)_{T1}}{14.7 - \sum(P_x)_{T1}} \right) + \left( \frac{(P_x)_{T2}}{14.7 - \sum(P_x)_{T2}} \right)}{2} \times \Delta n \times M \times \text{CYC} \\
 &= \frac{\left( \frac{0.313}{14.7 - (0.313 + 0.888)} \right) + \left( \frac{0.626}{14.7 - (0.626 + 1.73)} \right)}{2} \times 0.042 \times 92 \times 25 \\
 &= 3.6 \text{ lb toluene/yr}
 \end{aligned}$$

**4.2.2 Option 2**

In this heating model, rising vapors from the vessel liquid contents displace the noncondensable gas components from the headspace through the process vessel vent. As the liquid mixture reaches the boiling point, all of the noncondensable component is purged from the vapor space. This model assumes that the average molar headspace volume remains constant relative to changes in the molar composition of the vessel headspace. Equation 8.4-15 is derived from performing material balances around the vessel headspace for the noncondensable component and for condensable component  $x$  during the heating (Hatfield, 1998a).

$$N_{x,\text{out}} = N_{\text{avg}} \ln \left( \frac{Pa_1}{Pa_2} \right) - (n_{x,2} - n_{x,1})_{\text{vessel}} \quad (8.4-15)$$

where

$N_{x,\text{out}}$	=	moles of volatile component $x$ leaving the vessel per batch
$N_{\text{avg}}$	=	average gas space molar volume during the heating process
$Pa_1$	=	partial pressure of noncondensable in the vessel headspace at initial temperature
$Pa_2$	=	partial pressure of noncondensable in the vessel headspace at final temperature
$n_{x,2}$	=	moles of volatile component $x$ in the vessel headspace at the final temperature
$n_{x,1}$	=	moles of volatile component $x$ in the vessel headspace at the initial temperature.

Note that when the liquid in the vessel contains more than one volatile component, Equation 8.4-15 estimates the total moles of volatile components emitted, and  $n_{x,1}$  and  $n_{x,2}$  are the total moles of all volatile components in the vessel headspace.

The term  $N_{\text{avg}}$  may be calculated using equation 8.4-16:

$$N_{\text{avg}} = \frac{1}{2}(n_1 + n_2) \quad (8.4-16)$$

where

$n_1$  = total moles of gas in the vessel headspace at the initial temperature  
 $n_2$  = total moles of gas in the vessel headspace at the final temperature.

The total number of moles ( $n_1$  and  $n_2$ ) may be calculated using the ideal gas law as shown in equation 8.4-17 and 8.4-18.

$$n_1 = \frac{P_1 V}{RT_1} \quad (8.4-17)$$

$$n_2 = \frac{P_2 V}{RT_2} \quad (8.4-18)$$

where

$P_1$  = total system pressure at initial temperature  
 $P_2$  = total system pressure at final temperature  
 $V$  = volume of gas space in the vessel  
 $R$  = gas constant  
 $T_1$  = initial temperature of vessel contents  
 $T_2$  = final temperature of vessel contents.

The total number of moles of volatile component  $x$  in the vessel headspace at the initial and final temperatures ( $n_{x,1}$  and  $n_{x,2}$ ) are also calculated using equations 8.4-17 and 8.4-18, except the partial pressures of the volatile component are used instead of the total system pressure.

#### Example 8.4-3

For the same disperser described in example 8.4-2, what heat-up emissions would be estimated using option 2?

**Step 1: Apply Equations 8.4-17 and 8.4-18, Determine Total Moles in the Vessel Headspace at Initial and Final Temperatures**

$$n_1 = \frac{P_1 V}{RT_1} = \frac{(14.7 \text{ psia})(133.68 \text{ ft}^3)}{\left(\frac{10.73 \text{ ft}^3 \text{ psia}}{\text{lbmole}^\circ \text{R}}\right)(537^\circ \text{R})}$$

$$= 0.341 \text{ lbmole}$$

$$n_2 = \frac{P_2 V}{RT_2} = \frac{(14.7 \text{ psia})(133.68 \text{ ft}^3)}{\left(\frac{10.73 \text{ ft}^3 \text{ psia}}{\text{lbmole}^\circ \text{R}}\right)(565^\circ \text{R})}$$

$$= 0.324 \text{ lbmole}$$

**Step 2: Apply Equation 8.4-16, Determine  $N_{\text{avg}}$** 

$$N_{\text{avg}} = \frac{1}{2}(n_1 + n_2) = \frac{1}{2}(0.341 + 0.324) = 0.333 \text{ lbmole}$$

**Step 3: Apply Equations 8.4-12 and 8.4-13, Calculation of Noncondensable Partial Pressures and Initial and Final Temperatures**

These calculations are shown in Step 4 of example 8.4-2.

$$P_{a_1} = 13.5 \text{ psia}$$

$$P_{a_2} = 12.34 \text{ psia}$$

**Step 4: Determine Partial Pressures of Volatile Components**

These values were determined in Steps 2 and 3 of example 8.4-2:

Component x	$(P_x)_{T1}$ , psia	$(P_x)_{T2}$ , psia
Toluene	0.313	0.626
MEK	0.888	1.73



**Step 5: Apply Equations 8.4-17 and 8.4-18, Determine Moles of Condensable Compounds in the Vessel Headspace at Initial and Final Temperatures**

$$\begin{aligned}
 n_{x,1} &= \frac{(\Sigma(P_x)_{T1})(V)}{RT_1} = \frac{(0.313 + 0.888 \text{ psia})(133.68 \text{ ft}^3)}{\left(\frac{10.73 \text{ ft}^3 \text{ psia}}{\text{lbmole}^\circ\text{R}}\right)(537^\circ\text{R})} \\
 &= 0.0279 \text{ lbmole} \\
 n_{x,2} &= \frac{(\Sigma(P_x)_{T2})(V)}{RT_2} = \frac{(0.626 + 1.73 \text{ psia})(133.68 \text{ ft}^3)}{\left(\frac{10.73 \text{ ft}^3 \text{ psia}}{\text{lbmole}^\circ\text{R}}\right)(565^\circ\text{R})} \\
 &= 0.0520 \text{ lbmole}
 \end{aligned}$$

**Step 6: Apply Equation 8.4-15, Calculate Total Moles of VOC Emissions**

$$\begin{aligned}
 n_{x,\text{out}} &= N_{\text{avg}} \ln\left(\frac{Pa_1}{Pa_2}\right) - (n_{x,2} - n_{x,1})_{\text{vessel}} \\
 &= (0.333) \ln\left(\frac{13.5}{12.34}\right) - (0.0520 - 0.0279) \\
 &= 0.00582 \text{ lbmole VOC / batch}
 \end{aligned}$$

Using the average vapor molecular weight from example 8.4-2, the total mass of VOC emitted per batch is:

$$E_{\text{VOC}} = \left(0.00582 \frac{\text{lbmole}}{\text{batch}}\right) \left(\frac{77 \text{ lb}}{\text{lbmole}}\right) = 0.448 \text{ lb/batch}$$

For 25 batches per year, the annual emissions are:

$$E_{\text{VOC}} = (0.448 \text{ lb/batch})(25 \text{ batches/yr}) = 11.2 \text{ lb/yr}$$

This estimate is essentially the same as the emissions estimated using option 1 in example 8.4-2.

**Step 7: Determine the Amount of Each Volatile Species in the Total VOC Emissions**

Compound	Average Partial Pressure, psia	Average Vapor Phase Mole Fraction	Number of lbmole Emitted	Molecular Weight	Mass Emission	
					lb/batch	lb/yr
Toluene	0.47	0.26	0.0015	92	0.138	3.45
MEK	1.31	0.74	0.0043	72	0.31	7.74
Totals	1.78		0.0058		0.448	11.2

**4.3 Emission Model for Spills**

The evaporation rate and VOC emissions that result from a liquid chemical spill can be estimated using a simple model if the size (area) of the spill is known or can be estimated. Other more complex spill models are also available, but they may require more input data (EPA, 1987). Equation 8.4-19, used for the simple model, is as follows:

$$E_x = \frac{M_x \times K_x \times A \times P_x \times 3600 \times HR}{R \times T} \quad (8.4-19)$$

where

$E_x$	=	emissions of VOC species x from the spill (lb/event)
$M_x$	=	molecular weight of VOC species x (lb/lb-mole)
$K_x$	=	gas-phase mass transfer coefficient for VOC species x (ft/sec)
$A$	=	surface area of spill (ft <sup>2</sup> )
$P_x$	=	vapor pressure of VOC species x (if a pure chemical is spilled) or the partial pressure of chemical x (if a mixture of VOCs is spilled) at temperature T (psia) <sup>1</sup>
3600	=	3600 sec/hr
HR	=	duration of spill (hr/event)
R	=	universal gas constant at 1 atmosphere of pressure, 10.73 psia-ft <sup>3</sup> /°R- lb-mole
T	=	temperature of the liquid spilled, °R (°F + 460).

<sup>1</sup> The vapor pressures of VOC species are listed in AP-42 on Table 7.1-3 (EPA, 1997b). The partial pressure of VOC species x ( $P_x$ ) may be calculated using Equation 8.4-3 or Equation 8.4-4.

The gas-phase mass transfer coefficient ( $K_x$ ) may be calculated using Equation 8.4-20:

$$K_x = 0.00438 \times U^{0.78} \times \left( \frac{D_x}{3.1 \times 10^{-4}} \right)^{2/3} \quad (8.4-20)$$

where

$$\begin{aligned} K_x &= \text{gas-phase mass transfer coefficient for VOC species } x \text{ (ft/sec)} \\ U &= \text{wind speed (mile/hr)} \\ D_x &= \text{diffusion coefficient for VOC species } x \text{ in air (ft}^2\text{/sec).} \end{aligned}$$

Diffusion coefficients ( $D_x$ ) can be found in chemical handbooks and are usually expressed in units of square centimeters per second ( $\text{cm}^2\text{/sec}$ ). If a diffusion coefficient is not available for a particular chemical, the gas-phase mass transfer coefficient ( $K_x$ ) may be estimated using Equation 8.4-21:

$$K_x = 0.00438 \times U^{0.78} \times \left( \frac{18}{M_x} \right)^{1/3} \quad (8.4-21)$$

where

$$\begin{aligned} K_x &= \text{gas-phase mass transfer coefficient for VOC species } x \text{ (ft/sec)} \\ U &= \text{wind speed (mile/hr)} \\ M_x &= \text{molecular weight of VOC species } x \text{ (lb/lb-mole).} \end{aligned}$$

Equations 8.4-20 and 8.4-21 and other similar correlations that are used in more complex models were developed to estimate evaporation from liquid surfaces exposed to natural wind effects. The standard practice when using these equations is that the wind speed is the value at a height 10 meters above the surface (EPA, 1994a). Thus, the equations should be acceptable for estimating mass transfer coefficients for spills that are outdoors. If the spill is indoors, however, the equation should be used with caution. The wind profile inside a building likely differs from the profile outside, so the velocity at a height of 10 meters (even if that much open space exists above the spill) will not have the same meaning as it would outdoors. At a minimum, when applying the equation to a spill indoors, the user should develop site-specific estimates of the air velocity above the spill and recognize the potential that using this approach may underestimate the emissions. An alternative approach for estimating gas-phase mass transfer coefficients is discussed in Section 4.5 of this chapter. The alternative replaces the windspeed variable with a constant reference mass transfer coefficient. This approach likely overstates the emissions, particularly in a room with little air movement, because it assumes the gas above the liquid is well mixed. Thus, equation 8.4-21 generally is preferable to the alternative for estimating emissions from spills and other surface evaporation scenarios.

Example 8.4-4 illustrates the use of equations 8.4-19 and 8.4-21.

#### Example 8.4-4

Methyl ethyl ketone (MEK) is spilled onto the ground outside of a building. The following data are given:

- The spill is not detected for 1 hour; it takes an additional 2 hours to recover the remaining MEK; the duration of the spill (HR), therefore, is 3 hours.
- The average wind speed (U) is 8 mile/hr.
- The ambient temperature (T) is 77°F or 537°R (°R = °F +460).
- The surface area of the spill (A) is 100 ft<sup>2</sup>.
- The molecular weight of MEK (M<sub>x</sub>) is 72.10 lb/lb-mole.
- The vapor pressure of MEK (P<sub>x</sub>) at 77°F is approximately 1.93 psia.

**Step 1: Using Equation 8.4-21, calculate the Gas-phase Mass Transfer Coefficient (K<sub>x</sub>)**

$$\begin{aligned}
 K_x &= 0.00438 \times U^{0.78} \times \left( \frac{18}{M_x} \right)^{1/3} \\
 &= 0.00438 \times 8^{0.78} \times \left( \frac{18}{72.1} \right)^{1/3} \\
 &= 0.01397 \text{ ft/sec}
 \end{aligned}$$

**Step 2: Using Equation 8.4-19, Calculate Emissions (E<sub>x</sub>)**

$$\begin{aligned}
 E_x &= \frac{M_x \times K_x \times A \times P_x \times 3600 \times \text{HR}}{R \times T} \\
 &= \frac{72.1 \times 0.01397 \times 100 \times 1.93 \times 3600 \times 3}{10.73 \times 537} \\
 &= 364 \text{ lb MEK/spill}
 \end{aligned}$$

## 4.4 Emission Model for Surface Evaporation

Emissions from surface evaporation of VOCs from open or partially covered mixing tanks during coating mixing operations can be estimated using Equation 8.4-22, which is also based on the simple vaporization model for spills.

$$E_x = \frac{M_x \times K_x \times A \times P_x \times 3600 \times H}{R \times T} \times B \quad (8.4-22)$$

where

$E_x$	=	emissions of VOC species x (lb/yr)
$M_x$	=	molecular weight of VOC species x (lb/lb-mole)
$K_x$	=	gas-phase mass transfer coefficient for VOC species x (ft/sec)
$A$	=	surface area of exposure or opening of tank (ft <sup>2</sup> )
$P_x$	=	true vapor pressure of VOC x (if a pure chemical is used) or the partial pressure of chemical x (if a mixture of VOCs is used) at temperature T (psia) <sup>2</sup>
3600	=	3600 sec/hr
$H$	=	batch time (hr/batch)
$R$	=	universal gas constant at 1 atmosphere of pressure, 10.73 psia-ft <sup>3</sup> /°R-lb mole;
$T$	=	temperature of the liquid, °R (°F+460)
$B$	=	number of batches per year (batches/yr).

Equations 8.4-20 or 8.4-21 can be used to estimate  $K_x$ . Total VOC emissions would equal the sum of all VOC species emissions. Note that using these equations to estimate mass transfer coefficients for VOC in a tank inside a building is subject to the same uncertainty discussed in Section 4.3 for spills inside a building because such applications differ from the situation for which the equation was developed.

<sup>2</sup> The partial pressure of VOC species x ( $P_x$ ) may be calculated using Equation 8.4-3 or Equation 8.4-4.

Examples 8.4-5 and 8.4-6 illustrate the use of Equation 8.4-22.

**Example 8.4-5**

A covered tank is used to mix toluene and various insoluble materials. What are the toluene emissions due to surface evaporation? The following data are given:

- Toluene is the only compound that is a liquid
- The batch time (H) is 4 hours.
- The number of batches per year (B) is 550.
- The average air velocity through the building above the tank (U) is 0.1 miles/hr.
- The ambient temperature (T) is 77°F or 537°R (°R = °F + 460).
- The opening in the cover of the mixing tank (A) for the agitator shaft is 4 ft<sup>2</sup>.
- The molecular weight of toluene (M<sub>x</sub>) is 92 lb/lb-mole.
- The partial vapor pressure of toluene (P<sub>x</sub>) at 77°F is approximately 0.55 psia.

**Step 1: Using Equation 8.4-21, calculate the Gas-phase Mass Transfer Coefficient (K<sub>x</sub>)**

$$\begin{aligned}K_x &= 0.00438 \times U^{0.78} \times \left( \frac{18}{M_x} \right)^{1/3} \\&= 0.00438 \times 0.1^{0.78} \times \left( \frac{18}{92} \right)^{1/3} \\&= 0.000422 \text{ ft/sec}\end{aligned}$$

**Step 2: Using Equation 8.4-22, calculate annual emissions ( $E_x$ )**

$$\begin{aligned} E_x &= \frac{M_x \times K_x \times A \times P_x \times 3600 \times H}{R \times T} \times B \\ &= \frac{92 \times 0.000422 \times 4 \times 0.55 \times 3600 \times 4}{10.73 \times 537} \times 550 \\ &= 117 \text{ lb toluene/yr} \end{aligned}$$

**Example 8.4-6**

An ink manufacturer uses a three roll mill to ensure that the finished ink product meets particle size and uniformity standards. Material is fed to the rollers between the feed and center rolls. Material is then transferred from the center roll to the apron roll where it is removed by a stationary knife blade. What are the emissions due to surface evaporation? The following data are given:

- The roller elements are 14 inches in diameter and 30 inches long;
- The printing ink being processed contains a light petroleum distillate oil with a molecular weight of 254;
- The rollers operate at ambient temperature of 77°F;
- The MSDS shows that the vapor pressure for the light petroleum distillate oil at 77°F is 0.097 psia;
- The mole fraction of petroleum distillate oil in the ink mixture is estimated to be 0.3;
- Each batch takes 1.5 hours; and
- 400 batches are processed annually.

**Step 1: Determine Liquid Surface Area on the Rollers**

For this illustration, it is assumed that liquid covers the entire surface area of each roller.

$$\begin{aligned} A &= \pi \times d \times L \times N_{\text{rollers}} \\ &= \pi \times 14 \times 30 \times 3 \\ &= 3,956 \text{ in}^2 (27.5 \text{ ft}^2) \end{aligned}$$

**Step 2: Apply Equation 8.4-3, Determine Partial Pressure of Light Petroleum Distillate Oil**

$$\begin{aligned} P_x &= m_x \times VP_x \\ &= 0.3 \times 0.097 \\ &= 0.0291 \text{ psia} \end{aligned}$$

**Step 3: Apply Equation 8.4-29, Determine Mass Transfer Coefficient**

Note that this example illustrates use of the alternative procedure described in Section 4.5. Equation 8.4-21 may be used if a site-specific estimate of air velocity over the rollers can be estimated.

$$\begin{aligned} K_x &= 0.83 \times \left( \frac{18}{M_x} \right)^{1/3} \\ &= 0.83 \times \left( \frac{18}{254} \right)^{1/3} \\ &= 0.343 \text{ cm/s} (0.0113 \text{ ft/s}) \end{aligned}$$



**Step 4: Apply Equation 8.4-22, Calculate Annual Emissions**

$$\begin{aligned}
 E_x &= \frac{M_x \times K_x \times A \times P_x \times 3600 \times H}{R \times T} \times B \\
 &= \frac{254 \times 0.0113 \times 7.5 \times 0.0291 \times 3600 \times 1.5}{10.73 \times 537} \times 400 \\
 &= 861 \text{ lb / yr}
 \end{aligned}$$

**4.5 Gas Sweep or Purge**

This section presents two models for estimating emissions from a gas sweep or purge through a partially filled process vessel. The first model (option 1) is from *Control of Volatile Organic Emissions from Batch Processes* (EPA, 1994c). The second model (option 2) is a modified version of the first model in that it includes a procedure based on site-specific conditions for estimating the degree to which the exhaust gas is saturated with organic compounds (Hatfield, 2003). Note that option 2 is recommended only for applications where the headspace exchange rate is less than 5 per minute because available data suggest it may underestimate emissions at higher exchange rates (Watson, 2004).

Applying the surface evaporation model to estimate emissions from a gas sweep or purge is inappropriate. As noted in section 4.3, the wind speed correlation for estimating the mass transfer coefficient was developed for scenarios where the flow is uniform across a relatively quiescent liquid surface, and the wind speed is taken at 10 meters above the surface. Flow inside a tank is not uniform, sweep air may be impinging on the liquid surface, the liquid surface is likely turbulent from agitation, material added while loading the vessel may be dropped on the liquid surface causing splashes, and the wind speed cannot be determined at 10 meters above the surface. Furthermore, even if the general correlation is still valid under these conditions, the gas velocity is not uniform across the surface of the liquid, and there is no consensus regarding the value to use or the point at which the velocity should be determined for use in the correlation.

**4.5.1 Option 1**

The equation for calculating gas sweep or purge emissions that is in *Control of Volatile Organic Compound Emission from Batch Processes* is shown in Equation 8.4-23 (EPA, 1994c).

$$E_x = \frac{P_x \times F_{nc} \times M_x \times 60 \times OH}{R \times T} \times \frac{P_T}{P_T - \sum P_x} \quad (8.4-23)$$

where

$E_x$	=	emissions of VOC species x, lb/yr
$P_x$	=	partial pressure of VOC species x, psia
$F_{nc}$	=	flow rate into the vessel, ft <sup>3</sup> /min
$M_x$	=	molecular weight of VOC species x, lb/lbmole
60	=	60 min/hr
OH	=	hours that the gas sweep or purge operates, hr/yr
R	=	universal gas constant (10.73 psia ft <sup>3</sup> /lbmole °R)
T	=	temperature of the exhaust gas, °R
$P_T$	=	total system pressure, psia.

Note that to use this model, the exhaust gas stream is assumed to be in equilibrium with the liquid if the flow rate into the vessel is less than 100 ft<sup>3</sup>/min (i.e., the partial pressure is equal to the vapor pressure for a tank with one compound in the liquid phase). The exhaust stream is assumed to be 25 percent saturated if the flow is greater than 100 ft<sup>3</sup>/min.

Example 8.4-7 illustrates the use of Equation 8.4-23.

#### Example 8.4-7

A gas sweep is operated while material is added to a high-speed disperser. What are the annual VOC emissions during purges? The following data are provided:

- The average composition of the material in the high-speed disperser while the sweep operates is 30% by weight toluene, 20% by weight MEK, and 50% by weight insoluble pigments and nonvolatile resins;
- The temperature of the material in the vessel and the exhaust gas is 77°F (537°R);
- The partial pressures of toluene and MEK at 77°F are 0.313 psia and 0.888 psia, respectively (see Example 8.4-2, Step 2);
- The inlet purge flow rate is 5 ft<sup>3</sup>/min;
- The molecular weight of toluene is 92.1 lb/lbmole;
- The molecular weight of MEK is 72.1 lb/lbmole; and
- The purge operates for 1,000 hr/yr.

**Step 1: Apply Equation 8.4-23 to Calculate Toluene Emissions**

Note that since the purge flow is <100 ft<sup>3</sup>/min, the exhaust gas stream is assumed to be saturated with toluene and MEK.

$$\begin{aligned}
 E_x &= \frac{P_x \times F_{nc} \times M_x \times 60 \times OH}{R \times T} \times \frac{P_T}{P_T - \Sigma P_x} \\
 &= \frac{0.313 \times 5 \times 92.1 \times 60 \times 1,000}{10.73 \times 537} \times \frac{14.7}{14.7 - (0.313 + 0.888)} \\
 &= 1,634 \text{ lb/yr}
 \end{aligned}$$

**Step 2: Apply Equation 8.4-23 to calculate MEK Emissions**

$$\begin{aligned}
 E_x &= \frac{0.888 \times 5 \times 72.1 \times 60 \times 1,000}{10.73 \times 537} \times \frac{14.7}{14.7 - (0.313 + 0.888)} \\
 &= 3,630 \text{ lb / yr}
 \end{aligned}$$

**Step 3: Sum the Emissions from Steps 1 and 2**

$$\begin{aligned}
 E_{VOC} &= 1,634 + 3,630 \\
 &= 5,264 \text{ lb / yr}
 \end{aligned}$$

**4.5.2 Option 2**

This model is the same as the model in Option 1 except that it adds a site-specific saturation factor for each VOC species in the exit gas stream. Equation 8.4-24 is used to calculate the saturation factor.

$$S_x = \frac{P_x}{P_x^{Sat}} = \frac{K_x A}{F + K_x A} = \frac{K_x A}{K_x A + F_{nc} + S_x F_x^{Sat}} \quad (8.4-24)$$

where

$S_x$	=	saturation factor for VOC species x
$K_x$	=	mass transfer coefficient for VOC species x
$A$	=	surface area of the liquid
$F_{nc}$	=	volumetric flow rate of the noncondensable purge (e.g., air, nitrogen)
$F_x^{Sat}$	=	volumetric flow rate of VOC species x at the saturated partial pressure.

Equation 8.4-24 was developed based on the following relationships and assumptions.

Equation 8.4-25 relates the evaporation rate for a VOC species x within a vessel to its molecular weight, mass transfer coefficient, surface area, and other known variables [Crowl & Louvar, 2002].

$$E_m = \frac{M_x K_x A}{RT} (P_x^{Sat} - P_x) \quad (8.4-25)$$

where

$E_m$	=	evaporation rate (lb/min)
$M_x$	=	molecular weight of VOC species x
$K_x$	=	mass transfer coefficient (ft/min)
$A$	=	surface area (ft <sup>2</sup> )
$R$	=	ideal gas constant
$T$	=	temperature of liquid
$P_x^{Sat}$	=	partial pressure of VOC species x in a saturated gas stream (true vapor pressure if the liquid is pure species x)
$P_x$	=	actual partial pressure of VOC species x next to the liquid surface.

Equation 8.4-26 is the basic equation for calculating the emission rate for VOC species x from a gas sweep or purge operation based on the exit gas flow rate, partial pressure of VOC species x, molecular weight, and other known variables.

$$E_v = \frac{FP_T}{RT} \frac{P_x}{P_T} M_x = \frac{M_x FP_x}{RT} \quad (8.4-26)$$

where

$E_v$	=	emissions from vessel vent (lb/min)
$F$	=	exit gas flow rate (ft <sup>3</sup> /min)
$P_T$	=	overall system pressure
$R$	=	ideal gas constant
$T$	=	temperature of liquid
$P_x$	=	actual partial pressure of VOC species x
$M$	=	molecular weight of VOC species x.

For a vessel at steady state conditions, the emission rate from the gas sweep activity is equal to the evaporation rate of VOC species x from the liquid within the vessel [Hatfield, 2003]. These two equations can be set equal and solved for the saturation level  $S_x$  (i.e.,  $P_x/P_x^{Sat}$ ), resulting in Equation 8.4-24.

Calculation of VOC emissions using Equation 8.4-24 is based on the following assumptions:

- The vessel is at steady state so that the evaporation reate equals the discharge rate in the exit gas stream.
- The vapor space is perfectly mixed so that once the VOC evaporates there is no additional resistance to mass transfer to the exit gas stream (this means the reference mass transfer coefficient, as discussed below, is also assumed to be for a perfectly mixed system).
- The equation is recommended only for headspace exchange rates up to 5 per minute.

The ratio of the mass transfer coefficients between the compound of interest ( $K_x$ ) and the reference compound ( $K_o$ ) is expressed using Equation 8.4-27 (Crowl and Louvar, 2002):

$$\frac{K_x}{K_o} = \left( \frac{D_x}{D_o} \right)^{2/3} \quad (8.4-27)$$

where

$K_x$	=	mass transfer coefficient for VOC species x
$K_o$	=	mass transfer coefficient for a reference compound
$D_x$	=	diffusion coefficient for VOC species x in air
$D_o$	=	diffusion coefficient for a reference compound in air.

The gas-phase diffusion coefficient  $D$  for a compound is estimated from the ratio of the molecular weight of the compound of interest and a known compound (normally water) using Equation 8.4-28:

$$\frac{D_x}{D_o} = \left( \frac{M_o}{M_x} \right)^{1/2} \quad (8.4-28)$$

where

$M_o$	=	molecular weight of a reference compound
$M_x$	=	molecular weight of VOC species x.

Combining Equations 8.4-27 and 8.4-28 results in a relationship that can be used to estimate the mass transfer coefficient of a given volatile compound:

$$K_x = K_o \left( \frac{M_o}{M_x} \right)^{1/3} \quad (8.4-29)$$

Water is commonly used as a base reference for estimating the mass transfer coefficient for many compounds of interest. The mass transfer coefficient of water at 77°F and 14.7 psia is 0.83 cm/s (0.0272 ft/s) (Matthiesen, 1986).

The saturated partial volumetric flow rate of VOC species x can be estimated from the saturated partial pressure of the VOC species x, the inlet gas purge rate, and the partial pressure of the non-condensable gas at saturated conditions using Equation 8.4-30:

$$F_x^{Sat} = F_{nc} \times \frac{P_x^{Sat}}{P_T - \sum P_x^{Sat}} \quad (8.4-30)$$

where

$F_x^{Sat}$	=	volumetric flow rate of VOC species x at the saturated partial pressure
$F_{nc}$	=	volumetric flow rate of the noncondensable gas (i.e., air, nitrogen)
$P_x^{Sat}$	=	partial pressure of VOC species x in a saturated gas stream (true vapor pressure if the liquid is pure species x)
$P_T$	=	total system pressure.

The saturation factor ( $S_x$ ) may be solved using the standard quadratic solution. Although the standard quadratic equation contains two roots, only the one solution shown in Equation 8.4-31 produces a realistic value since  $S_x$  must be a positive number between 0 and 1.0.

$$S_x = \frac{-(K_x A + F_{nc}) + \sqrt{(K_x A + F_{nc})^2 + 4F_x^{Sat} K_x A}}{2F_x^{Sat}} \quad (8.4-31)$$

Finally, the emission rate for VOC species x may be calculated using Equation 8.4-32, which is similar to Equation 8.4-23, except that the saturated partial pressure is multiplied by the saturation factor.

$$E_x = \frac{M_x \times S_x \times P_x^{Sat} \times F_{nc} \times 60 \times OH}{R \times T} \times \frac{P_T}{P_T - \sum P_x^{Sat}} \quad (8.4-32)$$

For multi-component liquid mixtures, Equation 8.4-24 may be expanded to include partial volumetric flow rates for each VOC species in the liquid, as shown in Equation 8.4-33:

$$S_{x+1} = \frac{K_x A}{K_x A + F_{nc} + S_x F_x^{Sat} + S_j F_j^{Sat} + \dots + S_n F_n^{Sat}} \quad (8.4-33)$$

In equation 8.4-33, the subscript x identifies the VOC species for which the saturation level is being calculated, and terms j through n represent the other VOC species in the liquid. Equation 8.4-33 is solved in an iterative trial and error manner with the initial value of S for each VOC species assigned to 1.0. The value of S that is calculated for each VOC species is then used as the starting point for the next iteration. Finally, when the saturation level S of each VOC species remains the same for subsequent iterations, the calculation process is stopped.

Examples 8.4-8 and 8.4-9 illustrate the use of Equations 8.4-29 through 8.4-33 to estimate emissions from purging a partially filled vessel.

#### Example 8.4-8

A high-speed disperser operates with a gas sweep while material is added to the vessel. What are the annual VOC emissions? The following data are given:

- Mineral spirits are the only material in the liquid phase;
- The molecular weight of mineral spirits is 145 lb/lbmole;
- The contents of the vessel and the purge are at a temperature of 77°F (537°R);
- Vapor pressure of mineral spirits at 77°F is 0.0032 psia;
- The gas sweep is 5 acfm;
- The diameter of the tank is 5 ft; and
- The gas sweep operates for 1,000 hr/yr.

#### **Step 1: Apply Equation 8.4-29, Estimate Mass Transfer Coefficient**

Using water as the reference compound results in the following equation:

$$\begin{aligned} K_x &= 0.83 \times \left( \frac{18}{M_x} \right)^{1/3} \\ &= 0.83 \times \left( \frac{18}{145} \right)^{1/3} \\ &= 0.414 \text{ cm / s } (0.815 \text{ ft / min}) \end{aligned}$$

**Step 2: Determine Surface Area of Liquid in the Tank**

$$\begin{aligned}
 A &= \frac{\pi \times d^2}{4} = \frac{\pi \times (5)^2}{4} \\
 &= 19.6 \text{ ft}^2
 \end{aligned}$$

**Step 3: Apply Equation 8.4-30, Determine Saturated Partial Volumetric Flow Rate of Mineral Spirits in Exit Gas Stream**

$$\begin{aligned}
 F_x^{\text{Sat}} &= F_{\text{nc}} \times \frac{P_x^{\text{Sat}}}{P_T - \Sigma P_x^{\text{Sat}}} \\
 &= 5 \times \frac{0.0032}{14.7 - 0.0032} \\
 &= 0.00109 \text{ ft}^3/\text{min}
 \end{aligned}$$

**Step 4: Apply Equation 8.4-31, Calculate Saturation Factor For Mineral Spirits in the Exit Gas Stream**

$$\begin{aligned}
 S_x &= \frac{-(K_x A + F_{\text{nc}}) + \sqrt{((K_x A + F_{\text{nc}})^2 + 4F_x^{\text{Sat}} K_x A)}}{2 F_x^{\text{Sat}}} \\
 &= \frac{-((0.815)(19.6) + 5) + \sqrt{(((0.815)(19.6) + 5)^2 + (4)(0.00109)(0.815)(19.6))}}{(2)(0.00109)} \\
 &= \frac{-20.974 + \sqrt{439.909 + 0.06965}}{0.00218} \\
 &= 0.76
 \end{aligned}$$

**Step 5: Apply Equation 8.4-32, Calculate Annual Emissions**

$$\begin{aligned}
 E_x &= \frac{M_x \times S_x \times P_x^{\text{Sat}} \times F_{\text{nc}} \times 60 \times \text{OH}}{R \times T} \times \frac{P_T}{P_T - \Sigma P_x^{\text{Sat}}} \\
 &= \frac{145 \times 0.76 \times 0.0032 \times 5 \times 60 \times 1,000}{10.73 \times 537} \times \frac{14.7}{14.7 - 0.0032} \\
 &= 18 \text{ lb/yr}
 \end{aligned}$$



**Example 8.4-9**

Determine the annual emissions from purging the high-speed disperser in example 8.4-7 using Option 2. The following additional information is provided:

The diameter of the tank is 5 ft.

**Step 1. Apply Equation 8.4-29, Estimate Mass Transfer Coefficients for Toluene and MEK**

For toluene:

$$K_x = 0.83 \times \left( \frac{18}{92.1} \right)^{1/3} = 0.482 \text{ cm/s} (0.948 \text{ ft/min})$$

For MEK:

$$K_x = 0.83 \times \left( \frac{18}{72.1} \right)^{1/3} = 0.523 \text{ cm/s} (1.029 \text{ ft/min})$$

**Step 2: Determine Surface Area of Liquid in the Tank**

$$A = \frac{\pi \times d^2}{4} = \frac{\pi \times (5)^2}{4} = 19.6 \text{ ft}^2$$

**Step 3: Determine Saturated Partial Pressures of VOC Species**

See Example 8.4-2, Step 2 for the calculations of the following:

VOC	VP at 77°F, psia	Liquid Mole Fractions	$P_x^{\text{Sat}}$ , psia
Toluene	0.58	0.54	0.313
MEK	1.93	0.46	0.888

**Step 4: Apply Equation 8.4-30, Determine Saturated Partial Volumetric Flowrate of Each VOC Species**

$$F_x^{\text{Sat}} = F_{\text{nc}} \times \frac{P_x^{\text{Sat}}}{P_T - \sum P_x^{\text{Sat}}}$$

$$\begin{aligned} F_x^{\text{Sat}} (\text{for toluene}) &= 5 \times \frac{0.313}{14.7 - (0.313 + 0.888)} \\ &= 0.1160 \text{ ft}^3/\text{min} \end{aligned}$$

$$\begin{aligned} F_x^{\text{Sat}} (\text{for MEK}) &= 5 \times \frac{0.888}{14.7 - (0.313 + 0.888)} \\ &= 0.3288 \text{ ft}^3/\text{min} \end{aligned}$$

**Step 5. Apply Equation 8.4-33, Calculate the Saturation Factors for Each VOC Species**

Using trial and error, the following results are obtained:

VOC	$K_x A$	$F_x^{\text{Sat}}$ , ft <sup>3</sup> /min	$S_x$ (iteration 0)	$S_x$ (iteration 1)	$S_x$ (iteration 2)	$S_x$ (iteration 3)
Toluene	18.617	0.116	1	0.77372	0.77682	0.77678
MEK	20.200	0.3288	1	0.78769	0.79065	0.79061

For example, the  $S_x$  (iteration 1) for toluene is calculated as follows:

$$\begin{aligned} S_x &= \frac{K_x A}{K_x A + F_{\text{nc}} + S_x F_x^{\text{Sat}} + S_j F_j^{\text{Sat}}} \\ &= \frac{18.617}{18.617 + 5 + (1)(0.116) + (1)(0.3288)} \\ &= 0.77372 \end{aligned}$$

**Step 6: Apply Equation 8.4-32, Calculate Annual Emissions**

$$E_x = \frac{M_x \times S_x \times P_x^{\text{Sat}} \times F_{\text{nc}} \times 60 \times \text{OH}}{R \times T} \times \frac{P_T}{P_T - \sum P_x^{\text{Sat}}}$$

$$E_x \text{ (toluene)} = \frac{92.1 \times 0.777 \times 0.313 \times 5 \times 60 \times 1000}{10.73 \times 537} \times \frac{14.7}{14.7 - (0.313 + 0.888)}$$

$$= 1,270 \text{ lb / yr}$$

$$E_x \text{ (MEK)} = \frac{72.1 \times 0.791 \times 0.888 \times 5 \times 60 \times 1000}{10.73 \times 537} \times \frac{14.7}{14.7 - (0.313 + 0.888)}$$

$$= 2,871 \text{ lb / yr}$$

**Step 7: Sum Emissions From Step 6**

$$E_{\text{VOC}} = 1,270 + 2,871$$

$$= 4,141 \text{ lb/yr}$$

**4.6 Solvent Reclamation**

After being collected from coating manufacturing operations, waste cleaning solvents may be purified and reused. Distillation is one of the most common methods of purifying a solvent. Many forms of distillation are used including batch, simple continuous, or steam distillation.

A batch distillation process consists of at least four separate activities including: (1) charging waste solvent into the still, (2) heating the batch to its boiling point, (3) collecting the distillate in a receiver, and (4) filling a container or vessel with the collected distillate for storage. Steps 1, 3 and 4 can be modeled using the filling model described earlier in this section (Equation 8.4-1).

Emissions from heating to boiling (Step 2) cannot be modeled using either of the equations for heatup described in Section 4.2 of this chapter because the equations are mathematically invalid when the partial pressure of air is zero. However, the emissions can be estimated using Equation 8.4-34.

$$E_{\text{VOC}} = \frac{(P_x)_o}{P_{a1}} \times \Delta n \times M_x \quad (8.4-34)$$

where

$(P_x)_o$	=	partial pressure of VOC species x at the condenser outlet temperature (also the vapor pressure of the pure compound because only one compound is condensing)
$\Delta n$	=	moles of air in the vessel headspace at the initial temperature
$M_x$	=	molecular weight of VOC species x
$P_{a_1}$	=	partial pressure of air at the condenser outlet temperature.

Calculation of VOC emissions using Equation 8.4-34 is based on the following assumptions:

- all of the air in the vessel headspace at the initial temperature has been expelled when the liquid in the vessel begins to boil
- the heated vapors leaving the still pass through a condenser
- air leaving the condenser is saturated with VOC vapors at the exit gas temperature of the condenser.

Furthermore, while the liquid in the vessel is boiling, emissions are assumed to be zero because only VOC vapor is expelled from the vessel and it all condenses in the condenser.

Example 8.4-10 illustrates the use of the filling and heating equations to estimate VOC emissions from solvent reclamation.

**Example 8.4-10**

The Bright Blue Paint Company in Case Study 8.3-1 recovers toluene from 300 tons/yr of waste cleaning solvent using a batch distillation unit. What are the estimated annual VOC emissions? The following data are given:

- The still is half filled for each distillation operation (i.e., the vessel vapor space equals the volume of waste solvent for each batch);
- The expelled air and VOC vapors are routed to a condenser that operates with an outlet temperature of 20°C (68°F);
- The still bottoms at the end of the distillation contain 3 percent of the initial waste solvent;
- Analysis shows the waste solvent is about 99 percent toluene (on a molar basis), and the remaining 1 percent is dissolved solids and nonvolatile liquids;
- Typical initial temperature of the waste solvent is 25°C (77°F);
- Toluene density is 7.21 lb/gal;
- Final temperature (toluene boiling point) is 111°C (232°F); and
- Displaced air from all filling steps is assumed to be saturated with toluene vapors (i.e., the saturation factor is 1.0).

**Step 1: Determine Volume of Waste Solvent Charged to the Still**

$$\begin{aligned}
 Q &= \left( 300 \frac{\text{tons solvent}}{\text{yr}} \right) \times \left( \frac{2,000 \text{ lb}}{\text{ton}} \right) \times \left( \frac{\text{gal}}{7.21 \text{ lb}} \right) \\
 &= 83,218 \text{ gal/yr}
 \end{aligned}$$

**Step 2: Determine the Toluene Vapor Pressure at the Initial Temperature**

Numerous resources are available for estimating vapor pressures. This example uses the Antoine equation (Dean, 1992).

$$\log(\text{VP}_x) = A - \frac{B}{T + C} \quad (8.4-35)$$

where

$VP_x$	=	vapor pressure of VOC species x, mm Hg
$T$	=	temperature, °C
$A,B,C$	=	Antoine Constants.

For toluene at the initial temperature of the still (25°C), the Antoine equation gives the following results:

$$\log (VP_x) = 6.954 - \frac{1,344.8}{25 + 219.48}$$
$$VP_x = 28.4 \text{ mm Hg} (0.549 \text{ psia})$$

**Step 3: Apply Equation 8.4-3, Determine Toluene Partial Pressure at the Initial Temperature**

$$P_x = M_x \times VP_x$$
$$= (0.99) \times (0.549)$$
$$= 0.544 \text{ psia}$$

**Step 4: Apply Equation 8.4-1, Calculate Toluene Emissions From Charging Waste Solvent to the Still**

$$E_{\text{VOC}} = \frac{12.46 \times S \times P_x \times M_x \times Q}{T}$$
$$= \frac{12.46 \times 1 \times 0.544 \times 9.21 \times 83.2}{537}$$
$$= 97 \text{ lb/yr}$$

**Step 5: Apply Equations 8.4-11 and 8.4-12, Determine Amount of Noncondensable Gas in the Vessel Headspace When Heating Begins.**

Although the description of the problem doesn't specify the size of each batch or the size of the still, it says the headspace volume for each batch is equal to the volume of waste solvent. Thus, the total volume of free space in the still at the start of heatup for all of the batches during the year equals the total volume of waste solvent processed (i.e., 83,218 gal).

$$\begin{aligned}
 Pa_1 &= 14.7 - \Sigma(P_x)_{T1} \\
 &= 14.7 - 0.544 \\
 &= 14.16 \text{ psia}
 \end{aligned}$$

$$\begin{aligned}
 \Delta n &= \frac{(Pa_1) \times (V)}{(R) \times (T)} \\
 &= \frac{(14.16) \times (83,218) \times \left(\frac{\text{ft}^3}{7.48 \text{ gal}}\right)}{(10.73) \times (537)} \\
 &= 27.3 \text{ lb mole of air expelled/yr}
 \end{aligned}$$

**Step 6: Apply Equation 8.4-35, Determine Vapor Pressure and Partial Pressure of Toluene at 20°C (Condenser Outlet Temperature)**

$$\begin{aligned}
 \log(VP_x) &= A - \frac{B}{T + C} \\
 &= 6.954 - \frac{1,344.8}{20 + 219.48} \\
 VP_x = P_x &= 21.80 \text{ mmHg} (0.422 \text{ psia})
 \end{aligned}$$

**Step 7: Apply Equation 8.4-34, Determine Amount of Toluene Emitted With the Expelled Air During Heatup**

$$\begin{aligned}
 E_{\text{VOC}} &= \frac{(P_x)_o}{Pa_1} \times \Delta n \times M_x \\
 &= \frac{(0.422)}{(14.7 - 0.422)} \times (27.3) \times (92.1) \\
 &= 74 \text{ lb / yr}
 \end{aligned}$$

**Step 8: Apply Equation 8.4-1, Calculate Emissions From Filling the Receiver with Distilled Toluene at 20°C (68°F)**

Note that since 3 percent of the initial waste solvent remains in the still, the total volume of recovered toluene is 97 percent of the total waste solvent processed.

$$\begin{aligned} E_{\text{VOC}} &= \frac{12.46 \times S \times P_x \times M_x \times Q \times 0.97}{T} \\ &= \frac{12.46 \times 1 \times 0.422 \times 92.1 \times 83.2 \times 0.97}{528} \\ &= 74 \text{ lb/yr} \end{aligned}$$

**Step 9: Apply Equation 8.4-1, Calculate Emissions From Filling a Storage Vessel or Drums With Distilled Toluene From the Receiver**

Assume the distilled toluene is still at 20°C (68°F)

$$\begin{aligned} E_{\text{VOC}} &= \frac{12.46 \times S \times P_x \times M_x \times Q \times 0.97}{T} \\ &= \frac{12.46 \times 1 \times 0.422 \times 92.1 \times 83.2 \times 0.97}{528} \\ &= 74 \text{ lb/yr} \end{aligned}$$

**Step 10: Sum the Emissions from Steps 4, 7, 8, and 9**

$$\begin{aligned} E_{\text{VOC}} &= 97 + 74 + 74 + 74 \\ &= 319 \text{ lb/yr} \end{aligned}$$

## 4.7 Emission Model for Liquid Material Storage

The preferred method for calculating emissions from storage tanks is the use of equations presented in *AP-42*. EPA has developed a software package (TANKS) for calculating these types of emissions. The reader is referred to Chapter 1 of this volume, *Introduction to Stationary Point Source Emissions Inventory Development*, for more information on using the TANKS program. Additionally, the reader should consult their state agency and/or the EPA's Clearinghouse for Inventories and Emission Factors (CHIEF) Website for the most recent version of TANKS.

## 4.8 Emission Model for Wastewater Treatment

VOC emissions from a wastewater treatment system may be estimated using equations presented in *Air Emissions Models for Waste and Wastewater* (EPA, 1994a), and Chapter 5, *Preferred and Alternative Methods for Estimating Air Emissions from Wastewater Collection and Treatment Facilities*, of this volume. These documents, as well as models such as WATER9 are available on the EPA's CHIEF Website.



## 5.0 Other Methods for Estimating Emissions

Section 4 presented models for estimating emissions from specific coating manufacturing activities. This section presents other types of methods for calculating emissions from manufacturing facilities. The other methods described in this section include emission factors, material balances, and testing.

### 5.1 Emission Calculations Using Emission Factors

Emission factors have long been used to calculate emissions from coating manufacturing facilities. EPA maintains a compilation of approved emission factors in *AP-42* for criteria pollutants and hazardous air pollutants (HAPs). Available emission factors for paint manufacturing can be found in Section 6.4 of *AP-42* and in a technical memorandum from EPA to the National Paint and Coatings Association (EPA, 1995f). Emission factors for ink manufacturing can be found in Section 6.7 of *AP-42*. The National Association of Printing Ink Manufacturers, Inc. (NAPIM), has also developed ink manufacturing emission factors (NAPIM, 1996). The most comprehensive source for toxic air pollutant emission factors is the Factor Information and REtrieval (FIRE) data system, which also contains criteria pollutant emission factors (EPA, 1999).

VOC emission factors are available in *AP-42* for calculating total plant emissions and mixing operation emissions from a paint manufacturing facility and for vehicle cooking and pigment mixing emissions from an ink manufacturing facility. In addition, emission factors are available for estimating VOC emissions from the following types of sources found in a coating manufacturing facility:

- Solvent reclamation systems;
- Parts washing equipment; and
- Process piping (i.e., equipment leaks).

Emission factors are also available for estimating PM/PM<sub>10</sub> emissions from coating manufacturing facilities.

#### 5.1.1 Total VOC Emissions from Paint Manufacturing Facilities

A VOC emission factor can be used for calculating total VOC emissions from paint manufacturing facilities. The emission factor presented in *AP-42* is essentially a loss factor that represents an emission rate to be applied to a production rate (NPCA, 1995). The VOC emission factor presented in *AP-42* for paint manufacturing is 30 lb total VOCs/ton product (EPA, 1995b). To calculate total VOCs using this emission factor, see Equation 8.5-1:

$$E_{\text{VOC}} = EF_{\text{VOC}} * Q_{\text{p}} \quad (8.5-1)$$

where

$E_{\text{VOC}}$  = total emissions of VOCs from the facility (lb/yr)  
 $EF_{\text{VOC}}$  = VOC emission factor (lb VOCs/ton product)  
 $Q_{\text{p}}$  = amount of product produced (ton/yr).

**Table 8.5-1. List of Variables and Symbols**

Variable	Symbol	Units
Total VOC emissions	$E_{\text{VOC}}$	lb/yr
VOC emission factor	$EF_{\text{VOC}}$	various
Amount of product produced	$Q_{\text{prod}}$	ton/yr
Emissions of VOC or PM species x	$E_{\text{x}}$	lb/yr
Amount of VOC species x used by the facility	$Q_{\text{x}}$	lb/yr
Total amount of solvents used	$Q_{\text{s}}$	lb/yr
Amount of VOC in spent solvent processed	$Q_{\text{VOC}}$	ton/yr
Concentration of VOC or PM/PM <sub>10</sub> species x in solvent or pigment x, respectively	$C_{\text{x}}$	mass %
Mass percent of species x in total mixture	$X_{\text{x}}$	mass %
Volume percent of species x in total mixture	$Y_{\text{x}}$	volume %
Number of species in total mixture	n	number
Flow rate through exhaust vent	FR	ft <sup>3</sup> /min
Molecular weight of total mixture	M	lb/lb-mole
Molecular weight of VOC or PM species x	$M_{\text{x}}$	lb/lb-mole
Operating hours	OH	hr/yr
Surface area of solvent exposed to the atmosphere	A	ft <sup>2</sup>
Number of cleaning units in use	NU	cleaning units
PM/PM <sub>10</sub> emissions	$E_{\text{PM}}$	lb/yr
PM/PM <sub>10</sub> emission factor	$EF_{\text{PM}}$	lb/ton
Amount of pigment containing species x used by the facility	$Q_{\text{x}}$	lb/yr, ton/yr
Quantity of VOC or PM species x that is received as a raw material	$Q_{\text{r}}$	lb/yr

**Table 8.5-1. (continued)**

Variable	Symbol	Units
Quantity of VOC or PM species x shipped out in final product	$Q_p$	lb/yr
Quantity of VOC or PM species x recovered by all methods	$Q_{rec}$	lb/yr
Quantity of VOC or PM species x contained in all waste generated	$Q_w$	lb/yr
Quantity of VOC or PM species x remaining in raw material inventory	$Q_{xi}$	lb/yr
Concentration of VOC or PM species x	$C_{xt}$	ppmv or ft <sup>3</sup> /MMft <sup>3</sup>

Because the VOC emissions calculated in Equation 8.5-1 are plantwide emissions, speciated emissions can be estimated based on total solvent used. Speciated VOC emissions are calculated using Equation 8.5-2:

$$E_x = E_{VOC} \times Q_x/Q_s \quad (8.5-2)$$

where

- $E_x$  = Emissions of VOC species x from the facility (lb/yr);
- $E_{VOC}$  = VOC emissions from the facility, calculated using Equation 8.5-1 (lb/yr);
- $Q_x$  = Amount of VOC species x used by the facility (lb/yr); and
- $Q_s$  = Total amount of solvents used by the facility (lb/yr).

With no other information available, one important assumption made in Equation 8.5-2 is that all solvents evaporate at the same rate. The amount of VOC species x used by a facility ( $Q_x$ ) can be obtained by reviewing purchase and inventory records and appropriate technical data sheets. Purchase and inventory records can be used to estimate the amount of a particular material consumed.

The sum of speciated emissions for all VOC components calculated using Equation 8.5-2 cannot exceed the total VOC emissions calculated in Equation 8.5-1. The use of Equations 8.5-1 and 8.5-2 is demonstrated in Example 8.5-1.

**Example 8.5-1**

This example shows how total and speciated VOC emissions may be calculated for a paint manufacturing facility using the production-based VOC emission factor from AP-42, Table 6.4-1, and Equations 8.5-1 and 8.5-2.

Given:

$$\begin{aligned} \text{EF}_{\text{VOC}} &= 30 \text{ lb VOC/ton product} \\ Q_{\text{prod}} &= 1,250 \text{ ton of paint/yr} \\ Q_{\text{xylene}} &= 250,000 \text{ lb used by the facility/yr} \\ Q_s &= 1,500,000 \text{ lb solvents used by the facility/yr} \end{aligned}$$

Total VOC emissions would be calculated using Equation 8.5-1:

$$\begin{aligned} E_{\text{VOC}} &= \text{EF}_{\text{VOC}} \times Q_{\text{prod}} \\ &= 30 \times 1,250 \\ &= 37,500 \text{ lb VOCs/yr} \end{aligned}$$

The amount of xylenes used by the facility ( $Q_{\text{xylene}}$ ) was estimated by conducting a review of purchase and inventory records and technical data sheets.

Xylenes emissions would be calculated using Equation 8.5-2:

$$\begin{aligned} E_{\text{VOC}} &= 37,500 \text{ lb VOCs emitted/yr} \\ Q_{\text{xylene}} &= 250,000 \text{ lb xylenes used by the facility/yr} \\ Q_s &= 1,500,000 \text{ lb solvents used by the facility/yr} \\ E_{\text{xylene}} &= E_{\text{VOC}} \times Q_{\text{x}}/Q_s \\ &= 37,500 \times 250,000/1,500,000 \\ &= 6,250 \text{ lb xylenes/yr} \end{aligned}$$

In addition to the 30 lb VOCs/ton product emission factor, EPA has recently restated the emission factor for total VOC emissions for overall operations from a paint manufacturing facility based on the amount of solvent used (EPA, 1995f). Development of the new proposed factor, 0.034 lb VOCs emitted/lb solvent used, is based on the following information and assumptions:

- The emission estimates used to develop the 30 lb VOCs/ton coating emission factor appear to be based on the formulation of conventional coatings that were prevalent in the late 1950s and early 1960s.
- Densities for conventional coatings were typically 10 to 15 lb/gal (an average density of 12.5 lb/gal was used) during the late 1950s and early 1960s.

- An average solvent content of 5.5 lb VOCs/gal coating was assumed for conventional coatings (EPA, 1995f).

Use of the proposed factor by facilities that primarily manufacture water-based, low-solvent, or high-solids coatings should result in more accurate emissions than use of the 30 lb VOCs/ton coating factor.

To calculate total VOCs using this proposed emission factor, use Equation 8.5-3:

$$E_{\text{VOC}} = EF_{\text{VOC}} \times Q_s \quad (8.5-3)$$

where

$E_{\text{VOC}}$	=	total VOC emissions from a facility (lb/yr)
$EF_{\text{VOC}}$	=	VOC emission factor (lb VOCs/lb solvent used)
$Q_s$	=	total amount of solvents used (lb/yr).

Speciated emissions are then calculated using Equation 8.5-4:

$$E_x = EF_{\text{VOC}} \times Q_x \quad (8.5-4)$$

where

$E_x$	=	emissions of VOC species x from a facility (lb/yr)
$EF_{\text{VOC}}$	=	VOC emission factor (lb VOCs/lb solvent used)
$Q_x$	=	amount of VOC species x used by the facility (lb/yr).

The sum of speciated emissions for all VOC components calculated in Equation 8.5-4 cannot exceed the total VOC emissions calculated in Equation 8.5-3. The use of Equations 8.5-3 and 8.5-4 is demonstrated in Example 8.5-2.

### 5.1.2 VOC Emissions from Paint Mixing Operations

VOC emissions from paint mixing equipment may be calculated using emission factors. *AP-42* suggests that “about 1 or 2 percent of solvent is lost even under very well controlled conditions” (EPA, 1995b). This percentage range can be translated into an emission factor range of 0.01 to 0.02 lb solvent lost/lb solvent used. Review of background information indicates that this emission factor range applies specifically to paint mixing operations (i.e., operations where solvents are added as raw materials) (EPA, 1995f).

*AP-42* states that the consumption-based emission factor of 0.01 to 0.02 lb VOCs lost/lb solvent used applies even to facilities that have emission sources that are well controlled. If a facility

contains mixers or other process vessels that are uncovered or otherwise poorly controlled, an emission factor greater than 0.02 lb solvent lost/lb solvent used may need to be applied (NPCA, 1995).

#### Example 8.5-2

This example shows how total and speciated VOC emissions may be calculated for a paint manufacturing facility using the proposed solvent-based VOC emission factor, as shown in Equation 8.5-3.

$$\begin{aligned} EF_{\text{VOC}} &= 0.034 \text{ lb VOCs/lb solvent used} \\ Q_s &= 350,000 \text{ lb solvents used by the facility/yr} \end{aligned}$$

$$\begin{aligned} E_{\text{VOC}} &= EF_{\text{VOC}} \times Q_s \\ &= 0.034 \times 350,000 \\ &= 11,900 \text{ lb VOCs/yr} \end{aligned}$$

Xylene emissions would be calculated using Equation 8.5-4:

$$\begin{aligned} EF_{\text{VOC}} &= 0.034 \text{ lb VOCs/lb solvent} \\ Q_x &= 15,000 \text{ lb xylenes contained in solvents used by the facility/yr} \end{aligned}$$

$$\begin{aligned} E_x &= EF_{\text{VOC}} \times Q_x \\ &= 0.034 \times 15,000 \\ &= 510 \text{ lb xylenes/yr} \end{aligned}$$

Total VOC emissions can also be calculated by summing the speciated VOC emissions.

Use Equation 8.5-5 for calculating speciated VOC emissions from mixers using the consumption-based emission factor.

$$E_x = EF_{\text{VOC}} \times Q_x \quad (8.5-5)$$

where

$$\begin{aligned} E_x &= \text{emissions of VOC species x from mixing equipment (lb/yr)} \\ EF_{\text{VOC}} &= \text{VOC emission factor (lb VOCs/lb solvent used)} \\ Q_x &= \text{amount of VOC species x added to mixing equipment as a raw material (lb/yr).} \end{aligned}$$

The amount of VOC species  $x$  used in mixing equipment ( $Q_x$ ) refers to the total amount of VOC species  $x$  that is added to mixing equipment as a raw material. Once the solvent is mixed with other materials, it is no longer considered a raw material.

The use of Equation 8.5-5 is also demonstrated in Example 8.5-3.

#### Example 8.5-3

This example shows how speciated VOC emissions from mixing equipment may be calculated using Equation 8.5-5 and the emission factor from Section 6.4.1 of *AP-42*. This example assumes an average level of VOC control on process equipment. Consequently, the average of the range (1 to 2 percent) reported in *AP-42* is used.

$$\begin{aligned} EF_{\text{VOC}} &= 0.015 \text{ lb xylenes emitted/lb xylenes used} \\ Q_x &= 15,000 \text{ lb xylenes added to mixing equipment/yr} \\ E_x &= EF_{\text{VOC}} \times Q_x \\ &= 0.015 \times 15,000 \\ &= 225 \text{ lb xylenes/yr} \end{aligned}$$

### 5.1.3 VOC Emissions from Ink Manufacturing Facilities

Emission factors are also available for VOC sources from ink manufacturing facilities. Section 6.7 of *AP-42* presents VOC emission factors for vehicle cooking. NAPIM has also developed VOC emission factors for mixing, milling, and tub wash processes for both paste and liquid inks (NAPIM, 1996). Emission factors are available for sheetfed three-roll mill and heatset paste inks, and for low-VOC and high-VOC liquid inks. Equation 8.5-6 can be used to estimate emissions using emission factors.

$$E_{\text{VOC}} = EF_{\text{VOC}} \times Q_p \quad (8.5-6)$$

where

$$\begin{aligned} E_{\text{VOC}} &= \text{VOC emissions (lb/yr)} \\ EF_{\text{VOC}} &= \text{VOC emission factor (lb VOC/ton product)} \\ Q_p &= \text{amount of product produced (ton/yr).} \end{aligned}$$

Speciated emissions can be calculated using Equation 8.5-7:

$$E_x = E_{\text{VOC}} \times Q_x / Q_s \quad (8.5-7)$$

where

$E_x$	=	emissions of VOC species x (lb/yr)
$E_{\text{VOC}}$	=	VOC emissions calculated using Equation 8.5-6 (lb/yr)
$Q_x$	=	amount of VOC species x used (lb/yr)
$Q_s$	=	total amount of solvent used (lb/yr).

With no other information available, one important assumption made in Equation 8.5-7 is that all solvents evaporate at the same rate. The amount of VOC species x used by a facility ( $Q_x$ ) can be obtained by reviewing purchase and inventory records and appropriate technical data sheets. Purchase and inventory records can be used to estimate the amount of a particular material consumed.

Example 8.5-4 illustrates the use of these equations.

#### Example 8.5-4

This example shows how VOC and speciated VOC emissions may be calculated for general vehicle cooking at an ink manufacturing facility using the production-based VOC emission factor from AP-42, Table 6.7-1, and Equations 8.5-6 and 8.5-7.

Given:

$EF_{\text{VOC}}$	=	120 lb VOC/ton product
$Q_p$	=	500 tons of ink/yr
$Q_{\text{toluene}}$	=	100,000 lb used/yr
$Q_s$	=	1,000,000 lb solvents used/yr

VOC emissions would be calculated using Equation 8.5-6:

$$\begin{aligned} E_{\text{VOC}} &= EF_{\text{VOC}} \times Q_p \\ &= 120 \times 500 \\ &= 60,000 \text{ lb VOCs/yr} \end{aligned}$$

The amount of toluene used ( $Q_{\text{toluene}}$ ) was estimated by conducting a review of purchase and inventory records, batch records, and technical data sheets.

Toluene emissions would be calculated using Equation 8.5-7:

$$\begin{aligned} E_{\text{VOC}} &= 60,000 \text{ lb VOCs emitted/yr} \\ Q_{\text{toluene}} &= 100,000 \text{ lb toluene used/yr} \\ Q_s &= 1,000,000 \text{ lb solvents used/yr} \\ E_{\text{toluene}} &= E_{\text{VOC}} \times Q_x / Q_s \\ &= 60,000 \times 100,000 / 1,000,000 \\ &= 6,000 \text{ lb toluene/yr} \end{aligned}$$



### 5.1.4 Total and Speciated VOC Emissions from Solvent Reclamation

VOC emissions from the loading and operation of a distillation device may be calculated using emission factors (EPA, 1995d).

To calculate total VOCs from loading or operation of the distillation device, use Equation 8.5-8:

$$E_{\text{VOC}} = EF_{\text{VOC}} \times Q_{\text{VOC}} \quad (8.5-8)$$

where

$E_{\text{VOC}}$	=	VOC emissions from loading or operation of the distillation device (lb/yr)
$EF_{\text{VOC}}$	=	VOC emission factor for loading of the distillation device or for the distillation column condenser vent (lb VOCs emitted/ton VOCs processed)
$Q_{\text{VOC}}$	=	amount of VOC in spent solvent processed through the distillation device (ton/yr).

Speciated VOC emissions are then calculated using Equation 8.5-9:

$$E_x = E_{\text{VOC}} \times C_x/100 \quad (8.5-9)$$

where

$E_x$	=	emissions of VOC species x from loading or operation of the distillation device (lb/yr)
$E_{\text{VOC}}$	=	VOC emissions from loading or operation of the distillation device, calculated using Equation 8.5-9 (lb/yr)
$C_x$	=	concentration of VOC species x in the solvent processed through the distillation system (mass %).

Example 8.4-5 illustrates the use of Equations 8.5-8 and 8.5-9.

If the species x concentration is provided on a volume basis, the volume percent will need to be converted to mass percent. If molecular weight of the total mixture is known, the volume percent of species x in the total mixture can be converted to mass percent using Equation 8.5-10:

$$X_x = Y_x \times \frac{M_x}{M} \times 100 \quad (8.5-10)$$

where

$X_x$	=	mass percent of species x in total mixture
$Y_x$	=	volume percent of species x in total mixture
$M_x$	=	molecular weight of species x
$M$	=	molecular weight of total mixture.

If molecular weight of the total mixture is not known, the volume percent can be converted to mass percent using Equation 8.5-11:

$$M = \sum_{x=1}^n \left( \frac{Y_x}{100} \times M_x \right) \quad (8.5-11)$$

where

$M$	=	molecular weight of total mixture
$n$	=	number of species in total mixture
$Y_x$	=	volume percent of species x in total mixture
$M_x$	=	molecular weight of species x.

#### Example 8.5-5

First, total VOC emissions from operation of a distillation device may be calculated using an emission factor from *AP-42*, Table 4.7-1 and Equation 8.5-8.

$$\begin{aligned} EF_{\text{VOC}} &= 3.30 \text{ lb VOCs/ton solvent processed} \\ Q_{\text{VOC}} &= 5 \text{ tons spent solvent processed/yr} \end{aligned}$$

$$\begin{aligned} E_{\text{VOC}} &= EF_{\text{VOC}} \times Q_{\text{VOC}} \\ &= 3.30 \times 5 \\ &= 16.5 \text{ lb VOCs emitted/yr} \end{aligned}$$

Next, total VOC emissions are speciated using the concentration of VOC species x (mass %) and Equation 8.5-9.

$$\begin{aligned} E_{\text{VOC}} &= 16.5 \text{ lb VOCs/yr (calculated above);} \\ C_x &= 99\% \text{ toluene in spent solvent} \end{aligned}$$

$$\begin{aligned} E_x &= E_{\text{VOC}} \times C_x/100 \\ &= 16.5 \times 99/100 \\ &= 16.3 \text{ lb toluene emitted/yr} \end{aligned}$$

### 5.1.5 VOC Emissions from Parts Cleaning

VOC emission factors for parts cleaning in cold cleaners, open-top vapor degreasers, or conveyorized degreasers are presented in *AP-42*. Emission factors for cold cleaners and vapor degreasers are in units of tons VOC/yr/unit or lb VOC/hr/ft<sup>2</sup>. Emission factors for vapor and nonboiling conveyorized degreasers are presented only in units of ton VOC/yr/unit. If using emission factors based on the surface area of the exposed solvent, use Equation 8.5-12.

$$E_{\text{VOC}} = EF_{\text{VOC}} \times A \times OH \quad (8.5-12)$$

where

$E_{\text{VOC}}$	=	VOC emissions from a cold cleaner or open-top vapor degreaser (lb/yr)
$EF_{\text{VOC}}^3$	=	VOC emission factor for cold cleaners or open-top vapor degreasers (lb/hr/ft <sup>2</sup> )
$A$	=	surface area of solvent exposed to the atmosphere (ft <sup>2</sup> )
$OH$	=	hours per year that the cold cleaner or vapor degreaser is in operation (hr/yr).

If using emission factors based on the number of cleaning units, use Equation 8.5-13.

$$E_{\text{VOC}} = EF_{\text{VOC}} \times NU \times 2000 \quad (8.5-13)$$

where

$E_{\text{VOC}}$	=	VOC emissions from a cold cleaner, an open-top vapor degreaser, or a conveyorized degreaser (lb/yr)
$EF_{\text{VOC}}$	=	VOC emission factor for cold cleaners, open-top vapor degreasers, or conveyorized degreasers (ton/yr/unit)
$NU$	=	number of cleaning units in use (units)
2000	=	2,000 lb/ton.

Speciated VOC emissions from parts cleaning may be calculated using Equation 8.5-14:

$$E_x = EF_{\text{VOC}} \times C_x / 100 \quad (8.5-14)$$

---

<sup>3</sup> Certain halogenated solvents that are widely used for solvent cleaning (e.g., 1,1,1-trichloroethane) have been categorized as “VOC-exempt” by various state and federal regulations. However, the emission factors reported in *AP-42* are still applicable for these solvents (EPA, 1995e).

where

$$\begin{aligned}E_x &= \text{emissions of VOC species } x \text{ from parts cleaning (lb/yr)} \\E_{\text{VOC}} &= \text{VOC emissions calculated using Equation 8.5-11 or 8.5-12 (lb/yr)} \\C_x &= \text{concentration of VOC species } x \text{ in cleaning solvent (mass \%)}.\end{aligned}$$

Examples 8.5-6 and 8.5-7 show the application of Equations 8.5-12, 8.5-13, and 8.5-14.

#### Example 8.5-6

This example shows how total and speciated VOC emissions from a cold cleaner may be calculated using Equations 8.5-12 and 8.5-14 and an emission factor (from *AP-42*, Table 4.6-2) that is based on the surface area of the exposed solvent. First, total VOC emissions are calculated using Equation 8.5-12.

$$\begin{aligned}EF_{\text{VOC}} &= 0.08 \text{ lb/hr/ft}^2 \\A &= 5.25 \text{ ft}^2 \\OH &= 3,000 \text{ hr/yr} \\E_{\text{VOC}} &= EF_{\text{VOC}} \times A \times OH \\&= 0.08 \times 5.25 \times 3,000 \\&= 1,260 \text{ lb VOC/yr}\end{aligned}$$

Next, total VOC emissions are speciated using the concentration of VOC species  $x$  (mass %) and Equation 8.5-14.

$$\begin{aligned}E_{\text{VOC}} &= 1,260 \text{ lb VOCs/yr (calculated above)} \\C_x &= 99\% \text{ trichloroethylene in cleaning solvent} \\E_x &= EF_{\text{VOC}} \times C_x/100 \\&= 1,260 \times 99/100 \\&= 1,247 \text{ lb trichloroethylene/yr}\end{aligned}$$

**Example 8.5-7**

This example shows how total VOC emissions are calculated from several cold cleaners using Equation 8.5-13 and an emission factor from Table 4-6.2 of *AP-42*.

$$\begin{aligned} \text{EF}_{\text{VOC}} &= 0.33 \text{ ton/yr/unit} \\ \text{NU} &= 5 \text{ units} \end{aligned}$$

$$\begin{aligned} \text{E}_{\text{VOC}} &= \text{EF}_{\text{VOC}} \times \text{NU} \times 2,000 \\ &= 0.33 \times 5 \times 2,000 \\ &= 3,300 \text{ lb VOC/yr} \end{aligned}$$

**5.1.6 VOC Emissions from Equipment Leaks**

Emissions factors for equipment leaks from pumps, valves, and connectors in the coating manufacturing industry were developed from a bagging study conducted to develop equations correlating total organic carbon readings as methane (obtained using Method 21) to VOC emission rate. Using these equations and method 21 screening data for facilities in the industry, average uncontrolled VOC emission factors, on a per component basis, were developed and are presented in the following table (Shine, 2003):

**Table 8.5-2. Emission Factors for Equipment Components at Coatings Manufacturing Facilities**

Component	Average Emission Factor	
	kg/hr/component	lb/hr/component
Pumps	0.004219	0.009301
Valves	0.000412	0.000908
Connectors	0.000015	0.000033

Additional information regarding various techniques for estimating equipment leak emissions is provided in Chapter 4 of this volume. Example 8.5-8 shows application of the emission factors in Table 8.5-2 to the equipment components for the Bright Blue Paint Company described in Case Study 8.3-1 of this chapter.

**Example 8.5-8**

The Bright Blue Paint Company in Case Study 8.3-1 uses 15 valves, 10 pumps, and 50 connectors in paint manufacturing operations. Assuming these equipment components are in service 8,760 hr/yr, what are the estimated annual VOC emissions from equipment leaks?

$$\begin{aligned}
 E_{\text{VOC}} &= (15 \text{ valves} \times 0.000908 \text{ lb/hr/valve} + \\
 &\quad 10 \text{ pumps} \times 0.009301 \text{ lb/hr/pump} + \\
 &\quad 50 \text{ connectors} \times 0.000033 \text{ lb/hr/connector}) \times 8,760 \text{ hr/yr} \\
 &= 949 \text{ lb/yr}
 \end{aligned}$$

**5.1.7 PM/PM<sub>10</sub> Emissions from a Paint or Ink Manufacturing Facility**

*AP-42* also presents PM emission factors from paint and ink manufacturing, which are based on the amount of pigment used by a facility. The *AP-42* factor for paint manufacturing is 20 lb PM/ton pigment. The *AP-42* factor for pigment mixing at an ink manufacturing facility is 2 lb PM/ton pigment. To calculate PM emissions using these emission factors, use Equation 8.5-15.

$$E_{\text{PM}} = EF_{\text{PM}} \times \Sigma Q_x \quad (8.5-15)$$

where

$$\begin{aligned}
 E_{\text{PM}} &= \text{total PM emissions (lb/yr)} \\
 EF_{\text{PM}} &= \text{PM emission factor (lb PM/ton pigment)} \\
 \Sigma Q_x &= \text{total pigment (ton/yr).}
 \end{aligned}$$

PM<sub>10</sub> can conservatively be estimated by assuming that all of the PM emitted is PM<sub>10</sub>.

Speciated PM emissions are calculated using Equation 8.5-16:

$$E_x = EF_{\text{PM}} \times Q_x \times C_x / 100 \quad (8.5-16)$$

where

$$\begin{aligned}
 E_x &= \text{total emissions of PM species } x \text{ (lb/yr)} \\
 EF_{\text{PM}} &= \text{PM emission factor from } AP-42, \text{ Table 6.4-1 or Table 6.7-1 (lb PM/ton pigment)} \\
 Q_x &= \text{amount of pigment containing species } x \text{ used by the facility (ton/yr)} \\
 C_x &= \text{Concentration of PM species } x \text{ in pigment } x \text{ (mass \%).}
 \end{aligned}$$

Use of Equation 8.5-16 is demonstrated in Example 8.5-9.

#### Example 8.5-9

This example demonstrates how speciated PM emissions from pigment mixing at an ink manufacturing facility may be calculated using the consumption-based PM emission factor from Table 6.7-1 of *AP-42* and Equation 8.5-16:

$$\begin{aligned}
 EF_{PM} &= 2 \text{ lb PM/ton pigment} \\
 Q_x &= 5 \text{ tons ZnO/yr} \\
 C_x &= 80\% \text{ Zn in ZnO} \\
 E_x &= EF_{PM} \times Q_x \times C_x/100 \\
 &= 2 \times 5 \times 80/100 \\
 &= 8 \text{ lb Zn/yr}
 \end{aligned}$$

## 5.2 VOC and PM Emission Calculations Using Material Balance

The material balance method requires the totaling of all materials received at the plant and then subtracting out all of the known losses or transfers of the material off-site (including finished product and waste material). The difference is assumed to have been emitted to the atmosphere. The quantity received and the quantity lost or used should be for the same time period, typically January 1 to December 31 for the year of the inventory (NPCA, 1995).

Use Equation 8.5-17 for calculating emissions using the material balance approach.

$$E_x = Q_r - Q_p - Q_{rec} - Q_w - Q_{xi} \quad (8.5-17)$$

where

$$\begin{aligned}
 E_x &= \text{emissions of VOC or PM species } x \text{ (lb/yr)} \\
 Q_r &= \text{quantity of VOC or PM species } x \text{ that is received as a raw material (lb/yr)} \\
 Q_p &= \text{quantity of VOC or PM species } x \text{ that is shipped out in the final product (lb/yr)} \\
 Q_{rec} &= \text{quantity of VOC or PM species } x \text{ that is recovered by all methods (e.g., solvent recovery) (lb/yr)} \\
 Q_w &= \text{quantity of VOC or PM species } x \text{ that is contained in all waste generated during the evaluation period (e.g., wastewater, sludge, drum residue) (lb/yr)} \\
 Q_{xi} &= \text{quantity of VOC or PM species } x \text{ that remains in the raw material inventory (lb/yr).}
 \end{aligned}$$

The use of Equation 8.5-17 is demonstrated in Example 8.5-10.

#### Example 8.5-10

This example shows how total ethylene glycol emissions for a paint manufacturing facility may be calculated using Equation 8.5-17. Data are as follows:

- In a given year, a paint facility receives 100,000 lb of ethylene glycol ( $Q_r$ ).
- Based on the total amount of product shipped off-site and records of product composition, the facility estimates that the amount of ethylene glycol shipped out in final product ( $Q_p$ ) is 69,000 lb;
- Based on waste composition analyses, the amount of waste sent off-site, and wastewater discharge rates, the facility estimates that the amount of ethylene glycol that was found in all wastes generated during the year ( $Q_w$ ) is 5,000 lb; and
- The amount of ethylene glycol that was found to be in the facility's inventory at the end of the evaluation period ( $Q_{xi}$ ) is 15,000 lb.

Emission of ethylene glycol are calculated as follows:

$$\begin{aligned}
 E_x &= Q_r - Q_p - Q_{rec} - Q_{xi} \\
 &= 100,000 - 69,000 - 10,000 - 5,000 - 15,000 \\
 &= 1,000 \text{ lb ethylene glycol/yr}
 \end{aligned}$$

### 5.3 Emission Calculations Using Test Data

Because vent or stack testing is relatively uncommon for paint and ink manufacturing facilities, emissions test data for these plants are typically in the form of exposure monitoring results. Industrial hygiene data may be used in conjunction with exhaust system flow rates to calculate fugitive emissions from a room, floor, or building (NPCA, 1995). Use Equation 8.5-18 for calculating these emissions.

$$E_x = \frac{FR \times 60 \times OH \times C_{xt} \times 0.0026 \times M_x}{1 \times 10^6} \quad (8.5-18)$$

where

$$\begin{aligned}
 E_x &= \text{emissions of VOC or PM species x (lb/yr)} \\
 FR &= \text{flow rate through exhaust ventilation system (ft}^3\text{/min)}
 \end{aligned}$$



60	=	60 min/hr
OH	=	hours per year that the exhaust system is operational (hr/yr)
$C_{xt}$	=	concentration of VOC or PM species x (ppmv or ft <sup>3</sup> /MMft <sup>3</sup> )
0.0026	=	molar volume of gas at 68°F (mole/ft <sup>3</sup> )
$M_x$	=	molecular weight of VOC or PM species x (lb/lb-mole)
$1 \times 10^6$	=	$1 \times 10^6$ ft <sup>3</sup> /MMft <sup>3</sup> .

Example 8.5-11 illustrates the use of Equation 8.5-18.

VOC losses from certain operations (e.g., filling of containers) may also be measured by performing a study using a gravimetric analysis such as American Society For Testing and Materials (ASTM) Standard D2369, *Test Method for Volatile Content of Coatings*. The operation under evaluation could be simulated on a small scale, and VOC analysis would be conducted on samples taken before and after the simulated activity (EPA, 1992b).

#### Example 8.5-11

This example shows how Equation 8.5-18 is used to calculate fugitive emissions of xylenes from a building where several mixing vessels are located. The following data are given:

- The building exhaust flow rate (FR) is 20,000 ft<sup>3</sup>/min;
- The exhaust system operates for 7,920 hr/yr (OH);
- Industrial hygiene data indicate that the concentration of mixed xylenes in the building ( $C_{xt}$ ) is 0.1 ppmv; and
- The molecular weight of mixed xylenes ( $M_x$ ) is 106 lb/lb-mole.

Xylenes emissions are calculated as follows:

$$\begin{aligned}
 E_x &= \frac{FR \times 60 \times OH \times C_{xt} \times 0.0026 \times M_x}{1 \times 10^6} \\
 &= \frac{20,000 \times 60 \times 7,920 \times 0.1 \times 0.0026 \times 106}{1 \times 10^6} \\
 &= 262 \text{ lb xylenes/yr}
 \end{aligned}$$

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**VOLUME II: CHAPTER 9**

# **PREFERRED AND ALTERNATIVE METHODS FOR ESTIMATING AIR EMISSIONS FROM SECONDARY METAL PROCESSING**

**January 2001**



Prepared by:  
Eastern Research Group, Inc.

Prepared for:  
Point Sources Committee  
Emission Inventory Improvement Program

## **DISCLAIMER**

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.



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# DEFINITIONS OF COMMONLY USED TERMS (ITI, 1992)

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**Alloying** refers to the addition of elements to metals for the purpose of altering the properties of the metals. Strength, ductility, toughness, and resistance to corrosion are examples of properties affected by alloying. Common alloying elements include nickel, vanadium, tungsten, silicon, zinc, molybdenum, boron, titanium, aluminum, and lead.

**Dross** refers to impurities and semisolid flux (see definition below) that accumulate on the surface of molten metal.

**Casting** is one of the oldest and most common methods of forming (see definition below). It requires the melting of a solid, heating it to the proper temperature, treating it to produce a desired chemical composition, and then pouring it into a cavity or mold for solidification.

**Chemical Reduction** refers to the overall process of breaking metallic-oxide bonds to produce pure metal. It is done in a blast furnace or other reducing furnace. Some metals produced from reduction include iron, aluminum, titanium, magnesium, and zinc.

**Ferrous Metals** are metal compounds that contain iron.

**Fluxes** are materials added to the scrap metal, usually during the melting process, to aid in the purification of the metal.

**Forming** is the process of shaping molten metal into a solid state. Forming can include the shaping of simple ingots or the casting of precision parts, such as engine blocks. (See casting.)

**Nonferrous Metals** are metal compounds that do not contain iron.

**Smelting** means the chemical reduction of metal compounds to its elemental or alloyed form through processing in high-temperature (greater than 980°C) furnaces including, but not limited to, blast furnaces, reverberatory furnaces, rotary furnaces, and electric furnaces.

**Oxidation** decreases the amount of carbon, silicon, manganese, phosphorous, and sulfur in a mixture of molten pig iron and scrap to form steel. Specific oxidation processes used to make steel include Bessemer, open-hearth, basic-oxygen, and electric furnace.

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# 1

## INTRODUCTION

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This chapter of EIIP Volume II, Point Sources describes emission estimation methods for the secondary metal processing industry. Included in the secondary metal processing industry are the following:

- Secondary magnesium processing;
- Secondary aluminum processing;
- Secondary lead processing;
- Secondary copper processing;
- Secondary zinc processing;
- Iron foundries; and
- Steel foundries.

These chapters serve two primary purposes. First, they are designed to be used as a reference for emission estimation methods. Second, through the use of a standard set of methods, the quality of emission inventories can be expected to improve. Much of the process information included in this document is based on the *AWMA Air Pollution Engineering Manual* and EPA's emission factor document, *AP-42* 5th edition (AWMA, 1992; U.S. EPA, 1995). Other information was collected from consultants to the industry and state agencies.

Section 2 of this chapter describes the primary types of operations in use at secondary metal processing facilities, the emission sources and emission controls techniques. Secondary operations, such as boilers and wastewater collection and treatment, are discussed in Chapters 2 and 5, respectively, of this EIIP volume. Section 3 provides an overview and comparison of available emissions estimation methods: stack sampling, emission factors, continuous emissions monitoring systems, and material balance.

Section 4 presents the preferred methods which differ depending on the process and pollutant for which an estimate is to be made. Section 5 presents the alternative methods. Quality assurance and quality control procedures are discussed in Section 6. More detailed information is provided in Chapter 1 of this volume and in the EIIP QA document, Volume VI. In Section 7, Data Coding Procedures, a list of Source Classification Codes (SCCs) and Aerometric Information Retrieval System (AIRS) control device codes are provided to encourage the widespread use of these two systems so that inventory data can be shared more easily. References are provided in Section 8.

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# 2

## GENERAL SOURCE CATEGORY DESCRIPTION

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This section provides a brief overview of secondary metal processing. The reader is referred to the *Air Pollution Engineering Manual* (referred to as *AP-40*) and *AP-42* 5th edition, for a more detailed description of the processes (AWMA, 1992; U.S. EPA, 1995).

### 2.1 PROCESS DESCRIPTIONS

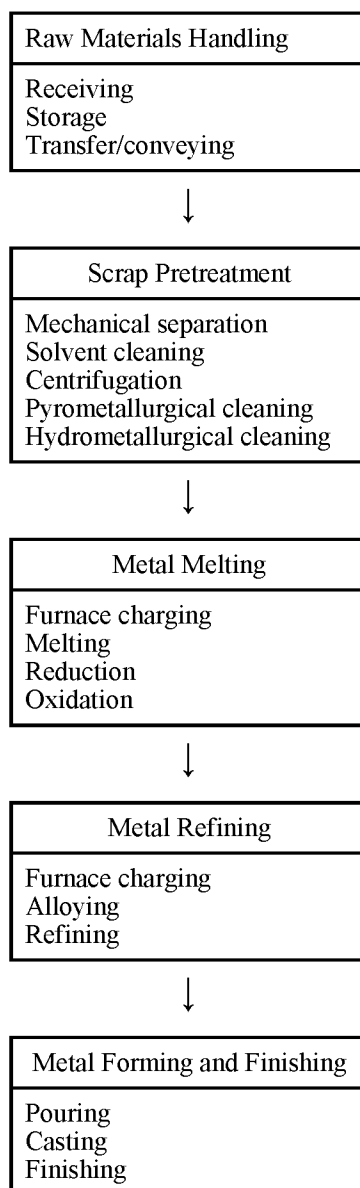
Secondary metal processing may be described as the processing of metal-containing materials to recover and reuse the metal. The specifics of the recovery process vary depending on the type of metal being processed, especially between ferrous and non-ferrous industries. Processes may even vary among facilities processing the same type of metal. However, the processes used by the different industries to recover metals may be grouped or classified by one of the following five general processes:

- Raw materials handling;
- Scrap pretreatment;
- Metals melting;
- Metal refining; and,
- Metal forming.

These processes are described in the following paragraphs and in Figure 9.2-1. The information is not intended to be used as descriptions of specific industries, but is intended to provide information on what types of operations and processes may result in emissions, regardless of the type of metal being processed. It should be noted that not all metal processing industries or facilities, use all of the five general processes.

#### 2.1.1 RAW MATERIALS HANDLING

Material handling operations include receiving, unloading, storing, and conveying the metal-containing materials and the materials required for metal processing (i.e., scrap metal, fluxes, alloys, fuels, and casting materials). The types of materials used may vary depending on the metal being processed. At iron foundries, for example, metallic raw materials might include

**FIGURE 9.2-1 FLOW DIAGRAM OF SECONDARY METAL PROCESSING OPERATIONS\***

\* It should be noted that not all industries, or facilities, use all of the processes and operations.

pig iron, iron and steel scrap, foundry returns, and metal turnings. Fluxes used at iron foundries might include carbonates (limestones, dolomite), fluoride (fluor spar), and carbide compounds (calcium carbide). Examples of alloys used in secondary aluminum processing include zinc, copper, manganese, magnesium, and silicon. The fuels used in secondary metal processing might include coal, oil, natural gas, or coke. Coal, oil, or natural gas are used to fire reverberatory furnaces; coke is used as fuel for cupolas and blast furnaces at iron foundries. Raw materials used in mold and core making for casts include sand and additives.

### **2.1.2 SCRAP PRETREATMENT**

Scrap refers to discarded materials, such as old appliances and automobile parts that contain a metal of interest, as well as to metal-bearing by-products or wastes generated by other operations in secondary metal processing. The scrap pretreatment process prepares the scrap for melting and involves sorting and processing metal-containing scrap to separate the metal of interest from unwanted materials and contaminants such as dirt, oil, plastics, and paint. Scrap pretreatment also involves the preliminary separation of the metal of interest from other metals contained in the scrap. The most commonly used operations, one or more of which are used by all secondary metal processing facilities, are described below.

#### ***Mechanical Separation***

Mechanical separation usually begins with sorting, crushing, pulverizing, shredding, and other mechanical means to break scrap into small pieces. Breaking the scrap into smaller pieces improves the efficiency of removing unwanted materials and concentrating the metal for further processing. Methods used to concentrate the metal include magnetic removal, eddy currents, screening, and pneumatic classification. Secondary copper processing and secondary aluminum processing are two of the secondary metal processing industries that make use of mechanical separation operations.

#### ***Solvent Cleaning***

Solvent cleaning of scrap is performed to remove grease and oils. This method is used at some facilities that utilize electric furnaces to melt metal.

#### ***Centrifugation***

Centrifugation, although rarely used, is another cleaning process for removing grease and oils from the scrap. Like solvent cleaning, this operation is found at some facilities that use electric furnaces.

#### ***Pyrometallurgical Cleaning***

Pyrometallurgical cleaning techniques, including roasting and sweating, use heat to separate the metal of interest from contaminants and other metals. The roasting process involves heating metal scrap that contains organic contaminants to temperatures high enough to vaporize or carbonize the organic contaminants, but not high enough to melt the metal of interest. Burning

insulation from copper wire is an example of a roasting process. In the aluminum industry, roasting is used to vaporize water.

The sweating process involves heating scrap containing the metal of interest and other metals to temperatures above the melting temperature of the metal of interest but below that of the other metals. For example, sweating recovers aluminum from high-iron-content scrap by heating the scrap to temperatures above the melting temperature of aluminum, but below the melting temperature of iron. This condition causes aluminum and other constituents with low melting points to melt and trickle down the sloped hearth, through a grate and into air-cooled molds or collecting pots. The materials with higher melting points, including iron, brass, and the oxidation products formed during the sweating process, are periodically removed from the furnace.

It should be noted that while pyrometallurgical cleaning is not used at iron and steel foundries, the metal may be preheated to facilitate melting and conserve energy.

### ***Hydrometallurgical Cleaning***

Hydrometallurgical cleaning techniques include leaching and heavy media separation. First, the scrap is crushed and then washed with water to remove water-soluble contaminants. The remaining material may be screened or magnetically separated before it goes to the melting process. Leaching is used in secondary copper and secondary zinc processing.

### ***Heavy Media Separation***

The heavy media separation process separates high density metal from low density metal using a viscous medium. Metal-containing materials are added to water. Compressed air is applied and chemicals are added that cause the low density metal to float to the surface of the liquid medium and form a foam of air bubbles. The foam is subsequently removed. Secondary aluminum processing and secondary copper processing use heavy media separation to separate metals.

## **2.1.3 METAL MELTING/SMELTING**

Melting is performed primarily to separate the metals of interest from their metallic compounds, although impurities and contaminants remaining after the pretreatment operation may also be removed. In addition, melting allows the creation of an alloy and allows castings to be made from the metal in a liquid state. Smelting in nonferrous metal processing, takes place in furnaces or heated crucibles. The furnaces may be heated with fuels or through the use of electricity.

Pretreated scrap, fuels, and flux materials are added (“charged”) to the furnace where melting takes place. The mixture of the flux materials depends on the type of metal being processed. In secondary lead processing, for example, flux materials may consist of rerun slag, scrap iron, coke, recycled dross, flue dust, and limestone. The flux may chemically react with the scrap in the presence of heat, breaking metallic-oxide bonds to produce pure metal. The process is called chemical reduction. Also, the flux may oxidize impurities in the scrap and further purify the metal.

The metal melting operation is sometimes performed in a series of furnaces. For example, copper scrap is melted in a blast furnace resulting in slag and impure copper. The impure copper is then charged to a reverberatory furnace, where copper of higher purity is produced.

#### **2.1.4 METAL REFINING**

The refining operations further purify the metal, producing the desired properties. Refining may take place in the melting furnace, or it may be performed in holding furnaces or other heated vessels separate from the melting furnace. These furnaces may be heated with fuels or with electricity. Materials are added to the molten metal in the furnace to remove impurities. For example, in copper processing, air is introduced to oxidize any contaminants. Chlorine or fluorides may be added to an aluminum refining furnace to react with magnesium, facilitating its separation from the aluminum.

Alloying is the adding of materials to melted metals in the refining furnace to produce desired properties of the metal. Strength, resistance to corrosion, and ductility are examples of properties enhanced by alloying. Alloying materials may include nickel, titanium, molybdenum, and silicon.

Another method of refining is distillation. In the distillation process used in the zinc industry, molten zinc is heated in a furnace until the zinc vaporizes. The zinc vapor is condensed and recovered in several forms depending upon temperature, recovery time, absence or presence of oxygen, and equipment used.

#### **2.1.5 METAL FORMING AND FINISHING**

After refining, the metal may be formed to make bars and ingots, or it may be formed to make a final product. At iron and steel foundries, this process is normally referred to as “metal coating” or “coating.” Bars and ingots, such as those produced in the secondary lead and aluminum industries, may be sent to another facility to make a final product. In some industries, such as at iron and steel foundries, the metal is cast into a final product at the melting facility.

Forming the metal into a final product requires the use of molds and cores. Molds are forms used to shape the exterior of castings. Cores are shapes used to make internal voids in castings. In the iron industry, molds are prepared from wet sand, clay, and organic additives, and are usually dried with hot air. Cores are made by mixing sand with organic binders or organic polymers and molding the sand into a core. Some cores are baked in an oven.

After the metal is formed, it is removed from the mold or container in which it was formed. If the formed metal is a final product, it may be necessary to grind or sand off rough edges. Also, the metal may be shot-blasted to remove mold sand or scale.

### **2.2 EMISSION SOURCES**

Emissions from secondary metal processing occur throughout production, beginning with material handling and storage. Some of the metal processing operations are enclosed and

emissions are collected and vented through stacks to reduce employee exposure. Secondary metal processing also produces fugitive emissions, much of which results from raw material storage and handling. The sources for emissions are discussed below.

Several types of pollutants may be generated during secondary metal processing. Among these are sulfur oxides ( $\text{SO}_x$ ), nitrogen oxides ( $\text{NO}_x$ ), carbon monoxide ( $\text{CO}$ ), carbon dioxide ( $\text{CO}_2$ ), particulate matter (PM), organic compounds, acid gases, chlorides, and fluorides (EPA, 1998b). Sulfur oxides,  $\text{NO}_x$ ,  $\text{CO}$ , and  $\text{CO}_2$  are primarily combustion byproducts; PM emissions occur from many of the operations. The constituents in PM, organic compounds, and acid gases vary according to the type of metal scrap being processed and the processes used. Data that may be used to identify specific hazardous air pollutants (HAPs) emitted as PM, organic compounds, or acid gases are limited. Generally in the case of PM, the constituents are elemental metals or metal oxides. Organic compounds may be contaminants that are being removed, additives used in the process, or byproducts generated during the process. Acid gases may be formed during some processes. It should be noted that not all processes produce all of the pollutants identified above. The pollutants produced are specific to the process and operation. Hazardous air pollutants associated with the various secondary metal processes are listed in Table 9.2-1 (EPA, 1998a).

Although the operations used in metal processing can be similar and have some pollutant emissions in common (for example,  $\text{NO}_x$ ,  $\text{CO}$ , and PM), there are no data available to indicate that qualitative and quantitative emissions information developed for one type of metal processing can be used to estimate emissions from another type of metal processing. Emission factors, for example, are specific to the industry for which they were developed. However, in some cases where processes and materials are similar, it may be reasonable to use emissions information or estimation methods from one industry for another.

### **2.2.1 RAW MATERIAL HANDLING AND STORAGE EMISSIONS**

Raw materials include scrap metal, fluxes, alloys, fuels, as well as sand and additives for molds and cores. Emissions are generated from receiving, unloading, storing, conveying, and mixing these materials. Particulate matter emissions are produced during the handling and storage of scrap and fluxes and sand handling and preparation. Organic compound emissions may occur from fuel and solvent storage tanks and from mold and core preparation. Emissions may be collected and released as stack emissions from enclosed processes or as fugitives from open processes.

### **2.2.2 SCRAP PRETREATMENT EMISSIONS**

Particulate matter emissions result from mechanical pretreatment operations such as shredding, crushing, and breaking, as well as during fuel combustion if preheating is used. Organic



TABLE 9.2-1

## HAZARDOUS AIR POLLUTANTS ASSOCIATED WITH SECONDARY METAL PROCESSING

**Ferroalloys Production**

Antimony & Compounds	Ethylene Glycol	Methyl Chloroform (1,1,1-Trichloroethane)
Chlorine	Hydrochloric Acid (Hydrogen Chloride [gas only])	Nickel & Compounds
Chromium & Compounds	Hydrogen Fluoride (Hydrofluoric Acid)	Polycyclic Organic Matter as 16-PAH
Cobalt Compounds	Lead & Compounds	
Cyanide Compounds	Manganese & Compounds	

**Iron Foundries**

1,4-Dioxane (1,4-Diethyleneoxide)	Ethylbenzene	Methyl Isobutyl Ketone (Hexone)
4-4'-Methylenediphenyl Diisocyanate	Ethylene Glycol	Methyl Isocyanate
Antimony & Compounds	Formaldehyde	Methylene Chloride
Arsenic & Compounds (inorganic including Arsine)	Glycol Ethers	Nickel & Compounds
Benzene	Hydrochloric Acid (Hydrogen Chloride [gas only])	Phenol
Cadmium & Compounds	Hydrogen Fluoride (Hydrofluoric Acid)	Polycyclic Organic Matter as 16-PAH
Chlorine	Lead & Compounds	Styrene
Chromium & Compounds	Manganese & Compounds	Toluene
Cobalt Compounds	Methanol	Trichloroethylene
Cumene	Methyl Chloroform (1,1,1-Trichloroethane)	Xylenes (includes o, m, and p)
Diethanolamine	Methyl Ethyl Ketone (2-Butanone)	

**Secondary Aluminum Production**

Antimony & Compounds	Dioxin/Furans as 2,3,7,8-TCDD TEQ	Lead & Compounds
Arsenic & Compounds (inorganic including Arsine)	Formaldehyde	Manganese & Compounds
Cadmium & Compounds	Hydrochloric Acid (Hydrogen Chloride [gas only])	Mercury & Compounds
Chromium & Compounds	Hydrogen Fluoride (Hydrofluoric Acid)	Nickel & Compounds

**Secondary Lead Smelting**

1,1,2,2-Tetrachloroethane	Chlorobenzene	Methyl Chloride
1,3-Butadiene	Chloroform	Methyl Ethyl Ketone (2-Butanone)
1,3-Dichloropropene	Chromium & Compounds	Methyl Iodide (Iodomethane)
Acetaldehyde	Cumene	Methylene Chloride
Acetophenone	Dibutyl Phthalate	Nickel & Compounds
Acrolein	Dioxin/Furans as 2,3,7,8-TCDD TEQ	Phenol
Acrylonitrile	Ethyl Carbamate (Urethane)	Polycyclic Organic Matter as 16-PAH
Antimony & Compounds	Ethylbenzene	Propionaldehyde
Arsenic & Compounds (inorganic including Arsine)	Formaldehyde	Styrene
Benzene	Hexane	Toluene

TABLE 9.2-1

(CONTINUED)

Biphenyl	Lead & Compounds	Trichloroethylene
Bis(2-ethylhexyl)phthalate	Manganese & Compounds	Xylenes (includes o, m, and p)
Cadmium & Compounds	Mercury & Compounds	
Carbon Disulfide	Methyl Bromide (Bromomethane)	
<b>Steel Foundries</b>		
1,1,2-Trichloroethane	Cresols (includes o,m,p)	Methyl Ethyl Ketone (2-Butanone)
2,4-Dinitrophenol	Cumene	Methyl Isobutyl Ketone (Hexone)
4-4'-Methylenediphenyl Diisocyanate	Cyanide Compounds	Methylene Chloride
Antimony & Compounds	Diethanolamine	Nickel & Compounds
Arsenic & Compounds (inorganic including Arsine)	Ethylbenzene	Phenol
Benzene	Ethylene Glycol	Phosphorus
Beryllium & Compounds	Formaldehyde	Polycyclic Organic Matter as 16-PAH
Biphenyl	Glycol Ethers	Quinoline
Cadmium & Compounds	Hydrochloric Acid (Hydrogen Chloride [gas only])	Selenium Compounds
Carbon Disulfide	Hydrogen Fluoride (Hydrofluoric Acid)	Styrene
Carbonyl Sulfide	Lead & Compounds	Tetrachloroethylene
Chlorine	Manganese & Compounds	Toluene
Chlorobenzene	Mercury & Compounds	Trichloroethylene
Chromium & Compounds	Methanol	Xylenes (includes o, m, and p)
Cobalt Compounds	Methyl Chloroform (1,1,1-Trichloroethane)	
<b>Steel Pickling HCl Process</b>		
Chlorine	Hydrochloric Acid (Hydrogen Chloride [gas only])	
<b>Taconite Iron Ore Processing</b>		
Benzene	Lead & Compounds	
Formaldehyde	Toluene	

compound emissions occur when solvent cleaning or pyrometallurgical cleaning are used. Pyrometallurgical cleaning also may result in emissions of CO, CO<sub>2</sub>, and NO<sub>x</sub>. Sulfur oxides are emitted when the scrap contains sulfur compounds and from sulfur in the fuel used for heating. Hydrogen chloride gas (HCl) will be generated if roasting is used to burn off insulation that contains chlorinated organics such as polyvinyl chloride. In secondary lead processing, sulfuric acid mist is released from battery breaking and crushing.

Pollutants from scrap treatment and control techniques for which data are available are listed in Table 9.2-2. No data are available for secondary magnesium processing; however, because of the similarity of some of the processes, the types of pollutants emitted are expected to be the same as those emitted from other metal processing, such as PM, CO, and organic compounds. Some facilities enclose scrap pretreatment operations and emissions are collected and vented from a stack. At facilities where these operations are performed in an open area, or where enclosures and ventilation are poorly maintained, fugitive emissions will result.

### 2.2.3 METAL MELTING EMISSIONS

Emissions from furnaces result from the interaction of the materials in the furnace (scrap metal, fluxes, alloys, etc.) and from the combustion of fuels used to heat the furnace. In the case of electric furnaces, there are no combustion emissions from the furnace and fuel combustion emissions occur only at facilities that generate their own electricity. The highest concentrations of fugitive emissions occur when the furnace lids and doors are opened during charging, alloying, and other operations. Furnace emissions are often collected and vented through a stack. Emissions that are not exhausted from the furnace stack are vented through building exhaust vents used to remove heat and create air circulation for the building.

Emissions from charging will consist of organic and inorganic particulate, organic vapors, and CO<sub>2</sub>. Emissions from furnace burners depend on the type of fuel used and may contain CO, CO<sub>2</sub>, NO<sub>x</sub>, and SO<sub>x</sub>. Organic compound emissions may also occur as residual oils or greases on the scrap are vaporized, depending on the degree of removal during pretreatment.

Emissions from fluxing operations depend on both the type of fluxing agents and the amount of flux required, both of which are a function of scrap quality. Emissions from fluxing generally include various chlorides and fluorides.

Table 9.2-3 presents a list of pollutants emitted and control techniques from metal melting operations for which data are available. Data are limited for secondary copper and secondary zinc processing. However, because of process similarities, some pollutants found at other types of secondary processing facilities, such as organic compounds and CO, would also be expected to be emitted.

TABLE 9.2-2

SCRAP PRETREATMENT EMISSIONS AND CONTROL TECHNIQUES <sup>a</sup>

Process	Pollutant	Control Technique	Typical Control Efficiency
Iron Foundries	Particulate matter (metal oxides)	No data	No data
	Organic compounds	Afterburners	95%
	Carbon monoxide	Afterburners	95%
Steel Foundries	Particulate matter (metal oxides)	No data	No data
	Organic compounds	Afterburners	95%
	Carbon monoxide	Afterburners	95%
Secondary Aluminum Processing	Particulate matter (metal oxides)	Fabric filter <sup>b</sup> with and without lime injection	95% - 99%
	Organic compounds	Afterburners	>90%
	Carbon monoxide	No data	No data
	Chlorides; fluorides; HCl	Afterburner; fabric filter with lime injection	>90% for HCl
	Sulfur oxides	No data	No data
Secondary Lead Processing	Particulate matter (metal oxides)	Fabric filter	No data <sup>b</sup>
	Sulfur oxides	Wet scrubbers	No data
	Sulfuric acid mist	Wet scrubbers	

**TABLE 9.2-2**  
**(CONTINUED)**

Process	Pollutant	Control Technique	Typical Control Efficiency
Secondary Copper Processing	Particulate matter (metal oxides)	Fabric filters	No data <sup>b</sup>
	Organic compounds	Afterburners	>90%
	HCl	No data	No data
Secondary Zinc Processing	Particulate matter (metal oxides)	No data	No data
	Zinc		

NOTE: No data for secondary magnesium processing were identified.

<sup>a</sup> Reference: U.S. EPA, 1995

<sup>b</sup> For more information on using control efficiencies of particulate matter for fabric filters, the reader is encouraged to review Table 12.3-6 and Section 12.4-21 in Chapter 12 of this volume.

TABLE 9.2-3

METAL MELTING EMISSIONS AND CONTROL TECHNIQUES <sup>a</sup>

Process	Pollutant	Control Technique	Typical Control Efficiency (%)
Iron Foundries, Grey Iron Cupolas	Particulate matter	Fabric filter	No data <sup>b</sup>
Iron Foundries, Open Hearth Furnace	Particulate matter	Electrostatic precipitator <sup>c</sup>	99.2
Iron Foundries, Electric Arc Furnace	Particulate matter	Fabric filter <sup>d</sup>	No data <sup>b</sup>
Iron Foundries, Sinter Furnace	Particulate matter	Electrostatic precipitator <sup>c</sup>	90 -94
Iron Foundries, Desulfurization	Particulate matter	Fabric filter	No data <sup>b</sup>
Iron Foundries	Particulate matter (metal oxides)	Scrubbers	45 - 95
		Fabric filters	No data <sup>b</sup>
	Organic compounds	Afterburners	95%
	Carbon monoxide	Afterburners	95%
	Sulfur dioxide	No data	No data
	Nitrogen Oxides		
	Chlorides; fluorides		
Steel Foundries	Particulate matter (metal oxides)	Fabric filters <sup>b</sup> ; scrubbers	No data
	Organic compounds	No data	No data
	Carbon monoxide		
	Sulfur dioxide		
	Chlorides; fluorides		

**TABLE 9.2-3**  
**(CONTINUED)**

Process	Pollutant	Control Technique	Typical Control Efficiency
Steel Foundries, Open Hearth Furnace	Particulate matter	Electrostatic precipitator <sup>c</sup>	99.2
Steel Foundries, Grey Iron Cupola	Particulate matter	Fabric filter	No data <sup>b</sup>
Steel Foundries, Sinter Furnace	Particulate matter	Electrostatic precipitator <sup>c</sup>	90 - 94
Steel Foundries, Desulfurization	Particulate matter	Fabric filter	No data <sup>b</sup>
Secondary Aluminum Processing	Chlorides; fluorides	Venturi scrubbers (fluorides)	No data
	Particulate matter (metal oxides)	Fabric filter <sup>b</sup> with lime injection	85 - 99
	Organic compounds	No data	No data
	Carbon monoxide		
	Nitrogen oxides	No data	No data
	Sulfur oxides		
	Chlorides; fluorides; HCl	Fabric filter with lime injection	>90 for HCl
Secondary Aluminum Processing, Baking Furnaces	Organic Compounds	Fabric filter with Reduction Cell <sup>e, d</sup>	99
	Particulate Matter	Fabric filter <sup>b</sup> with Reduction Cell <sup>e, d</sup>	99
Secondary Lead Processing	Particulate matter (metal oxides)	Mechanical Collector <sup>c</sup>	80 - 90
		Fabric filters	No data <sup>b</sup>
		Venturi scrubber with demister	99

**TABLE 9.2-3**  
**(CONTINUED)**

<b>Process</b>	<b>Pollutant</b>	<b>Control Technique</b>	<b>Typical Control Efficiency (%)</b>
Secondary Lead Processing (Continued)	Sulfur oxides	DMA Absorber <sup>c, d</sup>	92 - 95
	Organic compounds	Afterburner	98 <sup>e</sup>
	Carbon monoxide	No data	No data
	Sulfides; sulfates		
Secondary Magnesium Processing	Particulate matter	No data	No data
	Organic compounds		
	Carbon monoxide		
Secondary Copper Processing	Particulate matter (metal oxides)	Fabric filters	No data <sup>b</sup>
	Lead	No data	No data
Secondary Copper Processing, Multiple Hearth Roaster	Particulate matter	Electrostatic Precipitator	99
Secondary Copper Processing, Reverberatory Furnace	Particulate matter	Electrostatic Precipitator	97.2
Secondary Zinc Processing	Particulate matter (metal oxides)	Fabric filters	No data <sup>b</sup>
	Zinc	No data	No data



**TABLE 9.2-3**  
**(CONTINUED)**

Process	Pollutant	Control Technique	Typical Control Efficiency (%)
Secondary Zinc Processing	Particulate matter (metal oxides)	Fabric filter	No data <sup>b</sup>
	Zinc	No data	No data
Secondary Copper Processing, Multiple Hearth Roaster	Particulate matter	Electrostatic precipitator	99
Secondary Copper Processing, Reverberatory Furnace	Particulate matter	Electrostatic precipitator	97.2
All Secondary Metals Processing Types, Roasters	Particulate matter	Cold electrostatic precipitator <sup>c</sup>	95
		Hot electrostatic precipitator	20 - 80
All Secondary Metals Processing Types, Open Arc Furnaces	Carbon monoxide	Flare <sup>c</sup>	98
	Organic compounds	Flare <sup>c</sup>	98
All Secondary Metals Process Types, Smelters	Organic Compounds	Flare <sup>c</sup>	90
	Organic Compounds	Spray Dryer Absorber <sup>c</sup>	

<sup>a</sup> Reference: U.S. EPA, 1995; EIIP, 2000.

<sup>b</sup> For more information on using control efficiencies of particulate matter for fabric filters, the reader is encouraged to review Table 12.3-6 and Section 12.4-21 in Chapter 12 of this volume.

<sup>c</sup> Average control efficiency is reported. Source: EIIP, 2000.

<sup>d</sup> Control efficiencies for these control devices were not evaluated in the reference.

<sup>e</sup> Reference: U.S. EPA, 2000a.

## 2.2.4 METAL REFINING EMISSIONS

One emission source in metal refining is from fuel combustion used to heat the furnace. Combustion emissions including CO, CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub>, and PM are generated. When an electric furnace is used, there are no combustion emissions unless the facility produces its own electricity. Particulate matter is also generated when alloys are added to the molten metal. These alloys usually consist of various metals and although the amount of pollutants released may not be significant, numerous types of metals and metal compounds may be emitted, depending on the type of metal being processed.

Emissions may result when materials are added to enhance the refining process. For example, in secondary aluminum refining, chlorine or aluminum fluoride may be added to the molten metal to remove magnesium. Chlorides, fluorides, and HCl may be emitted from such operations.

Pollutants emitted from metal refining operations and control techniques for which data are available are presented in Table 9.2-4. No data are available for zinc processing, although some pollutants such as PM, CO, and organic compounds emitted from other types of metal processing would be expected to be emitted from zinc processing because of process similarities. Because refining in secondary aluminum and secondary magnesium industries occur in the same furnace as melting, the associated pollutants are shown in Table 9.2-3, Metal Melting Emissions and Control Techniques.

## 2.2.5 METAL FORMING AND FINISHING EMISSIONS

As the molten metal is poured into molds, PM, CO, and organic compound emissions are generated, with the emissions continuing as the mold cools. Particulate matter emissions are also produced when the form is released from the mold, especially when a shaking or vibrating operation is used. If the form requires finishing, such as grinding or milling, additional PM emissions will result. Data are available only for iron and steel foundries and secondary lead processing and are shown in Table 9.2-5. Particulate matter, CO, and organic compound emissions are expected from core baking, and organic compounds evaporate during mold drying. Pollutants emitted from mold and core production at iron and steel foundries are shown in Table 9.2-6. Emissions from mold and core production at other metal processing facilities are expected to be similar.

## 2.3 DESIGN AND OPERATING FACTORS INFLUENCING EMISSIONS

Several factors should be taken into account in order to develop an accurate estimate of emissions. Two important factors are the process design and operation. Both may vary significantly from facility to facility; thus, no specific guidance on how to adjust an emission estimate for a particular facility is provided. Information specific to the facility should be collected in order to derive the best emissions estimate. A few common factors to consider are listed below.

TABLE 9.2-4

METAL REFINING EMISSIONS AND CONTROL TECHNIQUES <sup>a</sup>

Process	Pollutant	Control Technique	Typical Control Efficiency
Iron Foundries	Particulate matter	Fabric filters <sup>b</sup>	No data
	Organic compounds	No data	
	Carbon monoxide	No data	
Steel Foundries	Particulate matter (metal oxides)	No data	No data
Secondary Aluminum Processing	Refining is performed in the melting furnace. See Table 9.2-2		
Secondary Lead Processing	Particulate matter (metal oxides)	No data	No data
	Sulfur Dioxide		
Secondary Magnesium Processing	Refining is performed in the melting furnace. See Table 9.2-2		
Secondary Copper Processing	Particulate matter (metal oxides)	No data	No data
	Sulfuric acid mist		
Secondary Zinc Processing	Particulate matter (metal oxides)	Fabric Filters	No data <sup>b</sup>

<sup>a</sup> Reference: U.S. EPA, 1995.<sup>b</sup> For more information on using control efficiencies of particulate matter for fabric filters, the reader is encouraged to review Table 12.3-6 and Section 12.4-21 in Chapter 12 of this volume.

**TABLE 9.2-5**  
**METAL FORMING EMISSIONS AND CONTROL TECHNIQUES <sup>a</sup>**

Process	Pollutant	Control Technique	Typical Control Efficiency
Iron Foundries	Particulate matter (metal oxides)	Fabric filters	No data <sup>b</sup>
Steel Foundries	Particulate matter (metal oxides)	Fabric filters <sup>b</sup> ; Venturi scrubbers	98% - 99.9%; 94% - 98%
Secondary Lead Processing	Particulate matter (metal oxides)	Fabric filters	No data <sup>b</sup>

NOTE: No data are available for secondary aluminum, magnesium, copper, and zinc processing.

<sup>a</sup> Reference: U.S. EPA, 1995.

<sup>b</sup> For more information on using control efficiencies of particulate matter for fabric filters, the reader is encouraged to review Table 12.3-6 and Section 12.4-21 in Chapter 12 of this volume.

TABLE 9.2-6

**MOLD AND CORE PRODUCTION EMISSIONS AND CONTROL TECHNIQUES<sup>a</sup>**

Process	Pollutant	Control Technique	Typical Control Efficiency
Iron Foundries	Particulate matter (metal oxides)	Scrubbers; fabric filters <sup>b</sup>	No data
	Organic compounds	Afterburners; scrubbers	
	Carbon monoxide	No data	
Steel Foundries	Particulate matter (metal oxides)	Scrubbers; fabric filters <sup>b</sup>	No data
	Organic compounds	Afterburner; scrubbers	
	Carbon monoxide	No data	

NOTE: No data are available for secondary aluminum, lead, magnesium, copper, and zinc processing.

<sup>a</sup> Reference: U.S. EPA, 1995.

<sup>b</sup> For more information on using control efficiencies of particulate matter for fabric filters, the reader is encouraged to review Table 12.3-6 and Section 12.4-21 in Chapter 12 of this volume.

- Is the facility operating as it was designed? Have process and ventilation systems been modified to accommodate any differences from design conditions?
- Does the facility have emission control equipment or practices in place? How effective are these?
- Has the facility optimized its operation to minimize emissions? For example, if scrap is not cleaned adequately, organic contaminants may remain and be volatilized later in the process. Where incineration is used, this will increase combustion byproducts.
- What are the facility's maintenance and housekeeping practices?
- Are systems enclosed or open?
- Are systems automated or manual?
- What kinds of contaminants are introduced in the scrap materials? At what concentrations are these contaminants?

## 2.4 CONTROL TECHNIQUES

Add-on control devices to reduce emissions are in common use at secondary metal processes. These include scrubbers for PM and acid gases; incinerators for organic compounds; and cyclones, ESPs, and fabric filters for filterable PM. These controls should be taken into account when estimating emissions from these processes. For example, if an emission factor representing emissions from an uncontrolled source is used to estimate emissions from a controlled source, the control efficiency of the control device used must be included in the emissions calculations. The available data relating to the types of control devices used in secondary metal processing and their respective control efficiencies are provided in Tables 9.2-2 through 9.2-6. No information was found on NO<sub>x</sub> or CO<sub>2</sub> control. Because of process similarities among the metals, some assumptions about the types of controls that may be in use can be made since there is a limited set of control technologies for any given pollutant. The control technologies used should be verified to be sure emissions are not underestimated. A brief description of each typical control devices is presented below. However, air pollution control references such as Chapter 12 in this EIIP volume, *How to Incorporate the Effects of Air Pollution Control Devices and Malfunctions into Emission Estimates*, should be consulted for details of operation and effectiveness of control devices. It should be noted that not all industries use all of the devices listed in this section.

### 2.4.1 WET SCRUBBERS

Wet scrubbers are used to reduce solid and condensible PM and acid gases such as HCl and SO<sub>2</sub>. Pollutant removal is achieved through the process of absorption, where liquid is selected in which the targeted pollutants are soluble and conditions (e.g., flow rate, temperature, and surface area for contact) are optimized to maximize pollutant removal.

### **2.4.2 THERMAL AND CATALYTIC INCINERATION**

Incineration is an effective method of reducing emissions of organic compounds. Incineration systems used as control devices consist of burners and a chamber. The burners ignite the fuel and combustion pollutants; the chamber provides appropriate residence time for the oxidation process.

In thermal incinerators, which are sometimes referred to as afterburners, the combustible waste gases pass over or around a burner flame into a residence chamber where oxidation of the gases is completed. Catalytic incineration is similar to thermal incineration. The main difference is that after passing through the flame area, the gases pass over a catalyst bed which promotes oxidation at a lower temperature than does thermal incineration. Metals in the platinum family and various oxides of copper, chromium, vanadium, nickel, and cobalt are frequently used as catalysts.

### **2.4.3 CYCLONES**

Cyclones provide a low-cost, low-maintenance method of removing relatively larger sizes of PM from gas streams. Particulate matter suspended in the gas stream enters the cyclone and is forced into a vortex by the circular shape of the cyclone. As the gas spirals in the cylindrical section of the cyclone, the PM moves outward to the cyclone wall due to the centrifugal force and is caught in the thin layer of air next to the wall. The PM is carried downward by gravity to be collected in the hopper at the cyclone base.

### **2.4.4 ELECTROSTATIC PRECIPITATORS (ESPs)**

An ESP is a PM control device that uses electrical forces to move the particles out of the flowing gas stream and onto collector plates. The particles are given an electric charge by forcing them to pass through a corona, a region in which gaseous ions flow. The charged particles are forced to the walls of the ESP by an electrical field coming from electrodes positioned in the center of the gas flow. When the particles come close enough to the wall, they are collected on plates. Once the particles are collected on the plates, they must be removed from the plates without reentering them into the gas stream. This is usually accomplished by knocking them loose from the plates, allowing the collected layer of particles to slide down into a hopper, from which they are removed.

### **2.4.5 FABRIC FILTERS**

Fabric filter systems, sometimes called baghouses, remove PM from a gas stream by passing the stream through a porous fabric. The particles form a porous layer of dust on the surface of the fabric which acts as a filter and causes additional PM removal. Also, fabric filter systems are available with pre-coated bags. The coating improves air flow and collection efficiency and protects the fabric from harsh start up environments. The two most common baghouse designs are the reverse-air and the pulse-jet types. These names describe the cleaning system used with the design.

Reverse-air baghouses operate by directing the dirty flue gas into the middle of the bags. Collection of dust is on the inside surface of the bags. The bags are cleaned periodically by reversing the flow of air, causing the previously collected dust cake to fall from the bags into a hopper below.

Pulse-jet baghouses are designed with internal frame structures, called cages, to allow collection of the dust on the outside of the bags. The dust cake is periodically removed by a pulsed jet of compressed air into the bag causing a sudden bag expansion. The dust is removed primarily by inertial forces when the bag reaches its maximum expansion.



# OVERVIEW OF AVAILABLE METHODS

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## 3.1 DESCRIPTION OF EMISSION ESTIMATION METHODOLOGIES

There are several available methods for estimating emissions from secondary metal processing facilities. The choice of method depends on how the estimate will be used and the degree of accuracy required. The availability of data or existing guidance from EPA or industry trade associations and the amount of available resources may determine the method. Regulatory agency requirements may establish minimum requirements for preparing estimates that limit the choice of method to be used for a facility or process.

Generally, methods that use site-specific data, such as stack sampling data, are preferred over methods that use industry averaged data, such as *AP-42* emission factors. Stack sampling data produce a more accurate estimate of emissions on a facility basis. However, industry averages may better represent emissions across multiple facilities and over longer time periods than limited site-specific data. This section presents the available methods for estimating emissions from secondary metal processing facilities. The methods are not listed in any particular order. Preferred estimation methods are identified on a pollutant basis; ranking of these methods is based on the accuracy of the resulting estimate without regard for cost or other resources.

### 3.1.1 STACK SAMPLING

Stack sampling provides site-specific data that can be used to estimate emissions. These data include pollutant concentrations in the stack gas and the stack gas volumetric flow rate. An emission rate for a particular pollutant is estimated by multiplying the pollutant concentration in the stack gas by the volumetric flow rate.

Two methods are typically used to measure pollutant concentrations in the stack gas: (1) manual methods and (2) instrumental methods. The manual methods involve a probe inserted into the stack through which a stream of the exhaust gas is extracted using a vacuum pump. Constituents (pollutants) of the gas are collected in or on various media and the volume of gas sampled is measured. The collection media undergo laboratory analyses to identify the type and mass of pollutant(s) collected. Pollutant concentrations are then determined by dividing the mass of pollutant collected by the volume of gas sampled. The sampling method is selected based on the pollutant of interest.

Instrument analyzers measure pollutant concentrations directly but do not “collect” the pollutants. Similar to the manual method, a probe is inserted into the stack and a sample of the gas stream is continuously withdrawn. The sample passes through an electronic instrument that is calibrated to respond to the pollutant of interest and that indicates the pollutant concentration on a volume basis, usually expressed as parts per million by volume (ppmv). The concentration of the pollutant on a volume basis is then converted to a mass basis using the ideal gas law

adjustments for nonideal conditions, and the molecular weight of the pollutant. The instrument analyzers used for stack sampling are often identical to those used in continuous emission monitoring systems.

To determine the stack gas volumetric flow rate, the second parameter needed for the emission estimate, the cross-sectional area of the stack is multiplied by the stack gas velocity. The stack area is obtained by direct measurement of the stack dimensions (diameter or length and width). The velocity may be measured with Pitot tubes or with electronic instruments.

Stack tests are usually performed during operating conditions that are representative of the normal operation of the process. Thus, although stack sampling provides a “snapshot” of emission levels during the stack test, the results are considered to represent emissions during routine operation. A discussion of the sampling and analytical methods available for each pollutant is provided in Chapter 1 of this volume.

Some state agencies may require facilities to perform stack tests under “worst case” conditions to determine maximum emission levels. During such tests, the facility may be operating at maximum capacity or under other conditions that maximize emissions. Emissions data generated during these tests overestimate emissions during routine operation. However, these peaks can be used to establish a better emissions profile where the facility has periodic peak releases.

### **3.1.2 EMISSION FACTORS**

Emission factors are available for many secondary metal processes and are based on the results of emission tests or studies performed at one or more facilities. Emission factors are usually developed by correlating an emission rate to a production rate. For example, if an emission rate developed from stack testing data is estimated in units of pounds per hour and the production rate from the emission source (process) is measured in tons per hour, then an emission factor is calculated by dividing the emission rate by the production rate. Chapter 1 of this volume contains a detailed discussion of the reliability and quality of emission factors.

EPA maintains a compilation of emission factors in *AP-42* for criteria pollutants and HAPs (EPA, 1995). A supplementary source of criteria and HAP emission factors is the Factor Information Retrieval (FIRE) system (EPA, 2000b). Chapter 1 of this volume provides a more complete discussion of available information sources for locating, developing, and using emission factors as an estimation technique.

### **3.1.3 CONTINUOUS EMISSION MONITORING SYSTEMS (CEMS)**

A CEMS consists of one or more instrument analyzers that are used to measure stack gas pollutant concentrations continuously over a period of time. Instrument analyzers are described in Section 3.1.1. Instrument analyzers used for CEMS differ from those used for stack sampling in that they are permanently installed in a fixed location. In addition, the CEMS method for determining pollutant concentrations is different from the stack sampling method in that stack sampling measures emissions over a limited period of time, usually a few hours, while a CEMS continuously measures emissions over extended periods of time, such as days, weeks, and even

months. Thus, emissions estimates developed from CEMS data are more representative of long term conditions than estimates developed from stack sampling data.

Similar to the stack sampling method, the pollutant concentrations measured by the CEMS on a volume basis are converted to a mass basis and multiplied by the stack gas volumetric flow rate to estimate emission rates. Stack gas flow rates can be measured with an instrument, but they are typically determined using manual methods (e.g., Pitot tube).

### **3.1.4 MATERIAL BALANCE**

The material balance method for estimating emissions compares the total amount of a raw material entering a process to the amount of material leaving the process as product and waste. Emissions are estimated by assuming the difference between the total amount of material used and the amount of material recovered, disposed of as waste, and retained in the product is emitted to the atmosphere.

## **3.2 COMPARISON OF AVAILABLE EMISSION ESTIMATION METHODOLOGIES**

Table 9.3-1 identifies the preferred (number 1) and alternative emission estimation approaches (numbers 2-4) for selected pollutants. For the pollutant of interest, the preferred and alternative method(s) can be identified based on whether emissions are collected and vented from a stack, or are fugitive in nature. It should be noted that for some processes and operations, it may not be practical to use the preferred method and an alternative method must be selected instead. For example, although stack sampling and CEMs are listed in Table 9.3-1 as the preferred method for several pollutants, it may not be practical to use either method for some processes because of high exhaust gas temperatures. In addition, for some processes, an alternative method may be selected. For example, although Table 9.3-1 identifies stack sampling as the preferred method for estimating VOC emissions and emission factors as an alternative method, there are some processes, such as scrap pretreatment, where emission factors may be selected as the method of choice. The inventory preparer and, where appropriate, the cognizant air quality agency representative, must decide whether to take cost and air pollution control requirements into account in choosing an emission estimation approach. In selecting a method, other considerations should include the time interval for the emission estimate (e.g., hourly, annual) and the data quality. The quality of the data will depend on multiple factors including the number and accuracy of data points to be used in the estimate and the representativeness of the data points. Chapter 1 of this document describes the limitations of the available emission estimation methodologies and factors to consider in the use of each method.

TABLE 9.3-1

**SUMMARY OF PREFERRED AND ALTERNATIVE EMISSION ESTIMATION METHODS  
FOR SECONDARY METAL PROCESSING<sup>a,b</sup>**

<b>Pollutant<sup>c</sup></b>	<b>CEMS</b>	<b>Stack Sampling Data</b>	<b>Material Balance</b>	<b>EPA/State Emission Factors</b>
PM - process		1		2
PM- fugitive				1
PM <sub>10</sub> - process		1		2
PM <sub>10</sub> - fugitive				1
SO <sub>2</sub> - process	1	2	3	4
SO <sub>2</sub> - combustion	1	2	3	4
NO <sub>x</sub>	1	2		3
CO	1	2		3
VOC		1	3	2
THC	1	2	4	3
Speciated organics		1		2
Metals		1		2

<sup>a</sup> Preferred = number 1. Alternative = numbers 2-4.

<sup>b</sup> Preferred emission estimation approaches do not include considerations such as cost. The costs, benefits, and relative accuracy should be considered prior to method selection. The reader is advised to check with their local air pollution control agency before choosing a preferred emission estimation approach.

<sup>c</sup> PM = Particulate matter.

PM<sub>10</sub> = PM less than, or equal to, 10 microns in aerodynamic diameter.

VOC = Volatile organic compounds.

THC = Total hydrocarbons.

### **3.2.1 STACK SAMPLING**

Stack sampling is the most accurate emission estimation methodology for process volatile organic compounds (VOCs), speciated organics, PM, PM<sub>10</sub> (particulate matter less than or equal to 10 µm), and metals. EPA reference methods and other standard methods are available for several pollutants and can be used to obtain accurate emissions estimates for a particular facility.

### **3.2.2 EMISSION FACTORS**

Due to their availability, ease of use, and low cost, emission factors have gained wide acceptance in the industry and are commonly used to prepare emission inventories. However, emission factors are often averages of limited industry-wide emissions data and so vary in their degree of quality. The underlying data and the resulting average may also inadequately represent emissions for an individual facility within that industry, introducing further error.

### **3.2.3 CEMS**

Continuous emissions monitoring systems are typically used at secondary metal processing facilities to measure SO<sub>2</sub>, NO<sub>x</sub>, CO, and THC emissions from processes that include combustion sources, such as drying and melting furnaces. Continuous emissions monitoring systems are used when detailed records of emissions are needed over time. EPA reference methods and other standards that use CEMS are available which improves the accuracy and comparability of the resulting data. Emissions estimates developed from CEM data can be equally accurate as those developed from stack sampling data for these pollutants.

### **3.2.4 MATERIAL BALANCE**

An emission estimate based on a material balance approach is the result of calculations with several inputs. Consequently, the accuracy of the emissions estimate is directly related to the accuracy of the values for the inputs. Where inputs to the calculations can not be measured directly (e.g., the amount of material leaving a process in the wastewater), the accuracy of the resulting emissions estimate may vary greatly.

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# 4

## PREFERRED METHODS FOR ESTIMATING EMISSIONS

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In Section 3 (Table 9.3-1), stack sampling and CEMS emission factors were identified as the preferred methods for estimating emissions from secondary metal processing operations. Optimally, the preferred method is used to estimate emissions. However, considerations such as the availability of resources often dictate the choice of method. Because some state agencies may specify the method(s) to be used, the inventory preparer should contact the appropriate state or local air quality agency before deciding on which emission estimation methodology to use.

This section describes how the preferred methods should be used for estimating emissions.

### 4.1 EMISSION ESTIMATIONS USING STACK SAMPLING DATA

Stack sampling is the preferred method for estimating emissions for process PM, VOCs, speciated organics, and metals. To illustrate how the results are used to estimate emissions, an example using a PM test based on EPA Method 5 is shown below. To estimate emissions in pounds per hour, the pollutant concentration is determined and then multiplied by the stack gas volumetric flow rate. The test results are given in Table 9.4-1, Equations 9.4-1 and 9.4-2 are used to derive the estimates, and Example 9.4-1 shows the calculations used to estimate PM emissions.

**TABLE 9.4-1**  
**TEST RESULTS - METHOD 5**

Parameter	Symbol	Run 1	Run 2	Run 3
Filter catch (grams)	$C_f$	0.0851	0.0449	0.0625
Standard metered volume (dscf)	$V_{m,STP}$	41.83	40.68	40.78
Volumetric flow rate (dscfm)	$Q_d$	17,972	17,867	17,914

Determine the PM concentration:

$$C_m = C_f / V_{m,STP} * 15.43 \quad (9.4-1)$$

where:

$$\begin{aligned} C_m &= \text{concentration of PM (grain/dry standard cubic feet [dscf])} \\ C_f &= \text{amount of PM collected on filter (grams)} \\ V_{m,STP} &= \text{volume of gas sampled at standard temperature and pressure (dscf)} \\ 15.43 \text{ grains} &= 1 \text{ gram} \end{aligned}$$

Calculate the mass emission rate:

$$E_{PM} = C_m * Q_d * 60 * 1/7,000 \quad (9.4-2)$$

where:

$$\begin{aligned} E_{PM} &= \text{PM emissions (lb/hr)} \\ Q_d &= \text{stack gas volumetric flow rate (dry standard cubic feet per minute [dscfm])} \\ 60 \text{ minutes} &= 1 \text{ hour} \\ 7,000 \text{ grains} &= 1 \text{ pound} \end{aligned}$$

#### Example 9.4-1

PM emissions calculated using Equations 9.4-1 and 9.4-2 and the stack sampling data for Run 1 (presented in Table 9.4-1 are shown below).

$$\begin{aligned} C_m &= C_f / V_{m,STP} * 15.43 \\ &= 0.085 \text{ grams} / 41.83 \text{ dscf} * 15.43 \text{ grain/gram} \\ &= 0.03 \text{ grain/dscf} \\ E_{PM} &= C_m * Q_d * 60 * 1/7,000 \\ &= 0.03 \text{ grain/dscf} * 17,972 \text{ dscf/min} * 60 \text{ min/hr} * \\ &\quad 1 \text{ lb} / 7,000 \text{ grain} \\ &= 4.62 \text{ lb/hr} \end{aligned}$$



## 4.2 EMISSION ESTIMATIONS USING EMISSION FACTORS

Emission factors are the preferred method for fugitive PM emissions. They are also frequently used to estimate emissions when site-specific emissions data are unavailable. The basic equation for estimating emissions using an emission factor is:

$$E_x = EF_x * \text{Activity or Production Rate} \quad (9.4-3)$$

where:

$E_x$  = emissions of pollutant x  
 $EF_x$  = emission factor for pollutant x

Example 9.4-2 describes how emissions may be estimated using an emission factor.

### Example 9.4-2

This example shows how potential hourly PM emissions may be calculated for a secondary lead reverberatory smelter using a PM emission factor from *AP-42*, Table 12.11-2. The lead smelter is assumed to operate 8,760 hours per year. Note that the emission factor is for an uncontrolled furnace.

$EF_{PM}$	=	323 lb PM/ton metal produced
Maximum metal production rate	=	50 ton/hr
PM emissions	=	$EF_{PM} * \text{metal production rate}$
	=	$323 \text{ lb/ton} * 50 \text{ ton/hr} * 1 \text{ ton}/2,000 \text{ lb} *$
		$8,760 \text{ hr/yr}$
	=	70,737 ton/yr

## 4.3 EMISSIONS ESTIMATING USING CEMS DATA

Use of CEMS is the preferred method for  $SO_2$ ,  $NO_x$ , CO, and THC. Calculations to estimate emissions using CEMS data are very similar to those using stack sampling data. Continuous emissions monitoring systems measure pollutant concentrations on a volume basis and the concentrations must be converted to a mass basis when calculating emissions. The mass-basis concentrations are then multiplied by the stack gas volumetric flow rate to estimate emissions. Equations 9.4-4 and 9.4-5 may be used to estimate emissions using CEMS data. Example 9.4-3 shows how the equations are used.

$$E_x = \frac{(C_v * MW * Q_d * 60)}{(V * 10^6)} \quad (9.4-4)$$

where:

$E_x$	= hourly emissions of pollutant x (lb/hr)
$C_v$	= pollutant concentration in ppmvd (part/ $10^6$ )
MW	= molecular weight of the pollutant (lb/lb·mole)
$Q_d$	= stack gas volumetric flow rate (dscf/min)
V	= volume occupied by one mole of ideal gas at standard temperature and pressure (385.5 ft <sup>3</sup> /lb·mole at 68°F and 1 atm)
60 minutes	= 1 hour

Emissions in tons per year can be calculated by multiplying the emission rate in pounds per hour by the number of annual operating hours (OpHrs) as shown in Equation 9.4-5.

$$E_{tpy,x} = E_x * OpHrs / 2000 \quad (9.4-5)$$

where:

$E_{tpy,x}$	= annual emissions of pollutant x (ton/yr)
$E_x$	= hourly emissions of pollutant x (lb/hr)
OpHrs	= annual operating hours (hr/yr)
2,000 pounds	= 1 ton

Example 9.4-3

Given:

SO<sub>2</sub> concentration = 175 ppmvd  
SO<sub>2</sub> molecular weight = 64 lb/lb·mole  
Stack gas volumetric flow rate = 1,500 dscf/min  
Annual operating hours per year = 2,000

Then, using equation 9.4-4:

$$\begin{aligned} E_{\text{SO}_2} &= (C_v * \text{MW} * Q_d * 60) / (V * 10^6) \\ &= (175 \text{ ppmvd} * 64 \text{ lb/lb}\cdot\text{mole} * 15,000 \text{ dscf/min} * \\ &\quad 60 \text{ min/hr}) / (385.5 \text{ dscf/lb}\cdot\text{mole} * 10^6) \\ &= 26 \text{ lb/hr} \end{aligned}$$

Annual emissions are calculated using Equation 9.4-5:

$$\begin{aligned} E_{\text{tpy,SO}_2} &= E_{\text{SO}_2} * \text{OpHrs} / 2,000 \\ &= 26 \text{ lb/hr} * 2,000 \text{ hr/yr} * 1 \text{ ton} / 2,000 \text{ lb} \\ &= 26 \text{ ton/yr} \end{aligned}$$

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# 5

## ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

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All of the methods described in Section 4 as preferred methods are also alternatives for some pollutants and some processes (refer to Table 9.3-1). Only the material balance approach is not a preferred method for any of the emission sources at secondary metal processing operations. The material balance approach is described below.

### 5.1 EMISSION ESTIMATIONS USING MATERIAL BALANCE

The material balance approach accounts for all the material (pollutant) entering and leaving a process. Measurements or estimates are made of the total amount of material entering a process; the fraction of the material in the product leaving the process; the fraction of the material that is recovered and used again; and the fraction of the material leaving the process in water and solid waste streams. The fraction of material unaccounted for is assumed to be emitted as a pollutant. The basic equation for estimating emissions using the material balance approach is:

$$E_x = (Q_{in} - Q_{out}) * C_x \quad (9.5-1)$$

where:

$E_x$	=	Total emissions of pollutant x (lb/hr)
$Q_{in}$	=	Material entering the process (gal/hr)
$Q_{out}$	=	Material leaving the process as waste, recovered, or in product (gal/hr)
$C_x$	=	Concentration of pollutant x (lb/gal)

The term  $Q_{out}$  may actually involve several different “fates” for an individual pollutant. This could include the amount recovered (or recycled), the amount leaving the process in the product, the amount leaving the process in the wastewater, or the amount of material shipped off-site as hazardous waste. A thorough knowledge of the different fates for the pollutant of interest is necessary for an accurate emissions estimate. Example calculation 9.5-1 illustrates the use of Equation 9.5-1.

Example 9.5-1

This example shows how hourly VOC emissions may be calculated for solvent cleaning of scrap metal.

$$\begin{aligned}Q_{\text{in}} &= 10 \text{ gal/hr} \\Q_{\text{out}} &= 9.5 \text{ gal/hr} \\C_{\text{VOC}} &= 4.8 \text{ lb VOC/gal}\end{aligned}$$

$$\begin{aligned}E_{\text{VOC}} &= (Q_{\text{in}} - Q_{\text{out}}) * C_{\text{VOC}} \\E_{\text{VOC}} &= (10 \text{ gal/hr} - 9.5 \text{ gal/hr}) * 4.8 \text{ lb VOC/gal} \\E_{\text{VOC}} &= 2.4 \text{ lb VOC/hr}\end{aligned}$$

# 6

## QUALITY ASSURANCE/QUALITY CONTROL

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Quality assurance (QA) and quality control (QC) are essential elements in producing high quality emission estimates and should be included in all methods used to estimate emissions. QA/QC of emissions estimates is accomplished through a set of procedures that ensure the quality and reliability of data collection and processing. These procedures include the use of appropriate emission estimation methods, reasonable assumptions, data reliability checks, and accuracy/logic checks of calculations. The *QA Source Document*, Volume VI of this series, describes methods and tools for performing these procedures. In addition, Chapter 1 of this volume *Introduction to Stationary Point Source Emission Inventory Development* provides QA/QC guidance for preparing point source emission estimates. The following sections discuss QA/QC considerations that are specific to the emission estimation methods presented in this chapter.

### 6.1 QA/QC CONSIDERATIONS FOR USING STACK SAMPLING AND CEMS DATA

In reviewing stack sampling or CEMS data, the first consideration is whether the method measures the pollutant of interest, or can only be used as a surrogate. Next, it should be determined whether the sampling conditions represent the operating conditions of interest for the emission estimate. For example, if the data are to be used to estimate emissions during typical operations, then sampling should have been done during typical operating conditions.

For CEMS, the accuracy of the data depend heavily on maintaining calibration. Thus, the calibration information should be evaluated. Parameters that should be evaluated in QA/QC of stack sampling and CEMS data and the acceptance criteria for each are presented in Chapter 1 of this volume.

### 6.2 QA/QC CONSIDERATIONS FOR USING EMISSION FACTORS

When using emission factors to estimate emissions from a source, the applicability and representativeness of the emission factor are the first two criteria to consider. To assess applicability, the process of interest must be examined to determine how closely it matches the process for which the emission factor is available. For example, metal refining emission factors cannot be used to estimate melting emissions. Similarly, the range of conditions on which the available emission factor is based should be reviewed to determine how well it compares to the conditions of interest. For example, an emission factor that is based on processes with 100 tons per hour is not the best emission factor for a 10 ton per hour process.

EPA emission factors often have a quality rating. The lower the quality rating of a factor, the more likely that the factor may not be representative of the source population. The reliability and uncertainty of using emission factors as an emission estimation method are discussed in the QA/QC Section of Chapter 1 of this volume.

### 6.3 QA/QC CONSIDERATIONS FOR USING MATERIAL BALANCES

The material balance method for estimating emissions may take various approaches, thus the QA/QC considerations vary and may be specific to an approach. Generally, the fates of all materials of interest are identified then the quantity of material allocated to each fate determined. Identifying the fates, such as material contained in a product or material leaving the process in the wastewater, is usually straightforward. However, estimating the amount of material allocated to each fate is sometimes complicated and is the prime QA/QC consideration in using the material balance approach. Amounts obtained by direct measurement are more accurate and produce emission estimates of higher quality than those obtained by engineering or theoretical calculations. QA/QC of an emissions estimate developed from a material balance approach should include a thorough check of all assumptions and calculations. A reality check looking at the estimate in the context of the overall process is also recommended.

### 6.4 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

One measure of emission inventory data quality is the DARS score. The *QA Source Document* (Volume VI, Chapter 4) and the QA/QC Section in Chapter 1 of this volume provide complete discussions of the DARS. The DARS assumes “activity” data and “factor” data are used to generate an inventory and provides criteria that are used to assign a numerical score to each data set. The activity score is multiplied by the factor score to obtain a composite score for the emissions estimate. The highest possible value for an individual or composite score is 1.0. The composite score for the emissions estimate can be used to evaluate the quality and accuracy of the estimate.

The DARS was used to evaluate the methods for estimating emissions that are presented in this chapter to provide an idea of the relative quality of each method. This was accomplished by assuming an inventory was developed using each method and using the DARS to score each inventory. Because the inventories are hypothetical, it was necessary to make some additional assumptions. The first assumption is that emissions are for a one-year period from one process or from one facility under normal operating conditions. All data used were assumed to be reasonably accurate. Some scores are expressed as a range with the lower value representing an estimate developed from low to medium quality data and the upper value representing an estimate based on relatively high quality data. Tables 9.6-1 through 9.6-5 present the DARS scores for the different emission estimation methods presented in this chapter.

Comparing the scores for the different methods, the preferred methods (CEMS, stack sampling, and emission factors) received higher scores and the alternative method (material balance) received the lowest. The CEMS method for estimating emissions received the highest DARS score (0.98 - 1.0) as shown in Table 9.6-1. Note that the score is based on the assumption that the factor data were measured continuously during the year (the inventory period). Also, note



**TABLE 9.6-1**  
**DARS SCORES: CEMS DATA**

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/Method	1.0	0.9 - 1.0	0.9 - 1.0	Continuous or near continuous measurement of activity; data capture >90%.	Lower scores reflect direct, intermittent measurement of activity; upper scores reflect direct, continuous measurement of activity.
Source Specificity	1.0	1.0	1.0	Factor developed specifically for the intended source.	Activity data represents the emission process exactly.
Spatial Congruity	1.0	1.0	1.0	Factor developed for and specific to the given spatial scale (one facility).	Activity data developed for and specific to the inventory area (one facility).
Temporal Congruity	1.0	1.0	1.0	Factor measured continuously, or near continuously, for a period of one year.	Activity data measured continuously, or near continuously, for a period of one year.
Composite Score	1.0	0.98 - 1.0	0.98 - 1.0		

TABLE 9.6-2

## DARS SCORES: STACK SAMPLING DATA

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/ Method	0.7 - 0.9	0.9 - 1.0	0.63 - 0.9	Lower score reflects a small number of tests at typical loads; upper score represents numerous tests over a range of loads.	Lower score reflects direct, intermittent measurement of activity; upper score reflects direct, continuous measurement of activity.
Source Specificity	1.0	1.0	1.0	Factor developed specifically for the intended source.	Activity data represents the emission process exactly.
Spatial Congruity	1.0	1.0	1.0	Factor developed for and specific to the given spatial scale (one facility).	Activity data developed for and specific to the inventory area (one facility).
Temporal Congruity	0.7 - 0.9	0.7 - 0.9	0.49 - 0.81	Lower score reflects factor developed for a shorter time period with moderate to low temporal variability; upper score reflects factor derived from an average of numerous tests over the year.	Lower score reflects activity data representative of short period of time with low to moderate temporal variability; upper score reflects activity data measured numerous times over the year.
Composite Score	0.85 - 0.98	0.90 - 0.98	0.78 - 0.95		

TABLE 9.6-3

**DARS SCORES: SOURCE-SPECIFIC EMISSION FACTOR DATA<sup>a</sup>**

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/ Method	1.0	0.9 - 1.0	0.9 -1.0	Continuous or near continuous measurement of pollutant.	Lower scores reflect direct, intermittent measurement of activity; upper scores reflect direct, continuous measurement of activity.
Source Specificity	0.8	1.0	0.8	Factor developed for a similar category; low variability.	Activity data represents the emission process exactly.
Spatial Congruity	0.9	1.0	0.9	Factor developed from a facility of similar size; low variability.	Activity data developed for and specific to the inventory area (one facility).
Temporal Congruity	1.0	0.7 - 0.9	0.7 - 0.9	Factor developed for and applicable to a period of one year.	Lower score reflects activity data representative of short period of time with low to moderate temporal variability; upper score reflects activity data measured numerous times over the year.
Composite Score	0.93	0.90 - 0.98	0.83 - 0.90		

<sup>a</sup> Assumes emission factor was developed from an identical or similar facility and is of high quality.

TABLE 9.6-4

## DARS SCORES: AP-42 EMISSION FACTOR DATA

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/ Method	0.3 - 0.6	0.9 - 1.0	0.27 - 0.6	Lower score reflects a factor of poor quality; upper score reflects a factor of high quality.	Lower scores reflect direct, intermittent measurement of activity; upper scores reflect direct, continuous measurement of activity.
Source Specificity	0.8	1.0	0.8	Factor developed from superset of intended source category; low variability.	Activity data represents the emission process exactly.
Spatial Congruity	0.1 - 0.9	1.0	0.1 - 0.9	Lower score reflects a factor of low quality developed for an unknown spatial scale; upper score reflects a high quality factor developed from a similar (size) facility.	Activity data developed for and specific to the inventory area (one facility).
Temporal Congruity	0.1 - 0.9	0.7 - 0.9	0.7 - 0.81	Lower score reflects a low quality factor, temporal basis unknown; upper score reflects a high quality factor derived from an average of numerous tests.	Lower score reflects activity data representative of short period of time with low to moderate temporal variability; upper score reflects activity data measured numerous times over the year.
Composite Score	0.3 - 0.8	0.90 - 0.98	0.47 - 0.78		

**TABLE 9.6-5**  
**DARS SCORES: MATERIAL BALANCE DATA<sup>a</sup>**

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/ Method	0.1	1.0	0.1	Factor is based on expert judgment.	Direct, continuous measurement of activity.
Source Specificity	1.0	1.0	1.0	Factor developed specifically for the intended source.	Activity data represents the emission process exactly.
Spatial Congruity	1.0	1.0	1.0	Factor developed for and specific to the given spatial scale.	Activity data developed for and specific to the inventory area (one facility).
Temporal Congruity	1.0	1.0	1.0	Factor developed for and applicable to the same temporal scale.	Activity data specific to one year.
Composite Score	0.78	1.0	0.78		

<sup>a</sup> The “activity” is the amount of material (pollutant) used in a year and is directly measurable. The “factor” is the fraction of material used that is emitted to the atmosphere. The fraction is based on engineering calculations and is assumed to remain constant over the year.

that if factor data and activity data are measured continuously over the year, a perfect score (1.0) is possible for an emissions estimate when using this method.

The stack sampling approach received the next highest overall score (0.78 - 0.95). As indicated by the scores, the major parameters affecting the quality of stack sampling data are the number of tests (range of loads, and numerous tests performed over the year) and the frequency of measurement of activity data (intermittent or continuous). A high DARS score for an emissions estimate based on stack sampling data is possible if the factor data are the result of numerous tests performed during typical operations and the activity data are the result of continuous measurements over the inventory period.

Two examples of using the DARS to score the emission factor approach are provided in order to illustrate how the representativeness (or quality) of an emission factor may vary and how emission factor quality affects emission estimates. The first example, shown in Table 9.6-3, assumes the emission factor was developed from a facility that is similar, if not identical, to the facility for which the emissions estimate was made. Because the emission factor represents a facility similar to the inventory facility, a high score is assigned. Assuming the activity data were measured continuously, a composite score of 0.83 to 0.90 is assigned. The second example, provided in Table 9.6-4, assumes that an *AP-42* emission factor was used to generate the emissions estimate and a score of 0.47 to 0.78 is assigned. The lower value reflects the score assigned to an estimate based on a lower quality emission factor while the upper value reflects an estimate based on a higher quality emission factor. As shown by the scores in the two tables, the quality of an emissions estimate developed from emission factors is directly affected by the quality of the emission factors and can vary greatly. The scores also indicate that a source-specific emission factor may produce an emissions estimate of higher quality than an estimate developed from an *AP-42* factor.

The material balance approach for estimating emissions received the lowest DARS score (0.78). This score is based on the assumption that some of the data are based on "expert judgment." Normally, when a material balance approach is used to estimate emissions from secondary metal processes, it is because the data have not been or cannot be measured directly and must be estimated using professional judgment or theoretical calculations. Consequently, because the emission estimate is not based on direct measurement of data, a relatively low DARS score is assigned to the estimate.

The examples provided in the tables are given as an illustration of the relative quality of each estimation method. If the DARS was applied to actual inventories developed from the preferred and alternative methods and data of reasonably good quality were used for each method, the scores could be different; however, the relative ranking of the methods would be expected to remain the same.

# DATA CODING PROCEDURES

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This section describes the methods and codes available for characterizing emissions from sources at secondary metal processing facilities. Using the EPA's Source Classification Codes (SCCs) and the Aerometric Information Retrieval System (AIRS) control device codes will assure consistent categorization and coding and will result in greater uniformity among inventories. The SCCs are the building blocks on which point source emissions data are structured. Each SCC represents a unique process or function within a source category that is logically associated with an emission point. The procedures described here will assist the reader who is preparing data for input to the Aerometric Information Retrieval System (AIRS) or a similar database management system (EPA, 1990). The use of the SCCs provided in Tables 9.7-1 through 9.7-8 is recommended for identifying emission sources of the various types of secondary metal processing operations. The codes presented here are currently in use, but may change based on further refinement of the codes. Refer to the EPA's Technology Transfer Network (TTN) internet site for the most recent list of SCCs for secondary metal processing operations (EPA, 2000c). This information is accessible at <http://www.epa.gov/ttn/chief/scccodes.html>.

## 7.1 SOURCE CLASSIFICATION CODES (SCCs)

SCCs for some of the secondary metal processing operations are presented in Tables 9.7-1 through 9.7-8. The units presented in the table are intended to be used with emission data that are input to AIRS. Emission data may be available, and can be used, in different units. A separate table for each metal has been provided. These include the following:

- Aluminum;
- Copper;
- Iron;
- Lead;
- Magnesium;
- Steel;
- Zinc; and
- Nickel.

SCCs that apply to the secondary processing of all of these metals are listed together in Table 9.7-9.

## **7.2 AIRS CONTROL DEVICE CODES**

Control device codes applicable to secondary metal processing operations are presented in Table 9.7-10. These should be used to enter the type of applicable emission control device into the AIRS Facility Subsystem (AFS). The "099" control code may be used for miscellaneous control devices that do not have a unique identification code.



TABLE 9.7-1

**SOURCE CLASSIFICATION CODES FOR SECONDARY ALUMINUM  
PRODUCTION PROCESSES  
(SIC CODES 3341, 3353, 3354, 3355, 3363, 3365)**

Process Description	SCC	Units (Pounds per ____)
<b>Process Emissions</b>		
Sweating Furnace	3-04-001-01	Tons of Material Produced
Smelting Furnace/Crucible	3-04-001-02	Tons of Metal Produced
Smelting Furnace/Reverberatory	3-04-001-03	Tons of Metal Produced
Fluxing: Chlorination	3-04-001-04	Tons of Chlorine Used
Fluxing: Fluoridation	3-04-001-05	Tons of Metal Produced
Degassing	3-04-001-06	Tons of Metal Produced
Hot Dross Processing	3-04-001-07	Tons of Metal Produced
Crushing/Screening	3-04-001-08	Tons of Metal Produced
Burning/Drying	3-04-001-09	Tons of Metal Produced
Annealing Furnace	3-04-001-12	Tons of Metal Produced
Slab Furnace	3-04-001-13	Tons of Metal Produced
Sweating Furnace - Grate	3-04-001-15	Tons of Material Produced
Dry Milling of Dross	3-04-001-16	Tons of Metal Produced
Wet Milling of Dross	3-04-001-17	Tons of Metal Produced
Leaching	3-04-001-18	Tons of Metal Produced
Demagging	3-04-001-30	Tons of Metal Produced
Material Handling	3-04-001-60	Tons of Material Processed
Other Not Classified	3-04-001-99	Tons of Material Produced

**TABLE 9.7-1****(CONTINUED)**

<b>Process Description</b>	<b>SCC</b>	<b>Units (Pounds per ____)</b>
<b>Metal Product Shaping</b>		
Foil Rolling	3-04-001-10	Tons of Product
Foil Converting	3-04-001-11	Tons of Material Produced
Pouring/Casting	3-04-001-14	Tons of Metal Charged
Can Manufacture	3-04-001-20	Tons of Material Produced
Roasting	3-04-001-21	Tons of Material Produced
Rolling/Drawing/Extruding	3-04-001-50	Tons of Material Produced
<b>Fugitive Emissions</b>		
Raw Material Charging	3-04-001-31	Tons of Material Charged
Raw Material Storage	3-04-001-32	Tons of Material Stored
Tapping	3-04-001-33	Tons of Metal Produced
Miscellaneous Fugitive Emissions	3-04-888-01 to -05	Tons of Product Produced

TABLE 9.7-2

**SOURCE CLASSIFICATION CODES FOR SECONDARY COPPER SMELTING  
AND ALLOYING  
(SIC CODES 3341, 3364, 3366)**

Process Description	SCC	Units (Pounds per ____)
<b>Process Emissions</b>		
Copper Smelting-Blast Furnace (Cupola)	3-04-002-03	Tons of Charge
Electric Induction Furnace	3-04-002-04	Tons of Charge
Preparation-Scrap Dryer (Rotary)	3-04-002-07	Tons of Charge
Preparation-Wire Burning Incinerator	3-04-002-08	Tons of Charge
Preparation-Sweating Furnace	3-04-002-09	Tons of Charge
Cupola-Charge with Scrap Copper	3-04-002-10	Tons of Charge
Cupola-Charge with Insulated Copper Wire	3-04-002-11	Tons of (Coke-free) Charge
Cupola-Charge with Scrap Copper and Brass	3-04-002-12	Tons of Charge
Cupola-Charge with Scrap Iron	3-04-002-13	Tons of Charge
Reverberatory Furnace-Charge with Copper	3-04-002-14	Tons of Charge
Reverberatory Furnace-Charge with Brass and Bronze	3-04-002-15	Tons of Charge
Rotary Furnace-Charge with Copper	3-04-002-16	Tons of Charge
Rotary Furnace-Charge with Brass and Bronze	3-04-002-17	Tons of Charge
Crucible and Pot Furnace-Charge with Copper	3-04-002-18	Tons of Charge
Crucible and Pot Furnace-Charge with Brass and Bronze	3-04-002-19	Tons of Charge
Electric Arc Furnace-Charge with Copper	3-04-002-20	Tons of Charge
Electric Arc Furnace-Charge with Brass and Bronze	3-04-002-21	Tons of Charge
Electric Induction-Charge with Copper	3-40-002-23	Tons of Charge

TABLE 9.7-2

(CONTINUED)

Process Description	SCC	Units (Pounds per ____)
Electric Induction-Charge with Brass and Bronze	3-04-002-24	Tons of Charge
Pretreatment-Scrap Metal	3-04-002-30	Tons of Charge
General-Casting (and Shot Production)	3-04-002-39	Tons of Casting Produced
Holding Furnace-Charge with Copper	3-04-002-40	Tons of Charge
Holding Furnace-Charge with Brass and Bronze	3-04-002-41	Tons of Charge
Reverberatory Furnace-Charge with Other Alloy (7%)	3-04-002-42	Tons of Charge
Reverberatory Furnace-Charge with High Lead Alloy (58%)	3-04-002-43	Tons of Charge
Reverberatory Furnace-Charge with Red/Yellow Brass	3-04-002-44	Tons of Charge
Converter-Charge with Copper	3-04-002-50	Tons of Charge
Converter-Charge with Brass and Bronze	3-04-002-51	Tons of Charge
Other Not Classified	3-04-002-99	Tons of Material Produced
<b>Fugitive Emissions</b>		
Scrap Dryer	3-04-002-31	Tons of Charge
Wire Incinerator	3-04-002-32	Tons of Charge
Sweating Furnace	3-04-002-33	Tons of Charge
Cupola Furnace	3-04-002-34	Tons of Charge
Reverberatory Furnace	3-04-002-35	Tons of Charge
Rotary Furnace	3-04-002-36	Tons of Charge
Crucible Furnace	3-04-002-37	Tons of Charge

**TABLE 9.7-2****(CONTINUED)**

<b>Process Description</b>	<b>SCC</b>	<b>Units (Pounds per ____)</b>
Electric Induction Furnace	3-04-002-38	Tons of Charge
Casting Operations	3-04-002-39	Tons of Castings Produced
Miscellaneous Fugitive Emissions	3-04-888-01 to -05	Tons Product

TABLE 9.7-3

**SOURCE CLASSIFICATION CODES FOR SECONDARY IRON PROCESSES  
(SIC CODE 3321)**

Process Description	SCC	Unit (Pounds per ____)
<b>IRON PRODUCTION</b>		
<b>Raw Material</b>		
Stockpiles - Coke Breeze, Limestone, Ore Fines	3-03-008-11	Tons of Material Produced
Transfer/Handling	3-03-008-12	Tons of Material Produced
Unloading to Blast Furnace - Ore, Pellets, Limestone	3-03-008-21	Tons of Ore Transferred
Stockpiles - Ore, Pellets, Limestone, Coke, Sinter	3-03-008-22	Tons of Material Processed
Transfer/Handling - Charge Material	3-03-008-23	Tons of Material Processed
<b>GREY IRON FOUNDRIES</b>		
<b>Process Emissions</b>		
Cupola Furnace	3-04-003-01	Tons of Metal Charged
Reverberatory Furnace	3-04-003-02	Tons of Metal Charged
Electric Induction Furnace	3-04-003-03	Tons of Metal Charged
Electric Arc Furnace	3-04-003-04	Tons of Metal Charged
Annealing Operations	3-04-003-05	Tons Processed
Inoculation	3-04-003-10	Tons of Metal Inoculated
Scrap Metal Preheating	3-04-003-14	Tons of Metal Charged
Charge Handling	3-04-003-15	Tons of Metal Charged
Tapping	3-04-003-16	Tons of Metal Produced
Pouring Ladle	3-04-003-17	Tons of Metal Charged
Pouring, Cooling	3-04-003-18	Tons of Gray Iron Produced
Core Making, Baking	3-04-003-19	Tons of Gray Iron Produced
Pouring/Casting	3-04-003-20	Tons of Metal Charged

**TABLE 9.7-3****(CONTINUED)**

<b>Process Description</b>	<b>SCC</b>	<b>Units (Pounds per ____)</b>
Magnesium Treatment	3-04-003-21	Tons of Gray Iron Produced
Refining	3-04-003-22	Tons of Gray Iron Produced
Castings Cooling	3-04-003-25	Tons Metal Charged
Miscellaneous Casting-Fabricating	3-04-003-30	Tons of Metal Processed
Casting Shakeout	3-04-003-31	Tons of Metal Charged
Casting Knockout	3-04-003-32	Tons of Sand Handled
Shakeout Machine	3-04-003-33	Tons of Sand Handled
Grinding/Cleaning	3-04-003-40	Tons of Metal Charged
Casting Cleaning/Tumblers	3-04-003-41	Tons of Castings Cleaned
Casting Cleaning/Chippers	3-04-003-42	Tons of Castings Cleaned
Sand Grinding/Handling	3-04-003-50	Tons of Sand Handled
Core Ovens	3-04-003-51	Tons of Sand Handled
Sand Grinding/Handling	3-04-003-52	Tons of Metal Charged
Core Ovens	3-04-003-53	Tons of Metal Charged
Core Ovens	3-04-003-54	Gallons of Core Oil Used
Sand Dryer	3-04-003-55	Tons of Sand Handled
Sand Silo	3-04-003-56	Tons of Sand Handled
Conveyors/Elevators	3-04-003-57	Tons of Sand Handled
Sand Screens	3-04-003-58	Tons of Sand Handled
Castings Finishing	3-04-003-60	Tons of Metal Charged
Shell Core Machine	3-04-003-70	Tons of Cores Produced
Core Machines/Other	3-04-003-71	Tons of Cores Produced
Other Not Classified	3-04-003-98	Gallons Material Processed
Other Not Classified	3-04-003-99	Tons of Metal Charged

TABLE 9.7-3

(CONTINUED)

Process Description	SCC	Units (Pounds per ____)
<b>Fugitive Emissions</b>		
Coal Unloading	3-05-104-03	Tons of Material Processed
Coke Unloading	3-05-104-04	Tons of Material Processed
Limestone Unloading	3-05-104-05	Tons of Material Processed
Scrap Metal Unloading	3-05-104-07	Tons of Material Processed
Unloading - Specify Chemical in Comments	3-05-104-96	Tons of Material Processed
Unloading - Specify Mineral in Comments	3-05-104-98	Tons of Material Processed
Unloading - Other Not Classified	3-05-104-99	Tons of Material Processed
<b>MALLEABLE IRON</b>		
Annealing	3-04-009-01	Tons of Metal Charged
Other Not Classified	3-04-009-99	Tons of Metal Charged



**TABLE 9.7-4**

**SOURCE CLASSIFICATION CODES FOR SECONDARY LEAD PROCESSING  
(SIC CODES 3341, 3364)**

<b>Process Description</b>	<b>SCC</b>	<b>Units (Pounds per ____)</b>
<b>Process Emissions</b>		
Pot Furnace	3-04-004-01	Tons of Metal Charged
Reverberatory Furnace	3-04-004-02	Tons of Metal Charged
Blast Furnace (Cupola)	3-04-004-03	Tons of Metal Charged
Rotary Sweating Furnace	3-04-004-04	Tons of Metal Charged
Reverberatory Sweating Furnace	3-04-004-05	Tons of Metal Charged
Pot Furnace Heater: Distillate Oil	3-04-004-06	1000 Gallons Burned
Pot Furnace Heater: Natural Gas	3-04-004-07	Million Cubic Feet Burned
Barton Reactor (Oxide Kettle)	3-04-004-08	Tons of Lead Oxide Produced
Casting	3-04-004-09	Tons of Lead Cast
Battery Breaking	3-04-004-10	Tons of Metal Charged
Scrap Crushing	3-04-004-11	Tons of Metal Charged
Agglomeration Furnace	3-04-004-15	Tons of Flue Dust Processed
Furnace Charging	3-04-004-16	Tons of Lead Produced
Furnace Lead/Slag Tapping	3-04-004-17	Tons of Lead Produced
Electric Furnace	3-04-004-18	Tons of Material Charged
Raw Material Dryer	3-04-004-19	Tons of Material Charged
Size Separation	3-04-004-24	Tons of Material Processed
Kettle Refining	3-04-004-26	Tons of Lead Produced
Other Not Classified	3-04-004-99	Tons of Material Processed
<b>Fugitive Emissions</b>		
Sweating Furnace	3-04-004-12	Tons of Metal Charged
Smelting Furnace	3-04-004-13	Tons of Metal Charged
Kettle Refining	3-04-004-14	Tons of Metal Charged

**TABLE 9.7-4****(CONTINUED)**

<b>Process Description</b>	<b>SCC</b>	<b>Units (Pound per ____)</b>
Raw Material Unloading	3-04-004-20	Tons of Raw Material Processed
Raw Material Transfer/Conveying	3-04-004-21	Tons of Raw Material Processed
Raw Material Storage Piles	3-04-004-22	Tons of Raw Material Processed
Slag Breaking	3-04-004-23	Tons of Material Processed
Casting	3-04-004-25	Tons Lead Produced
Other Not Classified	3-04-004-99	Tons of Material Processed

**TABLE 9.7-5****SOURCE CLASSIFICATION CODES FOR SECONDARY MAGNESIUM SMELTING  
(SIC CODE 3341)**

<b>Process Description</b>	<b>SCC</b>	<b>Units (Pounds per ____)</b>
<b>Process Emissions</b>		
Pot Furnace	3-04-006-01	Tons of Material Processed
Dow Seawater Process	3-04-006-02	Tons of Product Produced
Dow Seawater Process: Neutralization Tank	3-04-006-05	Tons of Product Produced
Dow Seawater Process: HCL Absorbers	3-04-006-06	Tons of Product Produced
Dow Seawater Process: Evaporator	3-04-006-07	Tons of Product Produced
Dow Seawater Process: Filtering/Concentration	3-04-006-08	Tons of Product Produced
Dow Seawater Process: Shelf Dryer	3-04-006-09	Tons of Product Produced
Dow Seawater Process: Rotary Dryer	3-04-006-10	Tons of Product Produced
Dow Seawater Process: Prilling	3-04-006-11	Tons of Product Produced
Dow Seawater Process: Granule Storage Tanks	3-04-006-12	Tons of Product Produced
Dow Seawater Process: Electrolysis	3-04-006-13	Tons of Product Produced
Dow Seawater Process: Regenerative Furnaces	3-04-006-14	Tons of Product Produced
Natural Lead Industrial (NLI) Brine Process	3-04-006-30	Tons of Product Produced
NLI Brine Process: MgCl <sub>2</sub> Melt/Purification	3-04-006-35	Tons of Product Produced
NLI Brine Process: 2nd Vessel, Further Purification	3-04-006-36	Tons of Product Produced
NLI Brine Process: Electrolysis	3-04-006-37	Tons of Product Produced
American Magnesium Process	3-04-006-50	Tons of Product Produced
American Magnesium Process: Purification II	3-04-006-55	Tons of Product Produced
American Magnesium Process: Electolysis	3-04-006-56	Tons of Product Produced
American Magnesium Process: Chlorine Recovery	3-04-006-60	Tons of Product Produced
Other Not Classified	3-04-006-99	Tons of Material Processed

TABLE 9.7-6

**SOURCE CLASSIFICATION CODES FOR STEEL FOUNDRY PROCESSES  
(SIC CODES 3324, 3325)**

Process Description	SCC	Units (Pounds per ____)
<b>Process Emissions</b>		
Electric Arc Furnace	3-04-007-01	Tons Metal Processed
Open Hearth Furnace	3-04-007-02	Tons Metal Processed
Open Hearth Furnace with Oxygen Lance	3-04-007-03	Tons Metal Processed
Heat Treating Furnace	3-04-007-04	Tons Metal Processed
Electric Induction Furnace	3-04-007-05	Tons Metal Processed
Sand Grinding/Handling	3-04-007-06	Tons Sand Processed
Core Ovens	3-04-007-07	Tons Sand Processed
Pouring/Casting	3-04-007-08	Tons Metal Processed
Casting Shakeout	3-04-007-09	Tons Metal Processed
Casting Knockout	3-04-007-10	Tons Sand Handled
Cleaning	3-04-007-11	Tons Metal Processed
Charge Handling	3-04-007-12	Tons Metal Processed
Casting Cooling	3-04-007-13	Tons Metal Processed
Casting Shakeout Machine	3-04-007-14	Tons Sand Handled
Finishing	3-04-007-15	Tons Metal Processed
Sand Grinding/Handling	3-04-007-16	Tons Metal Processed
Core Ovens	3-04-007-17	Tons Metal Processed
Core Ovens	3-04-007-18	Gallons Core Oil Used
Sand Dryer	3-04-007-20	Tons Sand Handled
Sand Silo	3-04-007-21	Tons Sand Handled
Muller	3-04-007-22	Tons Sand Handled
Conveyors/Elevators-Sand	3-04-007-23	Tons Sand Handled
Sand Screens	3-04-007-24	Tons Sand Handled

**TABLE 9.7-6****(CONTINUED)**

<b>Process Description</b>	<b>SCC</b>	<b>Units (Pounds per ____)</b>
Casting Cleaning/Tumblers	3-04-007-25	Tons Casting Cleaned
Casting Cleaning/Chippers	3-04-007-26	Tons Castings Cleaned
Shell Core Machines	3-40-007-30	Tons Core Produced
Other Core Machines	3-04-007-31	Tons Core Produced
Electric Arc Furnace: Baghouse	3-04-007-32	Tons Metal Processed
Electric Arc Furnace: Baghouse Dust Handling	3-04-007-33	Tons Metal Processed
Raw Material Unloading	3-04-007-35	Tons Raw Material Handled
Conveyors/Elevators-Raw Material	3-04-007-36	Tons Raw Material
Raw Material Silo	3-04-007-37	Tons Raw Material Stored
Scrap Centrifugation	3-04-007-39	Tons Scrap Processed
Reheat Furnace: Natural Gas	3-04-007-40	Tons of Material Reheated
Scrap Combustion	3-04-007-41	Tons Scrap Processed
Crucible	3-04-007-42	Tons Metal Processed
Pneumatic Converter Furnace	3-04-007-43	Tons Metal Processed
Ladle	3-04-007-44	Tons Metal Processed
Alloy Feeding	3-04-007-60	Tons of Material Handled
Billet Cutting	3-04-007-65	Tons of Material Handled
Scrap Handling	3-04-007-68	Tons of Material Handled
Slag Storage Pile	3-04-007-70	Tons of Material Handled
Slag Crushing	3-04-007-75	Tons of Material Handled
Limerock Handling	3-04-007-80	Tons of Material Handled
Roof Monitors-Hot Metal Transfer	3-04-007-85	Tons of Material Handled
Other Not Classified	3-04-007-99	Tons Processed

TABLE 9.7-6

(CONTINUED)

Process Description	SCC	Units (Pounds per ____)
<b>Fugitive Emissions</b>		
Fugitive Furnace Emissions	3-04-007-45	Tons of Material Processed
Miscellaneous Fugitive Emissions	3-04-888-01 to -05	Tons Product

TABLE 9.7-7

**SOURCE CLASSIFICATION CODES FOR SECONDARY ZINC PROCESSING INDUSTRY  
(SIC CODE 3341)**

Process Description	SCC	Units (Pounds per ____)
<b>Process Emissions</b>		
Retort Furnace	3-04-008-01	Tons of Material Produced
Horizontal Muffle Furnace	3-04-008-02	Tons of Material Produced
Pot Furnace	3-04-008-03	Tons of Material Produced
Galvanizing Kettle	3-04-008-05	Tons Zinc Used
Calcining Kiln	3-04-008-06	Tons of Material Produced
Concentrate Dryer	3-04-008-07	Tons of Material Processed
Rotary Sweat Furnace	3-04-008-09	Tons of Material Produced
Muffle Sweat Furnace	3-04-008-10	Tons of Material Produced
Electric Resistance Sweat Furnace	3-04-008-11	Tons of Material Produced
Kettle Sweat Furnace, Clean Metallic Scrap	3-04-008-14	Tons of Material Produced
Reverberatory Sweat Furnace, Clean Metallic Scrap	3-04-008-18	Tons of Material Produced
Kettle Sweat Furnace, General Metallic Scrap	3-04-008-24	Tons of Material Produced
Reverberatory Sweat Furnace, General Metallic Scrap	3-04-008-28	Tons of Material Produced
Kettle Sweat Furnace, Residual Metallic Scrap	3-04-008-34	Tons of Material Produced
Reverberatory Sweat Furnace, Residual Metallic Scrap	3-04-008-38	Tons of Material Produced
Alloying	3-04-008-40	Tons of Material Produced
Scrap Melting, Crucible	3-04-008-41	Tons of Material Produced
Scrap Melting, Reverberatory Furnace	3-04-008-42	Tons of Material Produced
Scrap Melting, Electric Induction Furnace	3-04-008-43	Tons of Material Produced
Retort and Muffle Distillation, Pouring	3-04-008-51	Tons of Material Produced
Retort and Muffle Distillation, Casting	3-04-008-52	Tons of Material Produced

TABLE 9.7-7

(CONTINUED)

Process Description	SCC	Units (Pounds per ____)
Graphite Rod Distillation	3-04-008-53	Tons of Material Produced
Retort Distillation/Oxidation	3-04-008-54	Tons of Zinc Oxide Produced
Muffle Distillation/Oxidation	3-04-008-55	Tons of Zinc Oxide Produced
<b>Fugitive Emissions</b>		
Crushing/Screening of Zinc Residues	3-04-008-12	Tons of Residues/Skimmings Processed
Reverberatory Sweating	3-04-008-61	Tons of Material Produced
Rotary Sweating	3-04-008-62	Tons of Material Produced
Muffle Sweating	3-04-008-63	Tons of Material Produced
Kettle (Pot) Sweating	3-04-008-64	Tons of Material Produced
Electrical Resistance Sweating	3-04-008-65	Tons of Scrap Processed
Sodium Carbonate Leaching	3-04-008-66	Tons of Material Produced
Kettle (Pot) Melting Furnace	3-04-008-67	Tons of Material Produced
Crucible Melting Furnace	3-04-008-68	Tons of Material Produced
Reverberatory Melting Furnace	3-04-008-69	Tons of Material Produced
Electric Induction Melting Furnace	3-04-008-70	Tons of Material Produced
Alloying Retort Distillation	3-04-008-71	Tons of Material Produced
Retort and Muffle Distillation	3-04-008-72	Tons of Material Produced
Casting	3-04-008-73	Tons of Material Produced
Graphite Rod Distillation	3-04-008-74	Tons of Material Produced
Retort Distillation/Oxidation	3-04-008-75	Tons of Material Produced
Muffle Distillation/Oxidation	3-04-008-76	Tons of Material Produced
Retort Reduction	3-04-008-77	Tons of Material Produced
Other, Not Classified	3-04-008-99	Tons of Material Processed



**TABLE 9.7-8**  
**SOURCE CLASSIFICATION CODES FOR SECONDARY**  
**NICKEL PRODUCTION PROCESSES**

Process Description	SCC	Units
<b>Process Emissions</b>		
Flux Furnace	3-04-010-01	Tons of Material Processed
Mixing/Blending/Grinding/Screening	3-04-010-02	Tons of Material Processed
Heat Treat Furnace	3-04-010-04	Tons of Material Processed
Induction Furnace (Inlet Air)	3-04-010-05	Tons of Material Processed
Induction Furnace (Under Vacuum)	3-04-010-06	Tons of Material Processed
Electric Arc Furnace with Carbon Electrode	3-04-010-07	Tons of Material Processed
Electric Arc Furnace	3-04-010-08	Tons of Material Processed
Finishing: Pickling/Neutralizing	3-04-010-10	Tons of Material Processed
Finishing: Grinding	3-04-010-11	Tons of Material Processed
Multiple Hearth Roaster	3-04-010-15	Tons of Material Processed
Converters	3-04-010-16	Tons of Material Processed
Reverberatory Furnace	3-04-010-17	Tons of Material Processed
Electric Furnace	3-04-010-18	Tons of Material Processed
Sinter Machine	3-04-010-19	Tons of Material Processed
<b>Fugitive Emissions</b>		
Roasting	3-04-010-61	Tons of Material Produced
Reverberatory Furnace	3-04-010-62	Tons of Material Produced
Converter	3-04-010-63	Tons of Material Produced
<b>Others</b>		
Other Not Classified	3-04-010-99	Tons of Material Processed

**TABLE 9.7-9**  
**SOURCE CLASSIFICATION CODES FOR PRODUCTION OF**  
**ALL SECONDARY METALS**

Source Description	Process Description	SCC	Units
Fuel Fired Equipment	Process Heaters, Grade 2 Oil (Distillate)	3-04-900-01	1000 Gallons Distillate Oil Burned
	Process Heaters, Residual Oil	3-04-900-02	1000 Gallons Residual Oil Burned
	Process Heaters, Natural Gas	3-04-900-03	Million Cubic Feet Natural Gas Burned
	Process Heaters, Process Gas	3-04-900-04	Million Cubic Feet Process Gas Burned
	Incinerators, Grade 2 Oil (Distillate)	3-04-900-11	1000 Gallons Distillate Oil Burned
	Incinerators, Residual Oil	3-04-900-12	1000 Gallons Residual Oil Burned
	Incinerators, Natural Gas	3-04-900-13	Million Cubic Feet Natural Gas Burned
	Incinerators, Process Gas	3-04-900-14	Million Cubic Feet Process Gas Burned
	Flares, Grade 2 Oil (Distillate)	3-04-900-21	1000 Gallons Distillate Oil Burned
	Flares, Residual Oil	3-04-900-22	1000 Gallons Residual Oil Burned
	Flares, Natural Gas	3-04-900-23	Million Cubic Feet Natural Gas Burned
	Flares, Process Gas	3-04-900-24	Million Cubic Feet Process Gas Burned
	Furnaces, Grade 2 Oil (Distillate)	3-04-900-31	1000 Gallons Distillate Oil Burned
	Furnaces, Residual Oil	3-04-900-32	1000 Gallons Residual Oil Burned

TABLE 9.7-9

(CONTINUED)

Source Description	Process Description	SCC	Units
Fuel Fired Equipment (Continued)	Furnaces, Natural Gas	3-04-900-33	Million Cubic Feet Natural Gas Burned
	Furnaces, Process Gas	3-04-900-34	Million Cubic Feet Process Gas Burned
	Furnaces, Propane	3-04-900-35	Million Cubic Feet Propane Burned
Miscellaneous Casting and Fabricating	Wax Burnout Oven	3-04-049-01	Tons of Wax Burned
	Wax Burnout Oven	3-04-049-02	Tons Solvent Consumed
	Wax Burnout Oven	3-04-049-99	Tons of Wax Burned
	Other Not Classified	3-04-050-01	Tons of Material Produced
	Other Not Classified	3-04-050-99	Each Material Processed
Fugitives Emissions	Bulk Material Unloading (Coal)	3-05-104-03	Tons of Material Processed
	Bulk Material Unloading (Coke)	3-05-104-04	Tons of Material Processed
	Bulk Material Unloading (Limestone)	3-05-104-05	Tons of Material Processed
	Bulk Material Unloading (Scrap Metal)	3-05-104-07	Tons of Material Processed
	Bulk Material Unloading, General Chemical (Specify in Comments)	3-05-104-96	Tons of Material Processed
	Bulk Material Unloading, General Mineral (Specify in Comments)	3-05-104-98	Tons of Material Processed
	Equipment Leaks	3-04-800-01	Each Year Facility Operating

TABLE 9.7-9

(CONTINUED)

Source Description	Process Description	SCC	Units
Fugitives Emissions (Continued)	Specify in Comments Field	3-04-888-01	Tons of Product Produced
	Specify in Comments Field	3-04-888-02	Tons of Product Produced
	Specify in Comments Field	3-04-888-03	Tons of Product Produced
	Specify in Comments Field	3-04-888-04	Tons of Product Produced
	Specify in Comments Field	3-04-888-05	Tons of Product Produced
Wastewater	Process Area Drains, Wastewater Aggregate	3-04-820-01	1000 Gallons Wastewater Throughput
	Process Equipment Drains, Wastewater Aggregate	3-04-820-02	1000 Gallons Wastewater Throughput
	Points of Generation, Specify Points	3-04-825-99	1000 Gallons Wastewater Throughput
Others	Other Not Classified	3-04-999-99	Tons of Material Processed

**TABLE 9.7-10****AIRS CONTROL DEVICE CODES FOR SECONDARY METAL PROCESSING<sup>a</sup>**

<b>Control Device</b>	<b>Code</b>
Wet Scrubber - High-Efficiency	001
Wet Scrubber - Medium-Efficiency	002
Wet Scrubber - Low-Efficiency	003
Centrifugal Collector (Cyclone) - High-Efficiency	007
Centrifugal Collector (Cyclone) - Medium-Efficiency	008
Centrifugal Collector (Cyclone) - Low-Efficiency	009
Electrostatic Precipitator - High-Efficiency	010
Electrostatic Precipitator - Medium-Efficiency	011
Electrostatic Precipitator - Low-Efficiency	012
Fabric Filter - High-Temperature	016
Fabric Filter - Medium-Temperature	017
Fabric Filter - Low-Temperature	018
Catalytic Afterburner	019
Catalytic Afterburner with Heat Exchanger	020
Direct Flame Afterburner	021
Direct Flame Afterburner with Heat Exchanger	022
Vapor Recovery System	047
Venturi Scrubber	053
Process Enclosed	054
Impingement Plate Scrubber	055
Dust Suppression - Water Spray	061
Dust Suppression - Chemical Stabilization	062
Wet Lime Slurry Scrubbing	067

**TABLE 9.7-10<sup>a</sup>****(CONTINUED)**

<b>Control Device</b>	<b>Code</b>
Sodium Carbonate Scrubbing	069
Sodium Alkali Scrubbing	070
Single Cyclone	075
Multiple Cyclone without Fly Ash Reinjection	076
Multiple Cyclone with Fly Ash Reinjection	077
Wet Cyclone Separator	085
Miscellaneous Control Device	099
Dust Suppression - Physical Stabilization	106

<sup>a</sup>Note: At the time of publication, these codes were under review by the EPA. EPA should be contacted for the most current list of control device codes.

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**VOLUME II: CHAPTER 10**

# **PREFERRED AND ALTERNATIVE METHODS FOR ESTIMATING AIR EMISSIONS FROM OIL AND GAS FIELD PRODUCTION AND PROCESSING OPERATIONS**

**September 1999**



Prepared by:  
Eastern Research Group, Inc.

Prepared for:  
Point Sources Committee  
Emission Inventory Improvement Program

## **DISCLAIMER**

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

## DISCLAIMER

The oil and gas field production and processing industry sector is one in which new emission estimation tools are rapidly being developed. Therefore, new tools may exist which are not addressed in this document. The reader should keep informed about new tools through the following websites:

- <http://www.api.org>
- <http://www.gri.org>
- <http://www.epa.gov/ttn/chief>

At the time of publication, however, the methodologies presented in this document are the best recommendations of the Emission Inventory Improvement Program Point Source Committee.

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# 1

## INTRODUCTION

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The purposes of the preferred methods guidelines are to describe emission estimation techniques for stationary point sources in a clear and unambiguous manner and to provide concise example calculations to aid in the preparation of emission inventories. While emissions estimates are not provided, this information may be used to select an emission estimation technique best suited to a particular application. This chapter describes these procedures and recommends approaches for estimating emissions from most oil and gas field production and processing operations common throughout the United States. Additional sources may exist, which are not addressed in this chapter, such as cogeneration units, cooling towers, and non-road mobile sources (e.g., helicopters, and crew and supply boats). Depending on the purpose of the inventory, emissions from these additional sources should also be included. For procedures to estimate emissions from these sources, contact the state or local agency or EPA.

Section 2 of this chapter contains a general description of the oil and gas field production and processing operations source category, identifies common emission sources, and overviews available control technologies used in oil and gas field processing operations. Section 3 of this chapter provides an overview of available emission estimation methods.

Section 4 presents the preferred methods for estimating emissions from oil and gas field production and processing operations, while Section 5 presents the alternative emission estimation techniques.

It should be noted that the use of site-specific emission data is preferred over the use of industry-averaged data such as *AP-42* emission factors (EPA, 1995a). Depending upon available resources, site-specific data may not be cost effective to obtain. However, this site-specific data may be a requirement of the State Implementation Plan (SIP) and may preclude the use of other data.

Quality assurance (QA) and quality control (QC) procedures are described in Section 6. Coding procedures used for data input and storage are discussed in Section 7. Some states use their own unique identification codes, so industry personnel using this document should contact their state or local agency to determine the appropriate coding scheme to use. References are listed in Section 8. Appendix A provides an example data collection form to assist in information gathering prior to emissions calculations.

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# 2

## GENERAL SOURCE CATEGORY DESCRIPTION

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This section provides a brief overview of most oil and gas field processing operations common throughout the United States. The reader is referred to the *Air Pollution Engineering Manual* (referred to as *AP-40*) and *AP-42, 5th Edition, January 1995*, for a more detailed discussion of these facilities.

Additional sources may exist, which are not addressed in this chapter, such as cogeneration units, cooling towers, and non-road mobile sources (e.g. helicopters, and crew and supply boats). In addition, equipment and emissions from off-shore operations, although not specifically addressed in this document, are believed to be similar to those from on-shore operations. Preferred and alternative emission estimation methodologies for off-shore sources are, therefore, expected to be the same as for on-shore sources. Depending on the purpose of the emission inventory, the inventory preparer should consider inclusion of emissions from these additional source types.

### 2.1 PROCESS DESCRIPTION

The petroleum industry is organized into the following four broad segments:

- Exploration and production;
- Transportation;
- Refining; and
- Marketing.

This chapter addresses only the field production and processing operations of the petroleum and natural gas industry found in the exploration and production (E&P) and transportation segments of the industry.

The oil and gas field production and processing operations begin with exploration to locate new sources of crude oil and natural gas. When potential sources are located, wells are drilled to

confirm the presence of oil or gas and to determine whether the reserves are economically sufficient to support production.

During production, crude oil and/or natural gas is recovered from wells and prepared for transportation from the field. Trucks, rail cars, barges and tankers are used to transport domestic crude oil to refineries. Domestic crude oil can also be transported from the field to refineries by a complex network of pipelines. Natural gas, which may be produced alone or in combination with crude oil, often must be processed at a gas plant to make it suitable for consumer use (Rucker and Strieter, 1992).

Oil and gas field production and processing operations are primarily defined by the following types of emission activities:

- Exploration and production;
- Processing;
- Combustion;
- Storage and transport; and
- Wastewater.

### **2.1.1 EXPLORATION AND PRODUCTION**

In the E&P segment of the industry, natural gas and crude oil are recovered from underground reservoirs. This industry segment encompasses exploration, well-site preparation, and drilling (Rucker and Strieter, 1992).

Seismic and other geophysical methods are used to locate subterranean formations that signal the potential presence of oil and gas reservoirs. When a likely formation is located, drilling is the only way to confirm that oil and gas are present (Rucker and Strieter, 1992).

Drilling operations include the activities necessary to bore through the earth's crust to access crude oil and natural gas resources. During drilling operations, specially formulated muds are circulated through the hole to remove cuttings from around the drill bit, to provide lubrication for the drill string, to protect the walls of the hole, and to control down-hole pressure. Cuttings are separated from the mud at the well surface as the mud is passed through shale shakers, desanders, desilters, and degassers. The mud flows to a tank for recycling, and the cuttings, which may be contaminated with hydrocarbons, are pumped to a waste pit for disposal (Rucker and Strieter, 1992).

Water and drilling muds from offshore operations can be discharged overboard if they meet various limitations and requirements set by EPA. If the water or drilling muds do not meet these limitations and requirements, they are brought back to land for onshore treatment or disposal.

When the desired well depth is reached, the well is completed by installing an outer annular casing. During this process a completion fluid (typically heavy salt water) is used to prevent premature gas/oil flow. Occasionally, the well formation pressure is greater than the completion fluid pressure and premature gas/oil flow or blowout occurs (GRI, 1994).

Well testing occurs at exploratory wells which have unknown reservoir potential. Testing occurs during well completion by measuring the potential gas or oil flow. Testing is conducted to determine the required specifications of the wellhead assembly. Gas vented during well testing is either flared or vented directly to the atmosphere (GRI, 1994). Oil extracted during well testing is collected in a storage tank.

Once a well has been completed and is producing crude oil or natural gas, an arrangement of high-pressure valves termed a "Christmas tree" is installed to control production. As the well ages, an artificial lift device may be needed to help bring product to the well surface (Rucker and Strieter, 1992).

### **2.1.2 PROCESSING**

After extracting the hydrocarbons from the underground reservoirs, additional processing is conducted in the field to prevent corrosion and other problems in downstream handling and processing equipment (GRI, August 1994). The first processing step employed at many production facilities involves separating the oil, gas, and water produced by the well (Rucker and Strieter, 1992). The gas is separated from liquids either in a two-phase process, in which gas is typically separated from water, or in a three-phase separation operation, in which gas, water, and liquid hydrocarbons are separated. Three-phase separation is necessary when appreciable liquid hydrocarbons are extracted with the gas and water (GRI, 1994).

Separators can be vertical, spherical, or horizontal, and typically employ a series of baffles to separate the gas from the liquid hydrocarbons. A horizontal separator is used when the gas-to-liquid hydrocarbons ratio is large; a vertical separator is used when the gas-to-liquid hydrocarbon ratio is small; and a spherical separator is used when the gas-to-liquid hydrocarbon ratio is in the intermediate range. When wellhead pressures are high, a series of separators may be operated at sequentially reduced pressures (GRI, 1994).

Separators provide only one stage of separation, and, in many cases, additional water and gas separation from the oil emulsion streams may be required.

## **Oil Processing**

Water in the oil can form an emulsion. This emulsion is broken using heat in heater treaters or electric energy in devices such as electrostatic coalescers. Cleaned oil flows from the emulsion breakers to crude oil storage tanks, prior to being transported to a pipeline, truck, rail car, barge, or tanker. The water that is recovered during emulsion breaking is often recycled through skimmers to recover remaining oil, filtered, and then stored in water tanks prior to underground injection or other discharge (Rucker and Strieter, 1992).

## **Natural Gas Processing**

**Glycol Dehydration.** Glycol dehydration units are used to remove water from natural gas streams to prevent the formation of hydrates and corrosion in the pipeline. The natural gas stream is passed through a stream of triethylene glycol (TEG), diethylene glycol (DEG), or ethylene glycol (EG). Other forms of glycol, such as tetraethylene glycol, may also be used. At the point of contact, the glycol will absorb water and water vapor from the natural gas stream. During the absorption process, aromatic hydrocarbons including benzene, toluene, ethyl benzene and xylene (BTEX), hexane as well as other volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) present in the gas stream are absorbed along with the water vapor into the glycol stream. When the glycol is saturated with water, it is considered "rich glycol." The rich glycol is then sent to a glycol still for regeneration to remove water and liquid hydrocarbons. After regeneration, the glycol is considered "lean glycol" and is suitable for reuse (TNRCC, 1996).

**Methanol Injection.** Methanol is often added to natural gas as a hydrate point depressant and antifreeze. The methanol is injected using a gas-powered chemical injection pump, which uses gas pressure to drive the pump piston (GRI, 1994).

**Particulate Removal.** When solid impurities (particulates) are present in the raw natural gas, they are removed by passing the gas stream through a particulate filter, such as the common cartridge type filter (GRI, 1994).

**Acid Gas Removal.** The acid gases hydrogen sulfide ( $H_2S$ ) and carbon dioxide ( $CO_2$ ) corrode the pipeline and can cause safety problems if not removed from the natural gas stream. The gas stream must be freed of these contaminants, or "sweetened", before the gas can be transported for use (TNRCC, 1996). There are several processes available for removing the acid gases from the natural gas stream including:

- **Amine Based Process:** The most common method of acid gas removal (AGR), the amine process, utilizes aqueous solutions of diethanolamine (DEA), monoethanolamine (MEA), methyldiethanolamine (MDEA), and diglycolamine (DGA). The natural gas is processed through a stream of one of the previous amine

solutions that will absorb  $\text{H}_2\text{S}$ ,  $\text{CO}_2$ , and VOCs. After the amine solution is saturated with the acid gases, it is piped to the amine regenerator. The regenerator heats the amine solution and the acid gases are released (TNRCC, 1996).

- **Selexol Process:** This process uses the dimethylether of polyethylene glycol as a solvent, which has a high physical absorption capability for  $\text{CO}_2$  and sulfur-based compounds including  $\text{H}_2\text{S}$ . In the presence of  $\text{CO}_2$ , the Selexol process can reduce the  $\text{H}_2\text{S}$ , carbonyl sulfide (COS) and mercaptan concentrations to 1 ppm, with the  $\text{CO}_2$  content retained or reduced to any required level (GRI, 1994).

The solvent is regenerated by flashing and/or stripping with steam or inert gas. The process vent stream from the flash tank usually has a high  $\text{CO}_2$  concentration, and is typically flared to combust undesirable products such as  $\text{H}_2\text{S}$ , acid gases, and VOCs. The vent stream from the stripper column is either vented, flared, or sent to a sulfur recovery process.

- **Fixed Bed Sorption Process:** Fixed bed sorption, or molecular sieve gas sweetening, is typically used to treat liquified natural gas plant feed gases. Molecular sieves physically adsorb  $\text{H}_2\text{S}$  and/or  $\text{CO}_2$ , along with water, to sweeten and dehydrate the gas stream. With two or more adsorption beds, one bed is used to treat the feed gas stream while the other is regenerated by a heated gas stream (usually a slip stream of dry process gas). Generally, process heaters burning natural gas are used to heat the regeneration gas stream. The regeneration gas is usually recycled to the process after it has been cooled and any free water and sulfur compounds have been removed in an adsorber and flashed. The sour gas stream from the flash tank may be vented, incinerated, or sent to sulfur recovery (GRI, 1994).
- **Other Acid Gas Removal Processes:** Scavenging processes, such as iron sponge, are also used for acid gas removal, primarily where the  $\text{H}_2\text{S}$  content is relatively low. Other processes, such as the hot potassium carbonate-based Benfield process, are most often used for natural gas containing high concentrations of  $\text{CO}_2$  (GRI, 1994). Other processes exist, but are used less frequently.

**Sulfur Recovery.** Exhaust gas from the sweetening process may be vented to a sulfur recovery process. There are two common methods of sulfur recovery:

- **Claus Sulfur Recovery Process:** The Claus sulfur recovery process is the most widely used technology for recovering elemental sulfur from sour gas (or sour crude oil). The Claus process is used to recover sulfur from the amine regenerator vent gas stream in plants where large quantities of sulfur are present (GRI, 1994). The Claus process consists of a multistage catalytic oxidation of  $\text{H}_2\text{S}$ . Each catalytic stage consists of a gas reheater, a catalyst chamber, and a condenser. The Claus process



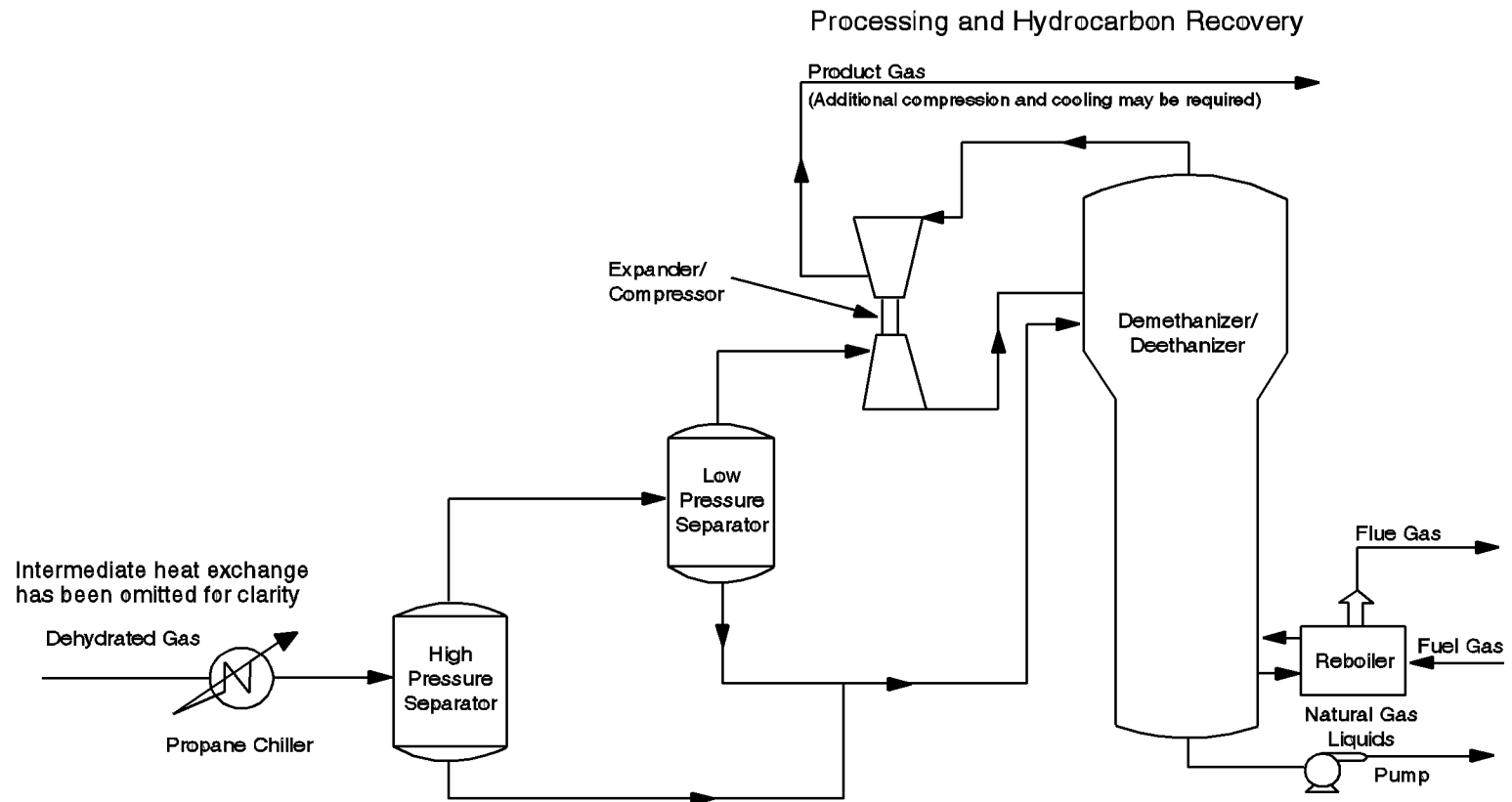
involves burning one-third of the  $H_2S$  with air in a reactor furnace to form sulfur dioxide ( $SO_2$ ) and water. The remaining uncombusted two-thirds of the  $H_2S$  reacts with  $SO_2$  to form elemental sulfur and water (EPA, 1995e).

- **Liquid Redox Sulfur Recovery Process:** Liquid redox sulfur recovery processes are liquid-phase oxidation processes which use a dilute aqueous solution of iron or vanadium to remove  $H_2S$  selectively by chemical absorption from sour gas streams. These processes can be used on relatively small or dilute  $H_2S$  streams to recover sulfur from the acid gas stream or, in some cases, they can be used in place of an acid gas removal (AGR) process. The mildly alkaline lean liquid scrubs the  $H_2S$  from the inlet gas stream, and the catalyst oxidizes the  $H_2S$  to elemental sulfur. The reduced catalyst is regenerated by contact with air in the oxidizer(s). Sulfur is removed from the solution by flotation or settling, depending on the process (GRI, 1994).

**Hydrocarbon Recovery.** Several processes are used in the industry to separate and recover non-methane hydrocarbons from natural gas (GRI, 1994):

- **Cryogenic Expansion:** In the cryogenic expansion process, the gas stream is initially treated by low-temperature separation to remove any residual water in the gas. The dehydrated gas is split, and part of the gas is cooled to  $-25^\circ$  Fahrenheit (F) using residue gas. The remainder of the gas is chilled to  $4^\circ$ F using propane as the refrigerant. The split streams are combined and enter the high pressure separator where the cold liquid hydrocarbons are separated from the gas. The cold liquid hydrocarbons leave the high pressure separator and are reduced in pressure across a valve to lower the temperature to  $-45^\circ$ F. This cold liquid hydrocarbon stream provides the heat sink for the upstream heat exchangers used to chill the incoming gas stream. After passing through these heat exchangers, the warm liquid enters the deethanizer (GRI, 1994).

The gas stream from the high pressure separator is expanded to reduce the temperature to  $-85^\circ$ F. This gas stream enters the low pressure separator where the hydrocarbon liquids are separated from the gas. The separated liquid stream is circulated as the coolant in the condenser on the deethanizer column and reintroduced as reflux to the deethanizer. The gas stream from the low pressure separator is used to further cool the overhead stream from the deethanizer, and then is combined with the deethanizer overhead stream. This combined gas stream is compressed to pipeline pressure (GRI, 1994). Figure 10.2-1 illustrates an example cryogenic expansion process.



**Figure 10.2-1 Cryogenic Expansion Process**  
(Source: GRI, 1994)

- **Refrigeration Process:** In the conventional refrigeration process, the inlet gas stream is initially contacted with a lean glycol solution to remove water from the gas stream. The gas/glycol stream is chilled to  $-30^{\circ}\text{F}$  to separate the condensible liquid hydrocarbons from the dry gas stream. The liquid hydrocarbons are separated from the rich glycol solution and sent to a stabilizer, where the lighter gas stream is separated from the heavier liquid hydrocarbons. The rich glycol stream is regenerated to remove the absorbed water and recycled to the process (GRI, 1994).
- **Absorption Process:** In the absorption process, the wet field gas is contacted with an absorber oil in a packed or bubble tray column. Propane and heavier hydrocarbons are absorbed by the oil while most of the ethane and methane pass through the absorber. The enriched absorber oil is then taken to a fractionator where the absorbed propane and heavier hydrocarbons are stripped from the oil. The overhead gas product stream from the absorber is then compressed to pipeline pressure (GRI, 1994).
- **Adsorption Process:** The adsorption process utilizes two or more molecular sieve beds to adsorb all hydrocarbons except methane. The beds are used alternately, with one or more beds on-stream while the others are being regenerated by means of heat or steam which remove the adsorbed hydrocarbons. If steam is used, the steam/hydrocarbon vapor stream is condensed and liquid hydrocarbons fed to a fractionation process where the various compounds are separated (GRI, 1994).

**Pneumatic Devices.** Pneumatic devices such as pressure and level controllers are used in gas field production operations to control field equipment. Natural gas is typically used as the pneumatic medium (GRI, 1994).

**Blowdown.** Equipment such as compressors is occasionally shutdown for emergencies and scheduled maintenance. Any gas remaining in the equipment and corresponding pipelines must be vented to reduce pressure prior to servicing. This process is called blowdown (GRI, 1994).

### 2.1.3 COMBUSTION

**External Combustion.** Boilers and heaters provide process heat and steam for many processes such as electric generation, glycol dehydrator reboilers, and amine reboiler units.

**Internal Combustion Engines and Gas Turbines.** Compressors are often used to transport natural gas from the field to processing plants. Reciprocating internal combustion engines (ICEs) or gas turbines are used to drive compressors. The inlet and outlet gas streams are passed through a scrubber/separator to remove any condensed liquids. The ICE or gas turbine driver combusts a slip stream of the gas being transported (GRI, 1994). ICEs and gas turbines also

have many other purposes, such as compression of petroleum gases and refrigerants, electrical generation, and pump and crane operation.

**Flares.** Flares are often used to control VOC emissions and to convert  $H_2S$  and reduced sulfur compounds to  $SO_2$ . Flares can be used to control emissions from storage tanks, loading operations, glycol dehydration units, vent collection systems, and gas sweetening amine units (Boyer and Brodnax, 1996). Flares can also be used as a backup system for sulfur recovery units.

## 2.1.4 STORAGE AND TRANSPORT

Storage tanks are used to store crude oil, liquified natural gas (LNG), water or brine, process condensate, as well as other materials used or generated during the production of oil and natural gas. Crude oil is transported from production operations to refineries by tank trucks, rail cars, tankers, barges, and pipelines. Loading methods include splash loading, submerged pipe fill, and bottom loading. Natural gas is transported by pipeline.

Pipeline pigging operations are conducted to assist in product transfer and product separation, as well as for maintenance activities. A pig is a physical device which varies in size and shape and can be made of a variety of materials such as plastic, urethane foams, and rubber. Pigs can be solid, inflatable, foam, or made of a viscous gel. The specific design of a particular pig depends upon the pipeline as well as the purpose of the pigging operation (GRI, 1993).

Three types of pigging operations occur in pipelines at oil and gas field production and processing facilities: product transfer, product separation, and maintenance. Pigging following product transfer is used to remove residual product from the pipeline after loading occurs. Pigs can also be used for product separation to transport more than one product, such as oil, gas, or condensate as well as for maintenance activities such as pipeline cleaning, gauging, or dewatering. During pigging operations, a pig is inserted into the pipeline and is forced through the pipeline by a compressed gas, such as nitrogen. When the pig gets to the end of the line, it is trapped in a receiver. The gas is then bled off from behind the pig (TNRCC, 1998a; TNRCC, 1998b; GRI, 1993). Depending on the specific pigging operation, waste removed from the pipeline may also be an issue.

## 2.1.5 WASTEWATER

During oil and gas field production and processing operations, wastewater is generated from processes such as product separation and glycol dehydration. The wastewater may be treated on-site or it may be forwarded to an approved wastewater treatment facility.

Many types of units are used to treat, store, and transfer wastewater on-site. Some of these units include sumps, pits, storage tanks, brine tanks, and oil/water separators which may be in primary, secondary or tertiary treatment service.

## 2.2 EMISSION SOURCES

Emissions from oil and gas field processing operations result from both controlled (i.e., ducted) and uncontrolled sources. Section 7 of this chapter lists the source classification codes (SCCs) for these emission points. In addition to emissions from the sources described below, emissions result from process upsets such as pressure relief device releases due to over-pressure, and non-traditional sources such as cogeneration units, cooling towers and non-road mobile sources. In addition, equipment and emissions from off-shore operations, although not specifically addressed in this document, are believed to be similar to those from on-shore operations. Preferred and alternative emission estimation methodologies for off-shore sources are, therefore, expected to be the same as for on-shore sources. Depending on the purpose of the emission inventory, the inventory preparer should consider inclusion of emissions from these additional source types.

### 2.2.1 EXPLORATION AND PRODUCTION

Emission sources associated with exploration and production include exploration, well-site preparation, drilling, waste pits, blowouts, well testing, and gas/liquid separation. Fugitive dust and combustion emissions from exploration and well-site preparation result from vehicles, heavy equipment and engines and turbine operation.

Drilling operations are a significant source of short-term air pollutant emissions, which some states consider to be a temporary source. During drilling, gas may seep into the well bore and become dissolved or entrained in the drilling mud (EPA, 1977a). The gases are separated from the mud in a separator or degasser. Gases removed from the mud are either vented to the atmosphere or routed to a flare. Some states or local agencies may consider mud degassing a temporary source of emissions. Pollutants of concern are  $H_2S$ ,  $CH_4$ , VOC and HAPs. The use of oil-based drilling muds also results in additional  $H_2S$ ,  $CH_4$ , VOC and HAP emissions. When using oil-based drilling muds, the mud will be dispersed in oil rather than water. When the mud passes through the shale shaker, the oil vapors are exposed directly to the atmosphere (EPA, 1977a). Some state or local agencies may consider this a temporary source of emissions.

Waste pits storing hydrocarbon laden cuttings may be a source of VOC and HAP emissions. Well blowouts, although infrequent, are considered process upsets and can also be a source of VOC, HAP, and  $CH_4$  emissions. Well testing can result in VOC, HAP and  $CH_4$  emissions.

Emissions from gas/liquid separation processes include fugitive VOC and HAP from valves and fittings and from any operation upsets, such as pressure relief device releases due to over-pressure.

## 2.2.2 PROCESSING

### *Oil Industry*

Emissions from heater treaters result from fuel combustion and include typical fuel combustion pollutants: carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>), particulate matter less than or equal to 10 microns in diameter (PM<sub>10</sub>), particulate matter less than or equal to 2.5 microns in diameter (PM<sub>2.5</sub>), VOC, lead, and HAPs. Equipment leaks from piping components (e.g., valves, flanges and connectors) also result in fugitive VOC and HAP emissions.

### *Gas Industry*

Emissions associated with the glycol dehydration process may include vented emissions from the glycol dehydrator's flash tank as well as the glycol regenerator process vent. BTEX compounds, as well as hexane and other HAPs present in the gas, are carried with the rich glycol to the regenerator; thus the regenerator vent stream can be a major source of HAP emissions (GRI, 1994). Glycol regenerators either vent directly to the atmosphere or to vapor recovery or control systems.

The glycol regenerator reboiler typically fires natural gas and is also a potential source of HAP emissions. If the water is efficiently removed from the gas stream during the glycol dehydration process, the glycol regenerator reboiler can be used to thermally oxidize HAPs and VOCs emitted from the glycol regenerator process vent.<sup>1</sup> Gas-driven pumps often used in glycol units may produce HAP emissions. In most cases, the pump-driven gas is routed to the rich glycol stream upstream of the flash tank. Once the glycol reaches the flash tank or regenerator, the pump gas is separated with the gas from the absorber. Fuel combustion should be considered an emission source separate from the glycol regenerator reboiler. Other process-related sources of emissions include fugitive emissions from valves and fittings, and emissions from routine maintenance activities involving equipment depressurization (blowdown) or complete purging and filter replacement. Also, although DEG, TEG, and tetraethylene glycol are not listed HAPs, they may degrade at the high temperatures present in the regenerator to form compounds such as ethylene glycol, a listed HAP (GRI, 1994). If ethylene glycol is used, HAP emissions may be released.

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<sup>1</sup>Water-cooled condensers are generally more efficient than air-cooled condensers when used in the glycol dehydration process.

VOC and HAP emissions from the methanol injection process include fugitive losses from the transfer line fittings and from the methanol storage tank. Also, the gas-powered chemical injection pumps vent gas directly to the atmosphere and could emit VOC or HAP compounds present in the gas (GRI, 1994).

Potential emissions of VOC and HAP from particulate removal result from fugitive losses from valves, flanges, or other connections, and vented emissions from periodic routine maintenance to repair or clean the filter. Disposal of the filter cartridges may also be a source of emissions due to the volatility of some VOC or HAP compounds (GRI, 1994).

During the gas sweetening/acid gas removal process, the amine unit is a potential source of  $\text{SO}_2$ ,  $\text{H}_2\text{S}$ , VOC, HAP and  $\text{CO}_2$  emissions. As the amine regenerator heats the amine solution, the acid gases are released through the amine still vent. The amine still vent can be vented directly to the atmosphere, to a flare or incinerator, or to a sulfur recovery unit (SRU) (TNRCC, 1996). Amine units designed to remove only  $\text{CO}_2$  from the natural gas, generally, vent directly to the atmosphere. Amine units designed for the removal of  $\text{H}_2\text{S}$  and  $\text{CO}_2$ , generally, vent directly to a sulfur recovery unit.

During sulfur recovery, emissions sources in the Selexol process include the process vent streams, fugitive emissions from valves, flanges, and compressor seals, exhaust emissions associated with compressor operation and vented emissions due to periodic maintenance activities (GRI, 1994). Pollutants of concern are  $\text{SO}_2$ ,  $\text{H}_2\text{S}$ , and HAPs.

Emission sources associated with the fixed bed sorption process potentially include the sour gas vent from the flash tank associated with molecular sieve bed regeneration, exhaust emissions from process heaters associated with the regeneration cycle, fugitive emissions, and vented emissions from maintenance activities (GRI, 1994).

Emission sources associated with the Claus sulfur recovery process include the tail gas stream, which is usually incinerated or which may be passed through a liquid redox sulfur recovery unit, fugitive emissions from equipment leaks, and emissions from maintenance activities. In addition, residual  $\text{H}_2\text{S}$ , carbonyl sulfide ( $\text{COS}$ ), and carbon disulfide ( $\text{CS}_2$ ) may also be released to the atmosphere from the recovered molten sulfur (GRI, 1994).

In the liquid redox sulfur recovery process, vent gases from the oxidizer vessel are a potential source of emissions. Emissions associated with fixed bed adsorption or molecular sieve dehydration include fugitive emissions and emissions from maintenance activities which are considered minor sources of HAP emissions. Process heaters are often used to heat the regeneration stream, with the burner vents from these heaters being potential sources of HAP emissions (GRI, 1994).

Emissions from the refrigerated absorption process include flue gas from the rich oil fractionator reboiler, exhaust emissions from the compressor driver (a reciprocating engine or a gas turbine), fugitive emissions, and emissions from maintenance activities.

Cryogenics plant emissions primarily include exhaust from the compressor driver, flue gas from the deethanizer reboiler, fugitive emissions, and emissions from maintenance activities.

Emissions associated with the refrigeration process include the glycol regenerator off-gas, which is typically vented to the atmosphere and may potentially contain BTEX, as well as hexane and other HAPs present in the gas. The flue gas stream from the glycol regenerator reboiler is also typically vented to the atmosphere and may be a source of emissions. Other sources of emissions include fugitive emissions and vented emissions due to maintenance activities.

Absorption process emissions include exhaust from the compressor driver, exhaust gas from the fractionator reboiler, fugitive emissions, and vented emissions due to maintenance activities.

Emissions associated with the adsorption process primarily include exhaust gas from the regenerator, fugitive emissions, and maintenance activities.

### 2.2.3 COMBUSTION

Boilers and heaters provide local process heat, process steam, steam for electric generation, glycol dehydrator reboilers, and amine reboiler units. Internal combustion engines and gas turbines have many other purposes, such as compression of petroleum gases, compression of refrigerants, electrical generation, and pump and crane operation. The pollutants of concern include  $\text{NO}_x$ , CO, VOC,  $\text{PM}_{10}$ ,  $\text{PM}_{2.5}$ ,  $\text{SO}_2$ ,  $\text{CH}_4$ , and  $\text{CO}_2$ . HAPs, primarily formaldehyde and acetaldehyde, are also potential pollutants from these combustion sources.

Flares convert potentially hazardous gases into less hazardous emissions. VOC,  $\text{NO}_x$ , CO, HAPs and  $\text{CH}_4$  are the primary pollutants of concern with flares (TNRCC, 1996). If flares are used to oxidize  $\text{H}_2\text{S}$  and other reduced sulfur compounds,  $\text{SO}_2$  will also be emitted. Depending on the level of conversion achieved,  $\text{H}_2\text{S}$  and other reduced sulfur compounds may also be emitted.

Auxiliary fuel combustion is also a source of emissions. Fuel used to fire specific process or control equipment such as flares and incinerators result in additional combustion emissions. Depending on the fuel fired, pollutants may include  $\text{NO}_x$ , CO,  $\text{PM}_{10}$ ,  $\text{PM}_{2.5}$ , VOC,  $\text{SO}_2$ ,  $\text{CO}_2$ ,  $\text{CH}_4$ , and HAPs.

### 2.2.4 TRANSPORTATION

Emission sources related to transporting crude oil include loading losses and fugitive pipeline leaks. As crude oil is loaded into trucks, rail cars, barges, and tankers, vapors residing in the



vapor space are pushed out of the cargo tank. Pipeline transmission of natural gas is also an emission source. Pollutants include VOC, HAPs, and CH<sub>4</sub> contained in the material.

Pigging operations are also a potential source of VOC, HAP, and CH<sub>4</sub> emissions if residual vapors are vented to the atmosphere rather than to a flare or incinerator. As the pig travels through the pipeline, residual vapors are pushed through the line as well. If the vapors are not routed to a control device, they escape through openings on the device such as hatches, doors, or vents. Emissions can be significant depending on the amount and vapor pressure of the product (TNRCC, 1998a). Depending on the gas used to push the pig, the bleed-off step can also result in VOC, HAP, or CH<sub>4</sub> emissions if the gas is not vented to a control device.

Depending on the purpose of the emission inventory, pigging emissions may need to be included. The inventory preparer should contact the state or local agency to identify the preferred methods to estimate emissions from pigging operations.

### **2.2.5 STORAGE TANKS**

Storage tanks are used to store crude oil, LNG, water or brine, process condensate, as well as other materials used at oil and gas field processing facilities, and may be a potential source of VOC, HAP, CH<sub>4</sub> emissions. Emission losses from storage tanks in the oil and gas field processing industry include working losses, breathing losses, and flash losses. Working losses refer to the combined loss from filling and emptying the tank. Filling losses occur when the VOC contained in the saturated air are displaced from a fixed-roof vessel during loading. Emptying losses occur when air drawn into the tank becomes saturated and expands, exceeding the capacity of the vapor space. Breathing losses are the expulsion of vapor from a tank through vapor expansion caused by daily changes in temperature and pressure. Flash losses occur when fluids exiting vessels at pressures above atmospheric enter storage tanks operating at atmospheric pressure which are vented to the atmosphere. As the fluid pressure drops to atmospheric pressure, the gas which is entrained in the fluid is then released (TNRCC, 1996). Flash losses often exceed breathing and working losses (Boyer and Brodnax, 1996).

### **2.2.6 WASTEWATER**

If open to the atmosphere, units used to treat, store and transfer wastewater on-site may also be potential sources of VOC, HAP, CH<sub>4</sub>, and H<sub>2</sub>S emissions. Some of these units that may be present at oil and gas field production and processing operations are sumps, pits, storage tanks, brine tanks, and oil/water separators.

### 2.2.7 FUGITIVES

Fugitive emissions (equipment leaks), are leaks from sealed surfaces associated with process equipment. Specific fugitive source types include various equipment components such as valves, flanges and connectors. Equipment specific to the oil and gas field production and processing operations which result in fugitive emissions include equipment such as heater treaters, separators, pipelines, wellheads and pump stations. Pneumatic devices such as gas actuated pumps and pressure/level controllers also result in fugitive emissions. Pollutants of concern include VOC, HAPs, CH<sub>4</sub> contained in the gas.

## 2.3 DESIGN AND OPERATING PARAMETERS AFFECTING EMISSIONS

In general, the primary factors affecting emissions and their estimation for sources in oil and gas field processing operations are:

- Oil/gas composition;
- Production rate/frequency of operation; and
- Type of control/recovery, if any.

The specific influence of each of these factors as well as other source specific parameters affecting emissions are discussed below.

Glycol dehydrator emissions will be affected by the composition of the natural gas, particularly the concentration of glycol-soluble hydrocarbons. As water is adsorbed into the glycol stream, so are some glycol-soluble hydrocarbons such as BTEX. The rich glycol stream flows to the reboiler for regeneration by heating to remove the water. Water and adsorbed hydrocarbons are released from the glycol during the regeneration (Boyer and Brodnax, 1996).

Emissions from gas sweetening units are influenced by the concentration of acid gases in the waste gas stream as well as the type of control or recovery process that follows the sweetening process. The greater the H<sub>2</sub>S concentration in the sour gas, the greater the potential for H<sub>2</sub>S emissions. In the amine gas sweetening process, the amine solution absorbs H<sub>2</sub>S, CO<sub>2</sub>, and VOCs. After the amine solution is saturated with the acid gases, the solution is piped to the amine regenerator. The regenerator heats the amine solution and the acid gases are released from the amine solution through the amine still vent. If emissions from the still vent are released directly to the atmosphere, H<sub>2</sub>S, CO<sub>2</sub>, and VOC emissions will be released. If amine still vent emissions are vented to a flare or incinerator, H<sub>2</sub>S will be oxidized to SO<sub>2</sub> (TNRCC, 1996). Since the flare/incineration process converts the H<sub>2</sub>S to SO<sub>2</sub>, the greater the H<sub>2</sub>S concentration in the tail gas, the greater the SO<sub>2</sub> emissions. Also, CO<sub>2</sub> in the waste gas stream can lower the

British thermal unit (BTU) content of the gas, thereby reducing the flare efficiency. Fuel gas can be added to the waste gas to increase the BTU content and increase the flame's temperature. The type of auxiliary fuel fired will also impact emissions. VOC emissions are also affected by the control efficiency of the flare or incinerator (Boyer and Brodnax, 1996). If the still vent emissions are vented to a SRU, the  $H_2S$  will be converted to elemental sulfur and  $SO_2$  (TNRCC, 1996). The  $H_2S$  content of the tail gas, as well as the efficiency of the SRU, will affect  $SO_2$  emissions.

Emissions resulting from flashing are impacted by the change in pressure to which the entrained gases are subjected as well as the volume, temperature, and composition of the material being transferred. Flash losses occur from tanks, gun barrels, and separators, as the fluid moves from the high pressure lines to atmospheric pressure. Under high pressure, the fluid can readily dissolve more gases. As pressures are released from the saturated fluid, the dissolved gases will be released (TNRCC, 1996). All other factors being equal, the greater the pressure drop, the greater the gas volume released per barrel of oil produced (Boyer and Brodnax, 1996). The composition of the fluid will also impact emissions.

Emissions from gas actuated pumps will be impacted by the gas composition, fuel supply pressure, discharge head (pressure), and the flow rate of the liquid pumped, since manufacturer pump curves estimate gas use based on these variables (Boyer and Brodnax, 1996).

The amount of gas vented by pressure and level controllers is dependent on the manufacturer, application, age, and orifice size. In general, controllers in liquid service have larger orifices than those in pressure service. Valves in liquid service are designed to quickly open or close to avoid throttling which can erode the valve seat and reduce the life of the valve (Boyer and Brodnax, 1996).

Factors affecting internal combustion engine and turbine emissions include engine type/design and size, fuel type and firing rate, and operating conditions, such as the air to fuel ratio.

Factors affecting blowdown emissions include maintenance schedules, line pressures, and the volume of gas relieved (TNRCC, 1996). More frequent maintenance results in more frequent gas relief. Also, since emissions are estimated using the Ideal Gas Law, the greater the line pressure and the volume of gas to be relieved, the greater the emissions.

Material transportation and loading losses are affected by the composition of the previous material transported and the current material to be loaded. If the empty cargo tank has not been cleaned, any vapors remaining in the tank will be expelled during the loading process. Also, the loading method will impact emissions. Splash loading will result in greater emissions than submerged pipe fill loading or bottom filling.

## 2.4 CONTROL TECHNIQUES

Control techniques and devices typically used in oil and gas field processing operations are described below and presented in Table 10.2-1. Control efficiency for a specific piece of equipment will vary depending on the type of equipment and quality of the maintenance/repair program at a particular facility.

### 2.4.1 CONTROL TECHNIQUES FOR VOC

VOC is probably the pollutant emitted in greatest quantities from oil and gas field processing operations. Flares are used as a method of controlling VOC emissions throughout these facilities when a flash tank is used in conjunction with a condenser. Vapor collection or header systems are commonly installed at oil and gas field processing operations to collect and route vapors to a flare or incinerator. Emissions from emergency and process vents (Boyer and Brodnax, 1996), loading operations (TNRCC, 1996), well casing gases (Rucker and Strieter, 1992), as well as other emission sources are typically routed to flares or incinerators. Control efficiencies of 98% for flares (Rucker and Strieter, 1992) and 99% or greater for incinerators can be achieved.

VOC emissions from emergency and process vents may also be routed to a vapor recovery compressor prior to pipeline injection (Boyer and Brodnax, 1996). Other devices that may be used to control VOC emissions from storage tanks and loading operations include vapor collection and vapor balance systems, carbon adsorption systems, and scrubbers (TNRCC, 1996). Submerged loading techniques will also help reduce VOC and HAP emissions. Another technique for reducing VOC and HAP emissions from storage tanks is the use of an internal floating roof.

Control methods for glycol dehydrators include condensers, flares, vapor recovery units, carbon adsorption, or combinations of these. Condenser efficiencies range from 35 to 98% depending on the type of condenser and the size of unit. Water-cooled condensers can achieve 85 to 98% efficiency. Air-cooled condenser efficiencies range from 35 to 98%. On smaller units, air cooled condensers are capable of achieving the upper end of this range, but efficiencies tend to decrease as the glycol dehydrator size increases. In addition, warmer climates may decrease the efficiency of air-cooled condensers. If the water is efficiently removed from the gas stream during the glycol dehydration process, the glycol regenerator reboiler can also be used to thermally oxidize VOC and HAP emissions from the glycol regenerator process vent. However, if the water is not efficiently removed from the gas stream during glycol dehydration, the glycol regenerator reboiler can become corroded resulting in inefficient combustion of VOC and HAP emissions.

TABLE 10.2-1

## TYPICAL OIL AND GAS FIELD PROCESSING EMISSION CONTROL TECHNIQUES

Emission Sources	Pollutant	Control Technique	Typical
Glycol Dehydrators	VOC, HAPs	Condensers <sup>a</sup>	35-98 <sup>k</sup>
		Flare <sup>a</sup>	98 <sup>b</sup>
		Incinerator	99
		Reboiler <sup>a,j,k</sup>	c
		Vapor recovery systems	c
		Carbon adsorption <sup>b</sup>	c
Amine Still Vents	H <sub>2</sub> S	Flare	98 <sup>b</sup>
		Incinerator	99
		Sulfur recovery unit	c
Emergency and Process Vents	VOC, HAPs	Flare <sup>a</sup>	98 <sup>b</sup>
		Incinerator	99
		Vapor recovery <sup>a</sup> compressor prior to injection	c
Mud Degassing	H <sub>2</sub> S, CH <sub>4</sub>	Flares <sup>l</sup>	98
		Incinerators	99
	CH <sub>4</sub>	Vapor recovery systems <sup>l</sup>	c
Storage Tanks	VOC, HAPs	Flare <sup>a</sup>	98 <sup>b</sup>
		Incinerator	99
		Vapor recovery <sup>a</sup> compressor prior to injection	c
		Internal floating roof	60-99 <sup>b</sup>
		Vapor balance system	c
		Carbon adsorption	c
		Scrubbers	c
Loading Losses	VOC, HAPs	Submerged loading	58 <sup>b,d</sup>
		Vapor recovery	85-95 <sup>b</sup>
		Flare <sup>e</sup>	98 <sup>b</sup>
		Incinerator <sup>e</sup>	99 <sup>b</sup>
		Vapor balance system <sup>e,f</sup>	90 <sup>b</sup>
		Carbon adsorption systems <sup>e</sup>	c
		Scrubbers <sup>e</sup>	c
Equipment Leaks	VOC	Leak detection and repair (LDAR)	c, g

TABLE 10.2-1

(CONTINUED)

Emission Sources	Pollutant	Control Technique	Typical
Pigging Operations	VOC, HAP, CH <sub>4</sub>	Flares	98
		Incinerators	99
Internal Combustion Engines, Rich-burn	NO <sub>x</sub>	Non-selective catalytic reduction <sup>c</sup>	c
		low emission combustion	c
Internal Combustion Engines, Lean-burn	NO <sub>x</sub>	Selective catalytic reduction	c
		Torch ignition	c
		Chamber redesign	c
		Low emission combustion	c
Gas Turbines	NO <sub>x</sub>	Water/steam injection <sup>h</sup>	c
		Selective catalytic reduction <sup>h</sup>	c
		Low-NO <sub>x</sub> burner	c
Boilers/External Combustion Devices	NO <sub>x</sub>	Low NO <sub>x</sub> burners <sup>i</sup>	30-70 <sup>i</sup>
		Flue gas recirculation <sup>i</sup>	50-75 <sup>i</sup>
		Selective non-catalytic reduction <sup>i</sup>	25-40 <sup>i</sup>
		Selective catalytic reduction <sup>i</sup>	80-90 <sup>i</sup>

<sup>a</sup> Source: Boyer and Brodnax, 1996.<sup>b</sup> Source: Rucker and Strieter, 1992.<sup>c</sup> Control efficiency not documented; efficiency may vary depending on operational parameters of emission source and/or control technique.<sup>d</sup> Emission reduction efficiency relative to splash filling.<sup>e</sup> Source: TNRCC, 1996.<sup>f</sup> For vapor balance systems, the loading loss saturation factors in AP-42 equation have this reduction built into the calculation. Control efficiency need only be factored in to the calculation if an uncontrolled emission estimation technique is applied.<sup>g</sup> Efficiency of LDAR will vary based on source location (attainment area vs. nonattainment area), the I/M screening value for leakers, and the frequency of monitoring.<sup>h</sup> Source: EPA, 1995a.<sup>i</sup> Source: EPA, 1994a.<sup>j</sup> The reboiler can be used to thermally oxidize VOC and HAP emissions if water is efficiently removed from the gas stream during the glycol dehydration process.<sup>k</sup> Water-cooled condensers are generally more efficient than air-cooled condensers for removing water from the gas stream during the glycol dehydration process. On smaller units, air-cooled condensers are capable of achieving the upper end of this range, but efficiencies tend to decrease as glycol dehydrator size increases.<sup>l</sup> Source: EPA, 1977b.

Leak detection and repair (LDAR) programs are used to reduce equipment leak emissions from components such as valves, pumps, and flanges. Leaking equipment is identified during periodic inspections with a VOC-detection device. The leaking equipment is logged on a maintenance schedule and mechanical adjustments are made to repair the leaks. The efficiency of this control procedure is affected by how often the inspections are conducted and how soon the repairs are made (some states assume specific LDAR control efficiencies provided certain program criteria are met). Leakless equipment has been developed to reduce fugitive emission losses from such equipment as valves and pump seals (Rucker and Strieter, 1992).

Flares can also be used to reduce VOC, HAP and CH<sub>4</sub> emissions collected during pigging operations.

### **2.4.2 CONTROL TECHNIQUES FOR H<sub>2</sub>S**

Flares and incinerators are used to convert H<sub>2</sub>S in amine still vent streams to SO<sub>2</sub>. SRUs also help reduce H<sub>2</sub>S emissions from amine still vent streams.

### **2.4.3 CONTROL TECHNIQUES FOR COMBUSTION EMISSIONS**

Water/steam injection, selective catalytic reduction (SCR), and low-NO<sub>x</sub> burners are commonly used to reduce NO<sub>x</sub> emissions from gas turbines. Some SCR systems utilize a CO catalyst which also reduces CO emissions.

NO<sub>x</sub> abatement devices for rich-burn internal combustion engines primarily include non-selective catalytic reduction. Some rich-burn engines can also be prestratified charge engines. Lean-burn internal combustion engines use SCR, torch ignition or chamber redesign techniques to control NO<sub>x</sub> emissions. Low emission combustion is also used on internal combustion engines.

Low NO<sub>x</sub> burners, flue gas recirculation, and selective non-catalytic reduction are control options for boilers and other external control devices. Selective catalytic reduction can also be used. The reader is referred to Chapter 2 of this volume for more information on combustion sources.

# 3

## OVERVIEW OF AVAILABLE METHODS

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### 3.1 DESCRIPTION OF EMISSION ESTIMATION METHODOLOGIES

There are several methodologies available for calculating emissions from oil and gas field processing operations. The method used is dependent upon available data, available resources, and the degree of accuracy required in the estimate. In general, site-specific data is preferred over industry averaged data, such as *AP-42* emission factors, for accurate emissions estimates (EPA, 1995a). Each state may have a different preference or requirement and so it is suggested that the reader contact the appropriate state or local air pollution agency before deciding on which emission estimation methodology to use. This document evaluates emission estimation methodologies with respect to relative accuracy and does not mandate any emission estimation method. For purposes of calculating peak season daily emissions for State Implementation Plan inventories, refer to the Environmental Protection Agency's (EPA) *Procedures* manual (EPA, 1991a).

This section discusses the methods available for calculating emissions from oil and gas field processing operations and identifies the preferred method of calculation on a pollutant basis. The reader should not infer a preference based on the order emission estimation methodologies are listed in this section. A discussion of the sampling and analytical methods available for monitoring each pollutant is provided in Chapter 1, *Introduction to Stationary Point Source Emissions Inventory Development*.

Emission estimation techniques for auxiliary processes, such as use of EPA's TANKS program to calculate storage tank emissions, are also discussed in Chapter 1. For equipment leaks, the reader is referred to the emission estimation methodologies identified in Chapter 4, *Preferred and Alternative methods for Estimating Fugitive Emissions from Equipment Leaks*.

#### 3.1.1 STACK SAMPLING

Stack sampling provides a "snapshot" of emissions during the period of the stack test. Stack tests are typically performed during either representative (i.e., normal) or maximum load conditions, depending upon the requirements of the state. Samples are collected from the stack using probes inserted through a port in the stack wall, and pollutants are collected in or on various media and sent to a laboratory for analysis. Emissions rates are then determined by multiplying the pollutant concentration by the volumetric stack gas flow rate. Because there are many steps in



the stack sampling procedures where errors can occur, only experienced stack testers should perform such tests.

### 3.1.2 EMISSION FACTORS

Emission factors are available for many source categories and are based on the results of source tests performed at one or more facilities within an industry. Basically, an emission factor is the pollutant emission rate relative to the level of source activity. Chapter 1 of this volume contains a detailed discussion of the reliability, or quality, of available emission factors. EPA-developed emission factors for criteria and hazardous air pollutants are available in *AP-42*, the *Locating and Estimating Series* of documents, and the Factor Information REtrieval system (FIRE). Emission factors are also available from various industrial associations such as the American Petroleum Institute (API), the Gas Research Institute (GRI), and the Chemical Manufacturers Association (CMA). In addition, manufacturers often conduct research to develop emission factors for specific pieces of equipment. For a single facility, stack tests are usually preferable over emission factors, but for estimating emissions across a source category, emission factors can be used and may be the only reasonable means of estimating emissions due to the number of sources or lack of individual facility emission estimates.

### 3.1.3 CALCULATION PROGRAMS

Several calculation programs or theoretical “models” are available for use in estimating emissions from oil and gas field processing operations. Emission estimating programs/models are available for the following types of emission sources:

- Glycol dehydrators;
- Gas sweetening units;
- Emergency and process vents;
- Equipment leaks;
- External combustion devices;
- Internal combustion engines/gas turbines;
- Storage tanks;
- Flash losses; and
- Loading operations.

Inputs for programs/models generally fall into the following categories: chemical/physical properties of the material(s) involved (e.g., vapor pressure, vapor molecular weight), operating data (e.g., amount of material processed, operating hours), and physical characteristics/properties of the source (e.g., tank color, tank diameter).

The American Petroleum Institute (API) has developed the Exploration and Production Emissions Calculator (EPEC) and E&P TANK models. The EPEC model integrates user input, emissions calculations, and data summaries for many equipment types used in the oil and natural gas production industry (API, 1998). EPEC may be used to estimate emissions of VOC, HAPs, criteria pollutants, and other regulated pollutants.

The E&P TANK model was developed by the API and Gas Research Institute (GRI) and is designed to use site specific information to predict VOC and HAP emissions (flashing, working, and standing losses) from petroleum production field storage tanks (API, 1997).

GRI developed the GRI-HAPCalc model which estimates emissions from six major process units and from equipment leaks from the natural gas production industry. The GRI-HAPCalc model allows the use of *AP-42* emission factors, factors based on literature data, factors based on GRI data, and user-defined factors.

API, in collaboration with GRI, developed the AMINECalc model to estimate HAP and VOC emissions from amine-based sour gas and natural gas liquid sweetening unit.

When using any emission estimation model, the user should be cautious when collecting input data to make sure the correct data is collected and entered into the model. In addition, most models offer default values for some parameters if process-specific data is not available. While simplifying the data collection process, use of the defaults that are not appropriate for a particular unit may result in invalid or inaccurate emission estimates. In all cases, therefore, the user is encouraged to collect and use process-specific data to obtain the most accurate estimate that the model is capable of producing.

Also, depending on the purpose of the inventory, the user should check with the state or local agency to confirm the model is acceptable.

### 3.1.4 ENGINEERING CALCULATIONS

Various engineering calculations are also used to estimate emissions from oil and gas field processing operations. These calculations require data inputs similar to the calculation programs. Engineering calculations are available for the following sources:

- Emergency and process vents;

- Gas actuated pumps;
- Gas sweetening;
- Sulfur recovery units;
- Flares;
- Pneumatic devices;
- Mud degassing;
- Glycol dehydrators;
- Flash losses;
- Blowdown;
- Well blowouts;
- Well testing; and
- Loading losses

### **3.2 COMPARISON OF AVAILABLE EMISSION ESTIMATION METHODOLOGIES**

Table 10.3-1 identifies the preferred and alternative emission estimation approach(es) for selected pollutants. Table 10.3-1 is ordered according to the relative accuracy of the emission estimation approach. The reader and the local air pollution agency must decide which emission estimation approach is applicable based on costs and air pollution control requirements in their area. The method chosen should also recognize the time specificity of the emission estimate and the data quality. The quality of the data will depend on a variety of factors including the number of data points generated, the representativeness of those data points, and the proper operation and maintenance of the equipment being used to record the measurements. In general, source tests are preferable over emission factors for estimating emissions from a specific source operating under specific conditions, but for emissions across a source category, emission factors can be used and may be the only reasonable means of estimating emissions due to the number of sources or lack of individual emission factors.

TABLE 10.3-1

**SUMMARY OF PREFERRED EMISSION ESTIMATION METHODS FOR OIL AND GAS FIELD PROCESSING OPERATIONS**

<b>Emission Source</b>	<b>Pollutant<sup>a</sup></b>	<b>Preferred Emission Estimation Approach Ordered by Accuracy<sup>b</sup></b>
Internal combustion engines	CO, NO <sub>x</sub> , SO <sub>2</sub> , VOC, PM <sub>2.5</sub> , PM <sub>10</sub> , HAPs, CH <sub>4</sub> , CO <sub>2</sub>	1. Measurement 2. EPA/state/other published emission factors
Gas turbines	NO <sub>x</sub> , CO, PM <sub>2.5</sub> , PM <sub>10</sub> , CH <sub>4</sub> , CO <sub>2</sub>	1. Measurement 2. EPA/state/other published emission factors
Boilers/External flame burners	VOC, SO <sub>2</sub> , PM <sub>2.5</sub> , PM <sub>10</sub> , CH <sub>4</sub> , CO <sub>2</sub> , HAPs, NO <sub>x</sub> , CO	(See Chapter 2 of this series)
Mud degassing	VOC, HAPs, CH <sub>4</sub> , H <sub>2</sub> S	Displacement equation
Shale shakers/oil-based muds	VOC, HAPs, CH <sub>4</sub> , H <sub>2</sub> S	EPA/State/other published emission factors
Glycol dehydrator	VOC, HAPs	1. GRI-GLYCalc emission model 2. Measurement 3. Rich/lean method
Gas sweetening - amine units venting to smokeless flare or tail gas incinerator	SO <sub>2</sub> , H <sub>2</sub> S	1. Displacement Equation/Stoichiometry 2. EPA/state/other published emission factors
	VOC, HAPs	Destruction and removal efficiency
Gas sweetening - amine units venting to atmosphere	CO <sub>2</sub> , H <sub>2</sub> S	1. Displacement Equation 2. Measurement 3. Rich/lean method
	VOC, HAPs	AMINECalc Model
Gas sweetening amine units venting to sulfur recovery unit	SO <sub>2</sub> , H <sub>2</sub> S, HAPs	1. Sulfur recovery efficiency 2. EPA/state/other published emission factor

TABLE 10.3-1

(CONTINUED)

Emission Source	Pollutant <sup>a</sup>	Preferred Emission Estimation Approach Ordered by Accuracy <sup>b</sup>
Emergency and process vents	VOC, HAPs, CH <sub>4</sub>	Displacement Equation
Flares	NO <sub>x</sub> , CO, CH <sub>4</sub>	EPA/state/other published emission factors
	VOC, HAPs	Destruction and removal efficiency
	SO <sub>2</sub> , H <sub>2</sub> S	Displacement Equation/Stoichiometry
Gas actuated pumps	VOC, HAPs, CH <sub>4</sub>	Displacement Equation
Loading losses	VOC, HAPs, CH <sub>4</sub>	1. EPA published equations 2. Measurement
Pigging operations	VOC, HAPs, CH <sub>4</sub>	Measurement
Pneumatic devices	VOC, HAPs, CH <sub>4</sub>	1. Displacement Equation 2. EPA/state/other published emission factors
Storage tanks Working losses Breathing losses	VOC, HAPs, CH <sub>4</sub>	1. TANKS model (See Chapter 1 of this series) 2. GRI-HAPCalc 3. E&P Tank
Storage tanks Flash losses	VOC, HAPs	See methods for "Flash losses" listed below.
Flash losses - black oil systems	VOC, HAPs	1. E&P Tank Model 2. EPEC Model 3. Vazquez-Beggs/Rollins, McCain, and Creeger Correlations
Flash losses - gas condensate systems	VOC, HAPs	EC/R algorithm or E&P Tank model <sup>c</sup>
Blowdown	VOC, HAPs, CH <sub>4</sub>	Displacement Equation
Equipment leaks	VOC, HAPs, CH <sub>4</sub>	(See Chapter 4 of this series)
Blowout	VOC, HAPs, CH <sub>4</sub>	1. Displacement Equation
Well testing	VOC, HAPs, CH <sub>4</sub>	Displacement Equation

<sup>a</sup> VOC = Volatile organic compounds; HAPs = Hazardous air pollutants.<sup>b</sup> Preferred emission estimation approaches do not include considerations such as cost. The costs, benefits, and relative accuracy should be considered prior to method selection. Non-regulatory agency personnel are advised to check with their local air pollution control agency before choosing a preferred emission estimation approach.<sup>c</sup> Nizich and EC/R, 1999, reference lists results of both methods.

### **3.2.1 STACK SAMPLING**

Without considering cost, stack sampling is the preferred emission estimation methodology for NO<sub>x</sub>, CO, VOC, total hydrocarbons (THC), PM<sub>2.5</sub>, PM<sub>10</sub>, metals, and speciated organics. EPA reference methods and other methods of known quality can be used to obtain accurate estimates of emissions at a given time for a particular facility. It should be noted, however, that stack sampling provides a snapshot of emissions at the test conditions and does not address variability over time.

### **3.2.2 EMISSION FACTORS**

Due to their availability and acceptance in the industry, emission factors are commonly used to prepare emission inventories. The user should recognize that, in most cases, emission factors are averages of available industry-wide data, with varying degrees of quality, and may not be representative of individual facilities within that industry.

### **3.2.3 CALCULATION PROGRAMS**

Calculation programs often provide a more accurate estimate than emission factors, although they may require considerably more effort in some cases. Because the program inputs require process specific information, the results are process specific estimates.

### **3.2.4 ENGINEERING CALCULATIONS**

Similar to the calculation programs, engineering calculations often provide more accurate estimates than emission factors, although they may also require considerably more effort in some cases. Because the calculations are based on process specific information, the results are process specific estimates. Engineering calculations may be less accurate than emission factors since it may be necessary to make several assumptions when process specific data are not available.

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# 4

## PREFERRED METHODS FOR ESTIMATING EMISSIONS

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This section describes the preferred methods for estimating emissions for specific types of sources typically found in oil and gas field processing operations and provides examples to illustrate the use of each calculation technique. For certain source types (e.g., material storage), the reader is referred to other documents or other chapters in this document for details on using the suggested methodology.

The reader is also referred to Chapter 4 of this series of documents for emission estimation methods for equipment leaks and to Chapter 2 of this series of documents for emission estimation methods for boilers. Emission estimation methods for wastewater sources can be found in Chapter 5 of this series of documents. In addition, equipment and emissions from off-shore operations, although not specifically addressed in this document, are believed to be similar to those from on-shore operations. Preferred and alternative emission estimation methodologies for off-shore sources are, therefore, expected to be the same as for on-shore sources. Depending on the purpose of the emission inventory, the inventory preparer should consider inclusion of emissions from these additional source types.

Table 10.4-1 lists the variables used in Equations 10.4-1 through 10.4-16.

### 4.1 EMISSION CALCULATIONS USING EMISSION FACTORS

Emission factors are commonly used to calculate emissions from oil and gas field processing operations. EPA maintains a compilation of emission factors in *AP-42* for criteria pollutants and HAPs (*AP-42, 5th Edition*, January 1995). The Factor Information and REtrieval system (FIRE) (EPA, 1998) is a database containing *AP-42* emission factors as well as other emission factors that may be found in EPA documents such as the “Locating and Estimating” series for toxic pollutants. In addition, manufacturers often provide emission factors for specific equipment types. Emission factors for equipment leaks may be found in *Protocol for*



**TABLE 10.4-1****LIST OF VARIABLES AND SYMBOLS**

Variable	Symbol	Units
Emissions	$E_x$	Typically lb/hr of pollutant x
Emission factor	$EF_x$	Various
Activity, production or flow rate	$Q$	Various
Volume of fuel fired	$V$	Various
Heating value of the fuel	$H$	Various
Gas molecular weight	$MW$	lb/lb-mole
Mass fraction	$X_x$	lb x/total lb
Molar Volume of ideal gas	$C$	scf/lb-mole
Mole fraction of pollutant x in gas stream	$Y_x$	lb-mole x/total lb-mole
Molecular weight of pollutant x	$MW_x$	lb x/lb-mole x
Molecular conversion ratio of pollutant i to pollutant x	$M_x$	lb-mole x/lb-mole i
Equilibrium ratio for component x	$K_x$	lb-mole x (vapor)· lb-mole (liquid)/lb-mole x (liquid)· lb-mole (vapor)
Vapor pressure of component x at temperature T	$P_x(T)$	psia
Operating pressure	$P$	psia
Vapor pressure of material	$P_v$	pounds per square inch absolute (psia or atm)
Mole fraction of vapor flashed	$Y_v$	lb-mole (vapor)/lb-mole (liquid)
Density of condensate liquid	$\delta_{oil}$	lb/gallon
Days per year operation	$D$	Days/year

TABLE 10.4-1

(CONTINUED)

Variable	Symbol	Units
Temperature	T	Various
Molecular weight of vapor	MW <sub>v</sub>	lb/lb-mole
Loading loss saturation factor	S	Dimensionless
Arrival emission factor	C <sub>A</sub>	lb/Mgal
Generated emission factor	C <sub>G</sub>	lb/Mgal
Vapor growth factor	G	Dimensionless
Recovery/production factor	F <sub>x</sub>	lb-mole x/lb-mole
Recovery efficiency	RE	%
Destruction and removal efficiency	DRE	%
Stack gas concentration	C <sub>x</sub>	Mg/m <sup>3</sup> or ppmvd

*Equipment Leak Emission Estimates* (EPA-453/R-95-017, 1995h) and *Calculation Workbook for Oil and Gas Production Equipment Fugitive Emissions* (API, 1996).

Emission factors are the preferred emission estimation methodology for the following types of sources found in oil and gas field production and processing operations:

- Internal combustion engines/turbines;
- Flares; and
- Shale shakers.

Much work has been done to develop emission factors for HAPs, and AP-42 revisions include these factors (EPA, 1995a,b). Some states have developed their own HAP emission factors for certain source categories and require their use in any inventories including HAPs. In addition, industry organizations such as GRI and API have developed emission factors for HAPs as well as criteria pollutants for many sources which many key gas producing states recommend for use.

Refer to Chapter 1 of Volume III for a complete discussion of available information sources for locating, developing, and using emission factors as an estimation technique.

Emission factors developed from measurements for a specific source may sometimes be used to estimate emissions at other sites. For example, a company may have several units of similar model and size; if emissions were measured from one unit, an emission factor could be developed and applied to other similar units. It is advisable to consult with state/local agencies or the EPA prior to selection of an emission factor.

The basic equation for using an emission factor to calculate emissions is the following:

$$E_x = EF_x * Q \quad (10.4-1)$$

where:

$E_x$	=	Emissions of pollutant x
$EF_x$	=	Emission factor of pollutant x
$Q$	=	Activity or production rate

It should also be noted that depending on the emission factor, activity rate, and desired emissions units, additional variables may need to be factored into the equation, such as sulfur content of the fuel, hours per year of operation, and conversion from pounds to tons. For some sources (e.g., combustion sources), emission factors may be based on the Btu fired rather than volume of fuel fired. The actual Btu firing rate can be calculated based on the volume of fuel fired and the heating value of the fuel using the following equation:

$$Q = V * H \quad (10.4-2)$$

where:

$Q$	=	Activity or production rate to be used in equation 10.4-1
$V$	=	Volume of fuel fired
$H$	=	Heating value of the fuel

Calculations using emission factors are presented in Examples 10.4-1 through 10.4-4.

The EPEC model uses the emission factor method for estimating emissions from internal combustion engines, turbines, boilers, flares, and heater treaters. In some cases, the user has the choice of applying GRI or EPA AP-42 emission factors.

The GRI-HAPCalc model also uses the emission factor method to estimate HAP as well as criteria pollutant emissions from internal combustion engines, turbines, and external combustion devices. Users have the choice of emission factors based on GRI literature, GRI field tests, or EPA AP-42.

In all cases, it is advisable to consult with state/local agencies or the EPA prior to selection of an emission factor.

#### Example 10.4-1

Example 10.4-1 shows how potential hourly CO<sub>2</sub> emissions may be calculated for a 1 MMBtu/hr internal combustion engine firing natural gas. The CO<sub>2</sub> emission factor is from AP-42, Table 3.2-2. The heating value of the natural gas is 1,000 MMBtu/MMscf. At its rated capacity (1 MMBtu/hr) the fuel fire rate is 0.001 MMscf/hr. The engine operates for 4,000 hours per year.

$$\begin{aligned}
 EF_{CO_2} &= 110 \text{ lb/MMBtu} \\
 Q &= 0.001 \text{ MMscf/hr} \\
 E_{CO_2} &= EF_{CO_2} * Q \\
 &= 110 \text{ lb/MMBtu} * 0.001 \text{ MMscf/hr} * 1,000 \text{ MMBtu/MMscf} = 110 \text{ lb/hr} \\
 &= 110 \text{ lb/hr} * 4,000 \text{ hr/yr} = 440,000 \text{ lb/yr} \\
 &= 440,000 \text{ lb/yr} * \text{ton}/2,000 \text{ lb} = 220 \text{ ton/yr} \\
 &= 220 \text{ ton/yr}
 \end{aligned}$$

#### Example 10.4-2

Example 10.4-2 shows how potential hourly CO<sub>2</sub> emissions may be calculated for a gas turbine. The CO<sub>2</sub> emission factor is from Table 3.2-2 in AP-42. The heating value of the natural gas is 1,000 MMBtu/MMscf. The rated capacity of the turbine is 50 MMBtu/hr. The turbine is operated 2,500 hours per year.

$$\begin{aligned}
 EF_{CO_2} &= 110 \text{ lb/MMBtu} \\
 Q &= 50 \text{ MMBtu/hr} \\
 E_{CO_2} &= EF_{CO_2} * Q \\
 &= 110 \text{ lb/MMBtu} * 50 \text{ MMBtu/hr} = 5,500 \text{ lb/hr} \\
 &= 5,500 \text{ lb/hr} * 2,500 \text{ hr/yr} = 13,750,000 \text{ lb/yr} \\
 &= 13,750,000 \text{ lb/yr} * \text{ton}/2,000 \text{ lb} = 6,875 \text{ ton/yr} \\
 &= 6,875 \text{ ton/yr}
 \end{aligned}$$

Example 10.4-3

Example 10.4-3 illustrates the use of emission factors to calculate CO emissions from a natural gas fired steam generator with rated capacity of 55 MMBtu/hr. At its rated capacity, the fuel fire rate is 0.055 MMscf/hr. The CO emission factor is from Table 1.4-2 in AP-42. The source is operated 8,760 hours per year.

$$\begin{aligned}
 Q &= 0.055 \text{ MMscf/hr} \\
 EF_{CO} &= 35 \text{ lb/MMscf} \\
 E_{CO} &= Q * EF_{CO} \\
 &= 0.055 \text{ MMscf/hr} * 35 \text{ lb/MMscf} = 1.9 \text{ lb/hr} \\
 &= 1.9 \text{ lb/hr} * 8,760 \text{ hr/yr} = 16,600 \text{ lb/yr} \\
 &= 16,600 \text{ lb/yr} * \text{ton}/2,000 \text{ lb} = 8.3 \text{ ton/yr} \\
 &= 8.3 \text{ ton/yr}
 \end{aligned}$$

The reader is referred to Chapter 3 of this volume for more information on steam generators.

Example 10.4-4

Example 10.4-4 shows how potential hourly NO<sub>x</sub> emissions may be calculated for a smokeless flare. The NO<sub>x</sub> emission factor is from the CMA flare study (CMA). The heat content of the inlet gas is assumed to be 1,030 MMBtu/MMscf, and the gas processing rate is assumed to be 0.0002 MMscf/hr for 8,760 hours per year.

$$\begin{aligned}
 EF_{NOx} &= 0.1380 \text{ lb/MMBtu} \\
 V &= 0.0002 \text{ MMscf/hr} \\
 H &= 1,030 \text{ MMBtu/MMscf} \\
 Q &= V * H \\
 &= 0.0002 \text{ MMscf/hr} * 1,030 \text{ MMBtu/MMscf} \\
 &= 0.206 \text{ MMBtu/hr} \\
 E_{NOx} &= EF_{NOx} * Q \\
 &= 0.1380 \text{ lb/MMBtu} * 0.206 \text{ MMBtu/hr} = 0.0284 \text{ lb/hr} \\
 &= 0.0284 \text{ lb/hr} * 8,760 \text{ hr/yr} = 249 \text{ lb/yr} \\
 &= 249 \text{ lb/yr} * \text{ton}/2,000 \text{ lb} = 0.124 \text{ ton/yr} \\
 &= 0.124 \text{ ton/yr}
 \end{aligned}$$

**Example 10.4-5**

Example 10.4-5 estimates VOC and HAP emissions from a shale shaker processing oil-based mud. The mud flow rate is 500 gal/min and oil-based drilling muds are used 8 days per year. The emission factor is 0.36 lb/Mgal (Mgal = 1,000 gallons) throughput (EPA, 1977b). The benzene content of the VOC is 25%.

$$\begin{aligned}
 Q &= 500 \text{ gal/min} \\
 EF_{\text{VOC}} &= 0.36 \text{ lb/Mgal} \\
 X_{\text{benzene}} &= 0.25 \text{ lb benzene/lb VOC} \\
 E_{\text{VOC}} &= Q * EF_{\text{VOC}} \\
 &= 500 \text{ gal/min} * 0.36 \text{ lbVOC/Mgal} * \text{Mgal}/1,000 \text{ gal} \\
 &= 0.18 \text{ lb VOC/min} * 60 \text{ min/hr} * 24 \text{ hr/day} * 8 \text{ days/yr} = 2,074 \text{ lb VOC/yr} \\
 &= 2,074 \text{ lb VOC/yr} * \text{ton}/2,000 \text{ lb} * 1.037 \text{ ton VOC/yr} \\
 &= 1.037 \text{ ton VOC/yr} \\
 E_{\text{benzene}} &= E_{\text{VOC}} * X_{\text{benzene}} \\
 &= 2,074 \text{ lb VOC/yr} * 0.25 \text{ lb benzene/lb VOC} \\
 &= 518 \text{ lb benzene/yr} * \text{ton}/2,000 \text{ lb} \\
 &= 0.26 \text{ ton benzene/yr}
 \end{aligned}$$

## 4.2 EMISSION CALCULATIONS USING EMISSION MODELS

Emission models are the preferred emission estimation technique for glycol dehydrators, storage tanks, flash losses from black oil systems, and VOC and HAP losses from amine-based gas sweetening units venting to the atmosphere. The models for each of these sources are discussed below. Depending on the purpose of the inventory, the user should check with the state or local agency to confirm the model is acceptable.

### 4.2.1 EMISSION MODEL FOR GLYCOL DEHYDRATORS

VOC and HAP emissions from glycol dehydrators can be estimated using the Gas Research Institute (GRI) model GRI-GLYCalc. GLYCalc provides users the option of applying thermodynamic equations or the Rich/Lean method to estimate emissions. The preferred method of estimating emissions is use of the GLYCalc thermodynamic equations. The Rich/Lean method is discussed later in Section 5.

The preferred method uses fundamental chemical engineering thermodynamics along with empirical data and correlations to make emissions estimates (GRI, 1997). The software is designed as a screening tool to determine if emissions from a unit are of concern. In addition, GRI-GLYCalc only estimates emissions from EG and TEG units (Boyer and Brodnax, 1996). Therefore, if a more accurate estimate is required, or if the unit is not an EG or TEG unit, an alternative emissions estimation method should be selected. For information to obtain GRI-GLYCalc contact GRI.

GLYCalc requires process-specific data to produce an accurate emission estimate. As with any emission estimation model, the user should be cautious when collecting this data to make sure the correct data is collected at the right point in the process line. In addition, models including GLYCalc offer default values for some parameters if process-specific data is not available. While simplifying the data collection process, use of defaults that are not appropriate for a particular unit may result in invalid or inaccurate emission estimates. In all cases, therefore, the user is encouraged to collect and use process-specific data to obtain the most accurate emission estimate.

In addition, recommended guidelines for using the GLYCalc model and a Glycol Inspection Checklist developed and used by the Louisiana Department of Environmental Quality are included as Appendix B. Specific process parameters are listed along with acceptable ranges and suggested guidelines when using the GLYCalc model and are based on data collected from the field. If the acceptable ranges or the suggested guidelines are not appropriate for a particular unit, the user should select an alternative emission estimation technique. The checklist identifies specific data requirements for use with the GLYCalc model (LADEQ, 1998b).

#### **4.2.2 EMISSION MODEL FOR LIQUID MATERIAL STORAGE**

The preferred method for calculating working and breathing losses from storage tanks is the use of equations presented in AP-42. EPA has developed a software package (TANKS) for calculating these types of emissions. The TANKS computer program is based upon API equations that were derived for petroleum products, such as, gasoline, diesel fuel, jet fuel and stable crude oil (crude oil without dissolved gasses in solution that could be flashed from solution at a lower pressure). The TANKS computer program is commonly used to quantify working and breathing loss emissions. TANKS has chemical, climatological and component loss factor databases, but still requires knowledge of data specific to tank design and operation. You should check with your local or state authority as to whether TANKS is required for your facility. The use of the TANKS program for calculating emissions from storage tanks is discussed in Chapter 1 of this volume, *Introduction to Stationary Point Source Emissions Inventory Development*. Flash losses from storage tanks can be estimated using several approaches identified later in this chapter (See Sections 4.2.3, 4.3.2, and 5.3).

### 4.2.3 E&P TANK EMISSION MODEL FOR FLASH LOSSES

Recommendations for preferred methodologies for flash losses are based upon information generated by EPA's Emission Standards Division during development of the Oil and Gas Production NESHAP and limited datasets used for model development and verification restricting model applicability and from information provided by API.

The preferred method for estimating VOC and HAP flash losses from petroleum production storage tanks in black oil systems is the E&P TANK Model. The preferred emission estimation methodologies for gas condensate systems are the EC/R algorithm and the E&P TANK Model. The EC/R algorithm is a more simplified method, however, either method is preferred. The EC/R algorithm is presented in Section 4.3.2.

The E&P TANK Model developed by API and GRI, can be used for either black oil or gas condensate systems. Black oil is a hydrocarbon (petroleum) liquid with a gas-to-oil ratio (GOR) less than 50 cubic meters (1,750 cubic feet) per barrel and an API gravity less than 40 degrees. Gas condensate is a hydrocarbon (petroleum) liquid with a GOR greater than or equal to 50 cubic meters (1,750 cubic feet) per barrel and an API gravity greater than or equal to 40 degrees (FR 2/6/98). The E&P TANK Model is valid for liquids with API gravity ranging from 15 to 68 degrees.

The E&P TANK Model estimates emissions by applying rigorous thermodynamic relationships based on vapor-liquid equilibrium conditions from the Peng-Robinson equation-of-state (Martino, 1997). Data requirements include liquid composition, separator temperature and pressure, Reid Vapor Pressure of the liquid, API gravity of the liquid and the liquid production rate. For more information or to obtain a copy of the E&P TANK model, contact API.

### 4.2.4 EMISSION MODEL FOR AMINE SWEETENING UNIT

The method for estimating VOC and HAP emissions from amine units for sweetening natural gas and natural gas liquids venting to the atmosphere is use of the AMINECalc model. Data requirements depend on the option selected for calculating emissions. The mass balance option requires flow rates of rich and lean amine streams and composition of rich amine stream exiting the absorption column. Gas process options require sour gas feed data, lean amine circulation rate, and number of absorber trays.

## 4.3 EMISSION CALCULATIONS USING ENGINEERING EQUATIONS

Use of engineering equations is the preferred technique for estimating emissions from emergency and process vents, gas actuated pumps, pressure/level controllers, blowdown, well blowouts, well testing, gas sweetening units, flash losses from gas condensate systems,



transportation loading losses, sulfur recovery units and flares. Engineering equations are also preferred for non-amine gas sweetening units and TEG glycol dehydrators. These equations are discussed and illustrated below.

### 4.3.1 DISPLACEMENT EQUATION

Use of a displacement equation is the preferred method for estimating VOC, HAP, and CH<sub>4</sub> emissions from emergency and process vents, gas actuated pumps, pressure/level controllers, blowdown, well blowouts, and well testing. This displacement equation can also be used to estimate H<sub>2</sub>S and CO<sub>2</sub> emissions from gas sweetening units venting to the atmosphere and for H<sub>2</sub>S emissions from mud degassing operations. The following equations can be applied to estimate emissions when no chemical conversion occurs:

$$E_x = Q * MW * X_x * 1/C \quad (10.4-3)$$

where:

$E_x$	=	Emissions of pollutant x
$Q$	=	Volumetric flow rate/volume of gas processed
$MW$	=	Molecular weight of gas
	=	Specific gravity of gas * molecular weight of air
$X_x$	=	Mass fraction of pollutant x in gas
$C$	=	Molar volume of ideal gas, 379 scf/lb-mole at 60 degrees Fahrenheit and 1 atmosphere

Speciated VOC emissions are calculated using the following equation:

$$E_x = E_{VOC} * X_x \quad (10.4-4)$$

where:

$E_x$	=	emissions of pollutant x;
$E_{VOC}$	=	total VOC, calculated using equation 10.4-3; and
$X_x$	=	mass fraction of species x in VOC.

For well blowouts, if the amount of gas processed is unknown, the references “Methane Emissions from the U.S. Petroleum Industry” (EPA, 1996) and “Atmospheric Emissions from Offshore Oil and Gas Development and Production” (EPA, 1977b) provide some background information that may be of use.

Calculations using equations 10.4-3 and 10.4-4 are presented in Examples 10.4-6 through 10.4-13.

Example 10.4-6

Example 10.4-6 shows how VOC and HAP emissions can be calculated from emergency and process vents using the displacement equation. The gas volume released is assumed to be 10,000 scf/yr, the molecular weight of the gas is assumed to be 21 lb/lb-mole, and the VOC weight fraction is assumed to be 0.2.

$$\begin{aligned}
 Q &= 10,000 \text{ scf/yr} \\
 MW &= 21 \text{ lb/lb-mole} \\
 X_{\text{VOC}} &= 0.2 \text{ lb VOC/lb} \\
 C &= 379 \text{ scf/lb-mole @ } 60^\circ\text{F, 1 atm} \\
 E_{\text{VOC}} &= Q * MW * X_{\text{VOC}} * 1/C \\
 &= 10,000 \text{ scf/yr} * 21 \text{ lb/lb-mole} * 0.2 \text{ lb VOC/lb} * \text{lb-mole}/379 \text{ scf} = 111 \text{ lb VOC/yr} \\
 &= 111 \text{ lb VOC/yr} * \text{ton}/2,000 \text{ lb} = 0.055 \text{ ton VOC/yr} \\
 &= 0.055 \text{ ton VOC/yr}
 \end{aligned}$$

Xylene content of the exhaust VOC is assumed to be 10% by weight.

$$\begin{aligned}
 X_{\text{xylene}} &= 0.10 \text{ lb xylene/lb VOC} \\
 E_{\text{VOC}} &= 111 \text{ lb/yr} \\
 E_{\text{xylene}} &= X_{\text{xylene}} * E_{\text{VOC}} \\
 &= 0.10 \text{ lb xylene/lb VOC} * 111 \text{ lb VOC/yr} = 11.1 \text{ lb xylene/yr} \\
 &= 11.1 \text{ lb xylene/yr} * \text{ton}/2,000 \text{ lb} = 0.0055 \text{ ton xylene/yr} \\
 &= 0.0055 \text{ ton xylene/yr}
 \end{aligned}$$

Example 10.4-7

Example 10.4-7 shows how VOC and HAP emissions can be calculated from gas actuated pumps using the displacement equation. The gas volume consumed is determined from the manufacturer's pump curve and is assumed to be 2,000 scf/hr, the molecular weight of the gas is assumed to be 21 lb/lb-mole, and the VOC weight fraction is assumed to be 0.2. The pumps operate 4,000 hours per year.

$$\begin{aligned}
 Q &= 2,000 \text{ scf/hr} \\
 MW &= 21 \text{ lb/lb-mole} \\
 X_{\text{VOC}} &= 0.2 \text{ lb VOC/lb} \\
 C &= 379 \text{ scf/lb-mole @ } 60^\circ\text{F, 1 atm}
 \end{aligned}$$

Example 10.4-7 (Continued)

$$\begin{aligned}
 E_{\text{VOC}} &= Q * \text{MW} * X_{\text{VOC}} * 1/C \\
 &= 2,000 \text{ scf/hr} * 21 \text{ lb/lb-mole} * 0.2 \text{ lb VOC/lb} * \text{lb-mole}/379 \text{ scf} = 22.2 \text{ lb VOC/hr} \\
 &= 22.2 \text{ lb VOC/hr} * 4,000 \text{ hrs/yr} = 88,654 \text{ lb VOC/yr} \\
 &= 88,654 \text{ lb VOC/yr} * \text{ton}/2,000 \text{ lb} = 44.3 \text{ ton VOC/yr} \\
 &= 44.3 \text{ ton VOC/yr}
 \end{aligned}$$

Benzene content of the exhaust VOC is assumed to be 20% by weight.

$$\begin{aligned}
 X_{\text{benzene}} &= 0.2 \text{ lb benzene/lb VOC} \\
 E_{\text{VOC}} &= 88,654 \text{ lb/yr} \\
 E_{\text{benzene}} &= X_{\text{benzene}} * E_{\text{VOC}} \\
 &= 0.2 \text{ lb benzene/lb VOC} * 88,654 \text{ lb VOC/yr} = 17,731 \text{ lb benzene/yr} \\
 &= 17,731 \text{ lb benzene/yr} * \text{ton}/2,000 \text{ lb} = 8.87 \text{ ton benzene/yr} \\
 &= 8.87 \text{ ton benzene/yr}
 \end{aligned}$$

Example 10.4-8

Example 10.4-8 shows how VOC and HAP emissions can be calculated from pressure and level controllers using the displacement equation. The gas volume released is determined by either obtaining the manufacturer's estimate or by assuming an average release rate per controller. For this example, the release rate is assumed to be 20 scf/hr. The molecular weight of the gas is assumed to be 21 lb/lb-mole, and the VOC weight fraction is assumed to be 0.1. The controllers are assumed to operate 8,760 hours per year.

$$\begin{aligned}
 Q &= 20 \text{ scf/hr} \\
 \text{MW} &= 21 \text{ lb/lb-mole} \\
 X_{\text{VOC}} &= 0.1 \text{ lb VOC/lb} \\
 C &= 379 \text{ scf/lb-mole @ } 60^{\circ}\text{F, } 1 \text{ atm} \\
 E_{\text{VOC}} &= Q * \text{MW} * X_{\text{VOC}} * 1/C \\
 &= 20 \text{ scf/hr} * 21 \text{ lb/lb-mole} * 0.1 \text{ lb VOC/lb} * \text{lb-mole}/379 \text{ scf} = 0.11 \text{ lb VOC/hr} \\
 &= 0.11 \text{ lb VOC/hr} * 8,760 \text{ hr/yr} = 971 \text{ lb VOC/yr} \\
 &= 971 \text{ lb VOC/yr} * \text{ton}/2,000 \text{ lb} = 0.49 \text{ ton VOC/yr} \\
 &= 0.49 \text{ ton VOC/yr}
 \end{aligned}$$

Example 10.4-8 (Continued)

Xylene content of the exhaust VOC is assumed to be 10% by weight.

$$\begin{aligned}
 X_{\text{xylene}} &= 0.10 \text{ lb xylene/lb VOC} \\
 E_{\text{VOC}} &= 971 \text{ lb/yr} \\
 E_{\text{xylene}} &= X_{\text{xylene}} * E_{\text{VOC}} \\
 &= 0.10 \text{ lb xylene/lb VOC} * 971 \text{ lb VOC/yr} = 97.1 \text{ lb xylene/yr} \\
 &= 97.1 \text{ lb xylene/yr} * \text{ton}/2,000 \text{ lb} = 0.049 \text{ ton xylene/yr} \\
 &= 0.049 \text{ ton xylene/yr}
 \end{aligned}$$

Example 10.4-9

Example 10.4-9 calculates VOC and HAP emissions resulting from blowdown of a group of compressor engines. Blowdown occurs 4 times per year and the total volume of gas vented per event is 150 scf. The total annual volume of gas is 600 scf/yr. The molecular weight of the gas is 29.2 lb/lb-mole and the mass fraction of VOC in the gas is 0.3.

$$\begin{aligned}
 Q &= 600 \text{ scf/yr} \\
 MW &= 29.2 \text{ lb/lb-mole} \\
 X_{\text{VOC}} &= 0.3 \text{ lb VOC/lb} \\
 C &= 379 \text{ scf/lb-mole @ } 60^{\circ}\text{F, 1 atm} \\
 E_{\text{VOC}} &= Q * MW * X_{\text{VOC}} * 1/C \\
 &= 600 \text{ scf/yr} * 29.2 \text{ lb/lb-mole} * 0.3 \text{ lb VOC/lb} * \text{lb-mole}/379 \text{ scf} = 13.9 \text{ lb VOC/yr} \\
 &= 13.9 \text{ lb VOC/yr} * \text{ton}/2,000 \text{ lb} = 0.007 \text{ ton VOC/yr} \\
 &= 0.007 \text{ ton/yr}
 \end{aligned}$$

Gas analysis indicates benzene content of VOC is 25% by weight.

$$\begin{aligned}
 X_{\text{benzene}} &= 0.25 \text{ lb benzene/lb VOC} \\
 E_{\text{VOC}} &= 13.9 \text{ lb/yr} \\
 E_{\text{benzene}} &= X_{\text{benzene}} * E_{\text{VOC}} \\
 &= 0.25 \text{ lb benzene/lb VOC} * 13.9 \text{ lb VOC/yr} = 3.5 \text{ lb benzene/yr} \\
 &= 3.5 \text{ lb benzene/yr} * \text{ton}/2,000 \text{ lb} = 0.002 \text{ ton benzene/yr} \\
 &= 0.002 \text{ ton benzene/yr}
 \end{aligned}$$

Example 10.4-10

Example 10.4-10 calculates methane emissions from well blowout using the displacement equation. During the year, 1 well blowout occurred which lasted for 2 days. The well production rate is 465,000 SCF/day. It is assumed that the daily gas production rate of the well for those 2 days is released to the atmosphere. The amount of gas released to the atmosphere, therefore, is 930,000 SCF (465,000 SCF/day \* 2 days). The mass fraction of CH<sub>4</sub> in the gas is 0.90. The mass fraction of VOC in the gas is 0.10. The molecular weight of the gas is 22 lb/lb-mole

$$\begin{aligned}
 Q &= 930,000 \text{ scf/yr} \\
 C &= 379 \text{ scf/lb-mole @ } 60^\circ\text{F, 1 atm} \\
 MW &= 22 \text{ lb/lb-mole} \\
 X_{\text{VOC}} &= 0.10 \\
 X_{\text{CH}_4} &= 0.90 \\
 E_{\text{VOC}} &= Q * MW * X_{\text{VOC}} * 1/C \\
 &= 930,000 \text{ scf/yr} * 22 \text{ lb/lb-mole} * \frac{0.10 \text{ lb VOC}}{\text{lb}} * \frac{1 \text{ lb-mole}}{379 \text{ scf}} \\
 &= 5,398 \text{ lb VOC/yr} * \text{ton}/2,000 \text{ lb} \\
 &= 2.70 \text{ ton VOC/yr} \\
 E_{\text{CH}_4} &= Q * MW * X_{\text{CH}_4} * 1/C \\
 &= 930,000 \text{ scf/yr} * 22 \text{ lb/lb-mole} * \frac{0.90 \text{ lb CH}_4}{\text{lb}} * \frac{1 \text{ lb-mole}}{379 \text{ scf}} \\
 &= 48,586 \text{ lb CH}_4/\text{yr} * \text{ton}/2,000 \text{ lb} \\
 &= 24.3 \text{ ton CH}_4/\text{yr.}
 \end{aligned}$$

Example 10.4-11

Example 10.4-11 shows how VOC and HAP emissions can be estimated for well testing operations using the displacement equation. A total of 100 gas wells are tested each year and the total volume of gas vented is 285,000 scf/yr. The average VOC concentration of the vented gas is 0.15 lb VOC/lb. The average toluene concentration of the VOC is 0.25 lb toluene/lbVOC.

$$\begin{aligned}
 Q &= 285,000 \text{ scf/yr} \\
 MW &= 21 \text{ lb/lb-mole} \\
 X_{\text{VOC}} &= 0.15 \text{ lb VOC/lb} \\
 X_{\text{toluene}} &= 0.25 \text{ lb toluene/lb}
 \end{aligned}$$

Example 10.4-11 (Continued)

$$\begin{aligned}
 C &= 379 \text{ scf/lb-mole @ } 60^\circ\text{F, 1 atm} \\
 E_{\text{VOC}} &= Q * MW * X_{\text{VOC}} * 1/C \\
 &= 285,000 \text{ scf/yr} * 21 \text{ lb/lb-mole} * \frac{0.15 \text{ lb VOC}}{\text{lb}} * \frac{\text{lb-mole}}{379 \text{ scf}} * 2,369 \text{ lb VOC/yr} \\
 &= 2,369 \text{ lb VOC/yr} * \frac{\text{ton}}{2,000 \text{ lb}} = 1.2 \text{ ton VOC/yr} \\
 E_{\text{toluene}} &= 1.2 \text{ ton VOC/yr} \\
 &= X_{\text{toluene}} * E_{\text{VOC}} \\
 &= 0.25 \text{ lb toluene/lb VOC} * 2,369 \text{ lb VOC/yr} = 592 \text{ lb toluene/yr} \\
 &= 592 \text{ lb toluene/yr} * \frac{\text{ton}}{2,000 \text{ lb}} = 0.30 \text{ ton toluene/yr} \\
 &= 0.30 \text{ ton toluene/yr}
 \end{aligned}$$

Example 10.4-12

Example 10.4-12 illustrates the calculation of CO<sub>2</sub> and H<sub>2</sub>S emissions from an amine-based gas sweetening unit that vents to the atmosphere. The sour gas flowrate is 12.5 mmscf/day. The mass fraction of CO<sub>2</sub> and H<sub>2</sub>S in the sour gas is 0.19 and 0.01, respectively. The molecular weight of the sour gas is 18.33 lb/lb-mole. The unit operates continuously for 200 days throughout the year.

$$\begin{aligned}
 Q &= 12.5 \text{ mmscf/day} \\
 MW &= 18.33 \text{ lb/lb-mole} \\
 X_{\text{CO}_2} &= 0.19 \text{ lb CO}_2/\text{lb} \\
 X_{\text{H}_2\text{S}} &= 0.01 \text{ lb H}_2\text{S}/\text{lb} \\
 C &= 379 \text{ scf/lb-mole @ } 60^\circ\text{F, 1 atm} \\
 E_{\text{CO}_2} &= Q * MW * X_{\text{CO}_2} * 1/C \\
 &= 12.5 \text{ mmscf/day} * 18.33 \text{ lb/lb-mole} * \frac{0.19 \text{ lb CO}_2}{\text{lb}} * \frac{\text{lb-mole}}{379 \text{ scf}} * \frac{10^6 \text{ scf}}{\text{mmscf}} \\
 &= 114,865 \text{ lb CO}_2/\text{day} * 200 \text{ days/yr} * \text{ton}/2,000 \text{ lb} = 11,486 \text{ ton CO}_2/\text{yr} \\
 &= 11,486 \text{ ton CO}_2/\text{yr} \\
 E_{\text{H}_2\text{S}} &= Q * MW * X_{\text{H}_2\text{S}} * 1/C \\
 &= 12.5 \text{ mmscf/day} * 18.33 \text{ lb/lb-mole} * \frac{0.01 \text{ lb H}_2\text{S}}{\text{lb}} * \frac{\text{lb-mole}}{379 \text{ scf}} * \frac{10^6 \text{ scf}}{\text{mmscf}} \\
 &= 6,046 \text{ lb H}_2\text{S}/\text{day} * 200 \text{ day/yr} * \text{ton}/2,000 \text{ lb} = 605 \text{ ton H}_2\text{S/yr} \\
 &= 605 \text{ ton H}_2\text{S/yr}
 \end{aligned}$$

Example 10.4-13

Example 10.4-13 estimates H<sub>2</sub>S and CH<sub>4</sub> emissions from a drilling mud degassing operation. The volume of gas vented to the atmosphere is 10,000 ft<sup>3</sup>. The mass fraction of H<sub>2</sub>S and CH<sub>4</sub> in gas is 0.05 and 0.19, respectively. The molecular weight of the gas is 18.33 lb/lb-mole. The degassing operations occurred for four days.

$$\begin{aligned}
 Q &= 10,000 \text{ scf/day} \\
 X_{\text{CH}_4} &= 0.19 \text{ lb CH}_4/\text{lb-mole} \\
 X_{\text{H}_2\text{S}} &= 0.05 \text{ lb H}_2\text{S}/\text{lb-mole} \\
 \text{MW} &= 18.33 \text{ lb/lb-mole} \\
 C &= 379 \text{ scf/lb-mole} \\
 E_{\text{CH}_4} &= Q * \text{MW} * 1/C * X_{\text{CH}_4} \\
 &= 10,000 \text{ scf/day} * 18.33 \text{ lb/lb-mole} * \frac{\text{lb-mole}}{379 \text{ scf}} * \frac{0.19 \text{ lb CH}_4}{\text{lb}} = \frac{91.9 \text{ lb CH}_4}{\text{day}} \\
 &= 91.9 \text{ lb CH}_4/\text{day} * 4 \text{ days/yr} = 368 \text{ lb CH}_4/\text{yr} \\
 &= 368 \text{ lb CH}_4/\text{yr} * \text{ton}/2,000 \text{ lb} = 0.184 \text{ ton CH}_4/\text{yr} \\
 &= 0.184 \text{ ton CH}_4/\text{yr} \\
 E_{\text{H}_2\text{S}} &= Q * \text{MW} * 1/C * X_{\text{H}_2\text{S}} \\
 &= 10,000 \text{ scf/day} * 18.33 \text{ lb/lb-mole} * \frac{\text{lb-mole}}{379 \text{ scf}} * \frac{0.05 \text{ lb H}_2\text{S}}{\text{lb}} = \frac{24.2 \text{ lb H}_2\text{S}}{\text{day}} \\
 &= 24.2 \text{ lb H}_2\text{S}/\text{day} * 4 \text{ days/yr} = 96.8 \text{ lb H}_2\text{S}/\text{yr} \\
 &= 96.8 \text{ lb H}_2\text{S}/\text{yr} * \text{ton}/2,000 \text{ lb} = 0.048 \text{ ton H}_2\text{S}/\text{yr} \\
 &= 0.048 \text{ ton H}_2\text{S}/\text{yr}
 \end{aligned}$$

For sources where a chemical conversion takes place, such as gas sweetening units venting to a flare or incinerator, the displacement equation can be used to estimate SO<sub>2</sub> and H<sub>2</sub>S emissions, however, additional factors based on stoichiometry must be applied. The following equation can be applied to estimate SO<sub>2</sub> emissions from flares or incinerators where H<sub>2</sub>S is converted to SO<sub>2</sub>:

$$E_{\text{SO}_2} = Q * y_{\text{H}_2\text{S}} * \frac{1}{C} * M_{\text{SO}_2} * \text{MW}_{\text{SO}_2} \quad (10.4-5)$$

where:

$$\begin{aligned}
 E_{\text{SO}_2} &= \text{SO}_2 \text{ emissions, lb/yr} \\
 Q &= \text{Volume of gas processed, scf/yr} \\
 y_{\text{H}_2\text{S}} &= \text{Mole fraction of H}_2\text{S in inlet gas, lb-mole H}_2\text{S}/\text{lb-mole}
 \end{aligned}$$

$C$	=	Molar volume of ideal gas, 379 scf/lb-mole at 60 degrees Fahrenheit and 1 atmosphere
$M_{SO_2}$	=	Molar conversion ratio from $H_2S$ to $SO_2$ , $\frac{\text{lb-mole } SO_2}{\text{lb-mole } H_2S}$ (Based on stoichiometry and assuming complete conversion of $H_2S$ to $SO_2$ , $M_{SO_2} = 1$ )
$MW_{SO_2}$	=	Molecular weight of $SO_2$ , lb $SO_2$ /lb-mole $SO_2$

The residual  $H_2S$  emissions from this process can be estimated using the following equation:

$$E_{H_2S} = Q * y_{H_2S} * \frac{1}{C} * (1 - M_{SO_2}) * MW_{H_2S} \quad (10.4-6)$$

where:

$E_{H_2S}$	=	$H_2S$ emissions, lb/yr
$Q$	=	Volume of gas processed, scf/yr
$y_{H_2S}$	=	Mole fraction of $H_2S$ in inlet gas, lb-mole $H_2S$ /lb-mole
$C$	=	Molar volume of ideal gas, 379 scf/lb-mole at 60 degrees Fahrenheit and 1 atmosphere
$M_{SO_2}$	=	Molar conversion ratio from $H_2S$ to $SO_2$ , $\frac{\text{lb-mole } SO_2}{\text{lb-mole } H_2S}$ (Based on stoichiometry and assuming complete conversion of $H_2S$ to $SO_2$ , $M_{SO_2} = 1$ )
$MW_{H_2S}$	=	Molecular weight of $H_2S$ , lb $H_2S$ /lb-mole $H_2S$

If the conversion of  $H_2S$  to  $SO_2$  is completed, no residual  $H_2S$  emissions would result.



Example 10.4-14 illustrates the use of this equation.

#### Example 10.4-14

Example 10.4-14 shows how SO<sub>2</sub> and H<sub>2</sub>S emissions can be calculated from a gas sweetening unit venting to a flare using the displacement equation and assuming 98% conversion of H<sub>2</sub>S to SO<sub>2</sub>. The gas volume released is 50,000 scf/yr, and the mole fraction of H<sub>2</sub>S in the inlet gas is 0.2.

$$\begin{aligned}
 Q &= 50,000 \text{ scf/yr} \\
 y_{\text{H}_2\text{S}} &= 0.2 \text{ lb-mole H}_2\text{S/lb-mole} \\
 C &= 379 \text{ scf/lb-mole @ } 60^\circ\text{F, 1 atm} \\
 M_{\text{SO}_2} &= 0.98 \text{ lb-mole SO}_2/\text{lb-mole H}_2\text{S} \\
 MW_{\text{SO}_2} &= 64 \text{ lb/lb-mole} \\
 E_{\text{SO}_2} &= Q * y_{\text{H}_2\text{S}} * 1/C * M_{\text{SO}_2} * MW_{\text{SO}_2} \\
 &= 50,000 \text{ scf/yr} * 0.2 \text{ lb-mole H}_2\text{S/lb-mole} * \text{lb-mole}/379 \text{ scf} * 0.98 \frac{\text{lb-mole SO}_2}{\text{lb-mole H}_2\text{S}} \\
 &\quad * 64 \text{ lb SO}_2/\text{lb-mole SO}_2 = 1,655 \text{ lb SO}_2/\text{yr} \\
 &= 1,655 \text{ lb SO}_2/\text{yr} * \text{ton}/2,000 \text{ lb} = 0.83 \text{ ton SO}_2/\text{yr} \\
 &= 0.83 \text{ ton SO}_2/\text{yr}
 \end{aligned}$$

Residual H<sub>2</sub>S emissions are calculated below.

$$\begin{aligned}
 E_{\text{H}_2\text{S}} &= Q * y_{\text{H}_2\text{S}} * 1/C * (1 - M_{\text{SO}_2}) * MW_{\text{H}_2\text{S}} \\
 &= 50,000 \text{ scf/yr} * 0.2 \text{ lb-mole H}_2\text{S/lb-mole} * \text{lb-mole}/379 \text{ scf} * (1 - 0.98) \\
 &\quad * 34 \text{ lb H}_2\text{S/lb-mole H}_2\text{S} \\
 &= 17.94 \text{ lb H}_2\text{S/yr} * \text{ton}/2,000 \text{ lb} = 0.00897 \text{ ton H}_2\text{S/yr} \\
 &= 0.00897 \text{ ton H}_2\text{S/yr}
 \end{aligned}$$

### 4.3.2 EMISSION EQUATIONS FOR FLASH LOSSES FROM GAS CONDENSATE SYSTEMS

Recommendations for preferred methodologies for flash losses are based upon information generated by EPA's Emission Standards Division during development of the Oil and Gas Production NESHAP and limited datasets used for model development and verification restricting model applicability and from information provided by API.

The preferred methods for estimating flash losses from gas condensate systems are the EC/R algorithm and the E&P TANK Model. The EC/R algorithm is a more simplified method, however, either method is preferred. The E&P TANK Model is discussed in Section 4.2.3.

The EC/R algorithm calculates flash emissions based on the pressure drop of the process stream from the previous process vessel to a storage vessel and was derived from the behavior of the liquid stream based on changes in stream compositions and pressure (Akin and Battye, 1994).

This method assumes that the liquid and vapor streams reach equilibrium at standard temperature and pressure and that the storage tank is at standard temperature and pressure. The EC/R algorithm is valid for vapor pressure of liquid streams entering the storage tank between 1.6 atm and 5.1 atm. At vapor pressures less than 1.6 atm, flash losses can be assumed to approach zero. At vapor pressures greater than 5.1 atm, another method should be selected (see section 10.5.3). For more information on this method, see Akin and Battye, 1994. Procedures for applying the EC/R algorithm to estimate VOC and HAP emissions are described below. The first step in calculating flash losses from fixed-roof storage tanks in condensate systems is to estimate the equilibrium ratio. The equilibrium ratio ( $K_x$ ) in a multi component mixture of liquid and vapor phases is defined as the ratio of the mole fraction of that component in the vapor phase to the mole fraction of that component in the liquid phase. The equilibrium ratio can be estimated using Raoult's law and assuming ideal solution behavior:

$$K_x = P_x(T)/P \quad (10.4-7)$$

where:

$K_x$	=	Equilibrium ratio for component i, $\frac{\text{lb-mole component}_{i,v} * \text{lb-mole}_l}{\text{lb-mole component}_{i,l} * \text{lb-mole}_v}$
$P_x(T)$	=	Vapor pressure of component i at the condensate liquid storage tank temperature T, psia.
P	=	Pressure of the storage tank, psia

Then, estimate the mole fraction of vapor flashed using the following equation:

$$Y_v = 0.0523(P_v - 1.636) \quad (10.4-8)$$

where:

$Y_v$	=	Mole fraction of vapor flashed, lb-mole <sub>v</sub> /lb-mole <sub>l</sub>
0.0523	=	Coefficient, lb-mole <sub>v</sub> /lb-mole <sub>l</sub> · atm
$P_v$	=	Total vapor pressure of the condensate liquid stream in the previous vessel, atm

1.636 = Total vapor pressure of the condensate liquid stream in the previous vessel at which the flashing losses approach zero, atm

Having estimated the equilibrium ratio and the mole fraction of vapor flashed, emissions can be calculated as follows:

$$E_x = K_x * Q * \delta_{oil} * X_x * Y_v * D * 42 \quad (10.4-9)$$

where:

$E_x$	=	Component x emissions, lb/year
$K_x$	=	Equilibrium ratio for VOC, $\frac{\text{lb-mole } X_v * \text{lb-mole}_l}{\text{lb-mole } X_l * \text{lb-mole}_v}$
$Q$	=	Volume of condensate liquid processed, bbl/day
$\delta_{oil}$	=	Density of the condensate liquid, lb/gal
$X_x$	=	Mass fraction of component x in the condensate liquid, lb x/lb
$Y_v$	=	Mole fraction of vapor flashed, lb-mole <sub>v</sub> /lb-mole <sub>l</sub>
$D$	=	Days per year of operation, days/year
42	=	Conversion from barrels to gallons

Example 10.4-15 illustrates the use of Equations 10.4-7 through 10.4-9.

#### Example 10.4-15

Example 10.4-15 calculates flash losses resulting from condensate entering a storage tank at a total vapor pressure of 3.82 atm and a temperature of 70°F. The VOC concentration of the condensate stream is 0.65 lb/lb. The benzene concentration of the condensate stream is 0.015 lb benzene/lb. At 70°F, the vapor pressure of VOC is 4.23 psia and the vapor pressure of benzene is 1.54 psia. The volume of condensate processed is 135 bbl/day, and the condensate density is 7.25 lb/gal. The storage tank is at standard temperature and pressure. This source operates 365 days per year.

$P_{voc}(T)$	=	4.23 psia or lb-mole VOC <sub>v</sub> /lb-mole VOC <sub>l</sub>
$P_{benzene}(T)$	=	1.54 psia or lb-mole benzene <sub>v</sub> /lb-mole benzene <sub>l</sub>
$P$	=	14.7 psia
$P_v$	=	3.82 atm
$Q$	=	135 bbl/day

Example 10.4-15 (Continued):

$$\begin{aligned}
 \delta_{\text{oil}} &= 7.25 \text{ lb/gal} \\
 X_{\text{voc}} &= 0.65 \text{ lb/lb} \\
 X_{\text{benzene}} &= 0.015 \text{ lb benzene/lb} \\
 D &= 365 \text{ days/yr}
 \end{aligned}$$

Calculate the equilibrium ratios:

$$\begin{aligned}
 K_x &= P_x(T)/P \\
 K_{\text{voc}} &= 4.23 \text{ psia}/14.7 \text{ psia} \\
 &= 0.288 \text{ lb-mole VOC}_v \cdot \text{lb-mole}_l / \text{lb-mole VOC}_l \cdot \text{lb-mole}_v \\
 K_{\text{benzene}} &= 1.54 \text{ psia}/14.7 \text{ psia} \\
 &= 0.105 \text{ lb-mole benzene}_v \cdot \text{lb-mole}_l / \text{lb-mole benzene}_l \cdot \text{lb-mole}_v
 \end{aligned}$$

Calculate the mole fraction of vapor flashed:

$$\begin{aligned}
 Y_v &= 0.0523 \cdot (P_v - 1.636) \\
 &= 0.0523 \text{ lb-mole}_v \cdot \text{atm} / \text{lb-mole}_l \cdot (3.82 \text{ atm} - 1.636 \text{ atm}) \\
 &= 0.114 \text{ lb-mole}_v / \text{lb-mole}_l
 \end{aligned}$$

Calculate emissions:

$$\begin{aligned}
 E_{\text{voc}} &= K_{\text{voc}} \cdot Q \cdot \delta_{\text{oil}} \cdot X_{\text{voc}} \cdot Y_v \cdot D \cdot 42 \\
 &= 0.288 \frac{\text{lb-mole VOC}_v \cdot \text{lb-mole}_l}{\text{lb-mole VOC}_l \cdot \text{lb-mole}_v} \cdot 135 \text{ bbl/day} \\
 &\quad \cdot 7.25 \text{ lb/gal} \cdot 0.65 \text{ lb VOC/lb} \cdot \\
 &\quad \frac{0.114 \text{ lb-mole}_v}{\text{lb-mole}_l} \cdot 365 \text{ days/yr} \cdot 42 \text{ gal/bbl} \\
 &\quad \cdot \frac{1 \text{ lb-mole VOC}_l}{1 \text{ lb-mole VOC}_v} = 320,202 \text{ lb/yr} \\
 &= 320,202 \text{ lb/yr} \cdot \frac{\text{ton}}{2,000 \text{ lb}} = 160 \text{ ton/yr} \\
 &= 160 \text{ ton/yr}
 \end{aligned}$$

Example 10.4-15 (Continued):

$$\begin{aligned}
 E_{\text{benzene}} &= K_{\text{benzene}} * Q * \delta_{\text{oil}} * X_{\text{benzene}} * Y_v * D * 42 \\
 &= 0.105 * \frac{\text{lb-mole benzene}_v * \text{lb-mole}_l}{\text{lb-mole benzene}_l * \text{lb-mole}_v} * 135 \text{ bbl/day} \\
 &\quad * 7.25 \text{ lb/gal} * 0.015 \text{ lb benzene/lb} * \\
 &\quad * \frac{0.114 \text{ lb-mole}_v}{\text{lb-mole}_l} * 365 \text{ days/yr} \\
 &\quad * 42 \text{ gal/bbl} * \frac{1 \text{ lb-mole benzene}_l}{1 \text{ lb-mole benzene}_v} = 2,694 \text{ lb benzene/yr} \\
 &= 2,694 \text{ lb benzene/yr} * \text{ton}/2000 \text{ lb} = 1.35 \text{ ton benzene/yr} \\
 &= 1.35 \text{ ton benzene/yr}
 \end{aligned}$$

**4.3.3 EMISSION EQUATIONS FOR LOADING LOSSES**

VOC emissions resulting from loading liquid materials into tank trucks and tank cars may be calculated using the following loading loss equation (EPA, 1995c).

$$E_{\text{VOC}} = 12.46 * \frac{S * P_v * MW_v * Q}{T} \quad (10.4-10)$$

where:

- $E_{\text{VOC}}$  = VOC loading loss, lb/yr
- $S$  = Saturation factor, see Table 5.2-1 in AP-42
- $P_v$  = True vapor pressure of the material in the tank at temperature  $T$ , psia
- $MW_v$  = Vapor molecular weight, lb/lb-mole
- $Q$  = Volume of material loaded, Mgal/yr (Mgal = 1,000 gallons)
- $T$  = Temperature of material in the tank, °R.

Calculation of VOC emissions using Equation 10.4-10 is based on the following assumptions:

- The ideal gas law is applicable;
- The previous cargo that generated the vapors being displaced is the same as the liquid currently being loaded; and
- There is no mass or heat transfer from the loaded liquid to the previously existing vapors; only displacement is being modeled.

VOC emissions from the loading of crude oil into ships and ocean barges can be estimated using the following equation (which is presented in Section 5.2 of AP-42):

$$E_{\text{VOC}} = (C_A + C_G) * Q * X_{\text{VOC}} \quad (10.4-11)$$

where:

- $E_{\text{VOC}}$  = Total loading loss, lb/yr  
 $C_A$  = Arrival emission factor, contributed by vapors in the empty tank compartment before loading, lb/Mgal loaded. See Table 5.2-3 in AP-42.  
 $C_G$  = Generated emission factor, contributed by evaporation during loading, lb/Mgal loaded. See equation 10.4-12.  
 $Q$  = Volume of material loaded, Mgal/yr  
 $X_{\text{VOC}}$  = Mass fraction of VOC in vapor, lb VOC/lb. Default per AP-42 is 0.85

The parameter  $C_G$  can be calculated using the following equation (per Section 5.2 in AP-42):

$$C_G = 1.84 * (0.44 * P_V - 0.42) * \frac{MW_V * G}{T} \quad (10.4-12)$$

where:

- $P_V$  = True vapor pressure of loaded crude oil, psia. See AP-42 Figure 7.1-5 and Table 7.1-2.  
 $MW_V$  = Molecular weight of vapors, lb/lb-mole. See AP-42 Table 7.1-2.  
 $G$  = Vapor growth factor, 1.02 (dimensionless)  
 $T$  = Temperature of vapors, °R (°F + 460)

Examples 10.4-16 and 10.4-17 illustrate the use of these equations.

The EPEC model uses the *AP-42* method to estimate emissions from loading operations.

#### Example 10.4-16

Example 10.4-16 calculates loading losses resulting from splash loading crude oil into a tank truck in dedicated vapor balance service. Tank volume loaded is 100,000 gallons, liquid temperature is 70°F, true vapor pressure is 3.4 psia, and the molecular weight of vapors is 50 lb/lb-mole.

$$\begin{aligned}
 Q &= 100 \text{ Mgal/yr} \\
 T &= 70 + 460 = 530^\circ\text{R} \\
 P_v &= 3.4 \text{ psia} \\
 MW_v &= 50 \text{ lb/lb-mole} \\
 S &= 1.00 \text{ (see AP-42, Table 5.2-1)} \\
 E_{\text{VOC}} &= 12.46 * [S * P_v * MW_v * Q]/T \\
 &= 12.46 * [1.00 * 3.4 \text{ psia} * 50 \text{ lb/lb-mole} * 100 \text{ Mgal/yr}]/530^\circ\text{R} = 400 \text{ lb VOC/yr} \\
 &= 400 \text{ lb VOC/yr} * \text{ton}/2,000 \text{ lb} = 0.2 \text{ ton VOC/yr} \\
 &= 0.2 \text{ ton VOC/yr}
 \end{aligned}$$

Gas analysis indicates that 5% of the VOC by weight is benzene.

$$\begin{aligned}
 E_{\text{benzene}} &= E_{\text{VOC}} * X_{\text{benzene}} \\
 &= 400 \text{ lb VOC/yr} * 0.05 \text{ lb benzene/lb VOC} = 20 \text{ lb benzene/yr} \\
 &= 20 \text{ lb benzene/yr} * \text{ton}/2,000 \text{ lb} = 0.01 \text{ ton benzene/yr} \\
 &= 0.01 \text{ ton benzene/yr}
 \end{aligned}$$

#### Example 10.4-17

Example 10.4-17 estimates emissions from a loading operation which loads crude oil into a ship. The ship's previous cargo was volatile and the cargo tank was not cleaned. Vapor pressure of the crude oil to be loaded is 5.4 psia and the molecular weight of vapors is 50 lb/lb-mole. Vapor temperature is assumed to be at 75°F. Annual throughput under these conditions is 500,000 gallons. Mass fraction of VOC in vapor is 0.7.

$$\begin{aligned}
 C_A &= 0.86 \text{ lb/Mgal (see AP-42, Table 5.2-3)} \\
 P_v &= 5.4 \text{ psia} \\
 MW_v &= 50 \text{ lb/lb-mole} \\
 T &= 435^\circ\text{R} \\
 G &= 1.02
 \end{aligned}$$

**Example 10.4-17 (Continued):**

$$\begin{aligned}
 Q &= 500 \text{ Mgal/yr} \\
 X_{\text{VOC}} &= 0.7 \\
 C_G &= 1.84 * (0.44 * P_V - 0.42) * [\text{MW}_V * G]/T \\
 &= 1.84 * (0.44 * 5.4 \text{ psia} - 0.42) * [50 \text{ lb/lb-mole} * 1.02]/435^\circ\text{R} = 0.42 \text{ lb/Mgal} \\
 &= 0.42 \text{ lb/Mgal} \\
 E_{\text{VOC}} &= (C_A + C_G) * Q * X_{\text{VOC}} \\
 &= (0.86 + 0.42) * 500 \text{ Mgal/yr} * 0.7 \text{ lb VOC/lb} = 448 \text{ lb VOC/yr} \\
 &= 448 \text{ lb VOC/yr} * \text{ton}/2,000 \text{ lb} = 0.22 \text{ ton VOC/yr} \\
 &= 0.22 \text{ ton VOC/yr}
 \end{aligned}$$

Vapor analysis indicates the mass fraction of benzene in the VOC is 0.4.

$$\begin{aligned}
 E_{\text{benzene}} &= E_{\text{VOC}} * X_{\text{benzene}} \\
 &= 448 \text{ lb VOC/yr} * 0.4 \text{ lb benzene/lb VOC} = 179 \text{ lb benzene/yr} \\
 &= 179 \text{ lb benzene/yr} * \text{ton}/2,000 \text{ lb} = 0.09 \text{ ton benzene/yr} \\
 &= 0.09 \text{ ton benzene/yr}
 \end{aligned}$$

**4.3.4 EMISSION EQUATIONS FOR SULFUR RECOVERY UNITS**

H<sub>2</sub>S and SO<sub>2</sub> emissions from the sulfur recovery process are dependent on the degree of sulfur recovery achieved. The following equations can be used to estimate uncontrolled SRU emissions:

$$E_{\text{SO}_2} = Q * y_{\text{H}_2\text{S}} * F_s * \text{MW}_s * \frac{1}{C} * \frac{\text{MW}_{\text{SO}_2}}{\text{MW}_s} * F_{\text{SO}_2} * \left(1 - \frac{\text{RE}}{100}\right) \quad (10.4-13)$$

where:

$$\begin{aligned}
 E_{\text{SO}_2} &= \text{SO}_2 \text{ emission estimate, lb/hr} \\
 Q &= \text{Gas process rate, scf/hr} \\
 y_{\text{H}_2\text{S}} &= \text{mole fraction of H}_2\text{S in inlet gas stream} \\
 F_s &= \text{Sulfur recovery factor (1 mole sulfur/mole H}_2\text{S)} \\
 \text{MW}_s &= \text{Molecular weight of sulfur} \\
 C &= \text{Molar volume of ideal gas, 379 scf/mole at 60 degrees Fahrenheit and 1 atmosphere} \\
 \text{MW}_{\text{SO}_2} &= \text{Molecular weight of SO}_2 \\
 F_{\text{SO}_2} &= \text{SO}_2 \text{ production factor (1 mole SO}_2\text{/3 moles S)} \\
 \text{RE} &= \text{Sulfur recovery efficiency, \%}
 \end{aligned}$$



$$E_{\text{H}_2\text{S}} = Q * y_{\text{H}_2\text{S}} * F_s * \text{MW}_s * \frac{1}{C} * \frac{\text{MW}_{\text{H}_2\text{S}}}{\text{MW}_s} * F_{\text{H}_2\text{S}} * \left( 1 - \frac{\text{RE}}{100} \right) \quad (10.4-14)$$

where:

$E_{\text{H}_2\text{S}}$	=	H <sub>2</sub> S emission estimate, lb/hr
$Q$	=	Gas process rate, scf/hr
$y_{\text{H}_2\text{S}}$	=	mole fraction of H <sub>2</sub> S in inlet gas stream, mole H <sub>2</sub> S/mole
$F_s$	=	Sulfur recovery factor, 1 mole sulfur/mole H <sub>2</sub> S
$\text{MW}_s$	=	Molecular weight of sulfur, lb/mole
$C$	=	Molar volume of ideal gas, 379 scf/mole at 60 degrees Fahrenheit and 1 atmosphere
$\text{MW}_{\text{H}_2\text{S}}$	=	Molecular weight H <sub>2</sub> S, lb/mole
$F_{\text{H}_2\text{S}}$	=	H <sub>2</sub> S production factor, 2 mole H <sub>2</sub> S/3 moles S
$\text{RE}$	=	Sulfur recovery efficiency

Example 10.4-18 illustrates the use of these equations.

#### Example 10.4-18

Example 10.4-18 calculates emissions from a Claus sulfur recovery unit processing 10,000 scf/hr gas with an inlet H<sub>2</sub>S content of 20% by volume. The process operates 6,000 hours per year and has a sulfur recovery efficiency of 95%.

$Q$	=	10,000 scf/hr
$y_{\text{H}_2\text{S}}$	=	0.20 lb-mole H <sub>2</sub> S/lb-mole
$F_s$	=	1 lb-mole S/lb-mole H <sub>2</sub> S
$\text{MW}_s$	=	32 lb S/lb-mole S
$C$	=	379 scf/lb-mole @ 60°F, 1 atm

Example 10.4-18 (Continued)

$$\begin{aligned}
 MW_{H_2S} &= 34 \text{ lb } H_2S/\text{lb-mole } H_2S \\
 F_{H_2S} &= 2 \text{ lb-mole } H_2S/3 \text{ lb-mole } S \\
 MW_{SO_2} &= 64 \text{ lb } SO_2/\text{lb-mole } SO_2 \\
 F_{SO_2} &= 1 \text{ lb-mole } SO_2/3 \text{ lb-mole } S \\
 RE &= 95
 \end{aligned}$$

$$\begin{aligned}
 E_{SO_2} &= Q * y_{H_2S} * F_S * MW_S * \frac{1}{C} * \frac{MW_{SO_2}}{MW_S} * F_{SO_2} * \left( 1 - \frac{RE}{100} \right) \\
 &= 10,000 \text{ scf/hr} * \frac{0.20 \text{ lb-mole } H_2S}{\text{lb-mole}} * \frac{1 \text{ lb-mole } S}{\text{lb-mole } H_2S} * \frac{32 \text{ lb } S}{\text{lb-mole } S} * \frac{\text{lb-mole}}{379 \text{ scf}} * \\
 &\quad \frac{64 \text{ lb } SO_2}{\text{lb-mole } SO_2} * \frac{1 \text{ lb-mole } SO_2}{3 \text{ lb-mole } S} * \left( 1 - \frac{95}{100} \right) \\
 &\quad \left( \frac{32 \text{ lb } S}{\text{lb-mole } S} \right) = 5.63 \text{ lb } SO_2/\text{hr}
 \end{aligned}$$

$$\begin{aligned}
 &= 5.63 \text{ lb } SO_2/\text{hr} * 6,000 \text{ hr/yr} = 33,780 \text{ lb } SO_2/\text{yr} \\
 &= 33,780 \text{ lb } SO_2/\text{yr} * \text{ton}/2,000 \text{ lb} = 17 \text{ ton } SO_2/\text{yr} \\
 &= 17 \text{ ton } SO_2/\text{yr}
 \end{aligned}$$

$$\begin{aligned}
 E_{H_2S} &= Q * y_{H_2S} * F_S * MW_S * \frac{1}{C} * \frac{MW_{H_2S}}{MW_S} * F_{H_2S} * \left( 1 - \frac{RE}{100} \right) \\
 &= 10,000 \text{ scf/hr} * \frac{0.20 \text{ lb-mole } H_2S}{\text{lb-mole}} * \frac{1 \text{ lb-mole } S}{\text{lb-mole } H_2S} * \frac{32 \text{ lb } S}{\text{lb-mole } S} * \frac{\text{lb-mole}}{379 \text{ scf}} * \\
 &\quad \frac{34 \text{ lb } H_2S}{\text{lb-mole } H_2S} * \frac{2 \text{ lb-mole } H_2S}{3 \text{ lb-mole } S} * \left( 1 - \frac{95}{100} \right) \\
 &\quad \left( \frac{32 \text{ lb } S}{\text{lb-mole } S} \right) = 5.98 \text{ lb } H_2S/\text{hr}
 \end{aligned}$$

$$\begin{aligned}
 &= 5.98 \text{ lb } H_2S/\text{hr} * 6,000 \text{ hr/yr} = 35,880 \text{ lb } H_2S/\text{yr} \\
 &= 35,880 \text{ lb } H_2S/\text{yr} * \text{ton}/2,000 \text{ lb} = 18 \text{ ton } H_2S/\text{yr} \\
 &= 18 \text{ ton } H_2S/\text{yr}
 \end{aligned}$$

### 4.3.5 VOC AND HAP EMISSIONS FROM FLARES

The preferred approach for estimating VOC and HAP emissions from sources venting VOC and HAP emissions to flares is based on the gas processing rate and the destruction and removal efficiency (DRE) of the flare. The following equation can be applied:

$$E_x = Q * y_x * \frac{1}{C} * MW_x * \left( 1 - \frac{DRE}{100} \right) \quad (10.4-15)$$

where:

$E_x$	=	Emission estimate for pollutant x, lb/hr
$Q$	=	Gas process rate, scf/hr
$y_x$	=	Mole fraction of pollutant x in inlet stream, lb-mole x/lb-mole
$C$	=	Molar volume of ideal gas, 379 scf/lb-mole @ 60 degrees Fahrenheit
$MW_x$	=	Molecular weight of pollutant x
DRE	=	Destruction and removal efficiency, %

Example 10.4-19 illustrates the use of this equation.

#### Example 10.4-19

Example 10.4-19 calculates VOC and HAP emissions from a flare. The inlet gas process rate is 200 scf/hr and contains 25% VOC and 1% toluene, by volume. The flare operates 8,760 hours per year and is 98% efficient.

$Q$	=	200 scf/hr
$y_{VOC}$	=	0.25 scf VOC/scf
$y_{toluene}$	=	0.01 scf xylene/scf
$C$	=	379 scf/lb-mole @ 60°F
$MW_{VOC}$	=	50 lb/lb-mole
$MW_{toluene}$	=	92.13 lb/lb-mole
DRE	=	98%
$E_{VOC}$	=	$Q * y_{VOC} * \frac{1}{C} * MW_{VOC} \left( 1 - \frac{DRE}{100} \right)$

**Example 10.4-19 (Continued)**

$$\begin{aligned}
&= 200 \text{ scf} * 0.25 \text{ scfVOC/scf} * \frac{1 \text{ lb-mole VOC}}{379 \text{ scf VOC}} * \frac{50 \text{ lb VOC}}{\text{lb-mole VOC}} * \left(1 - \frac{98}{100}\right) = 0.132 \\
&= 0.132 \text{ lb VOC/hr} * 8,760 \text{ hr/yr} = 1,156 \text{ lb VOC/yr} \\
&= 1,156 \text{ lb VOC/yr} * \text{ton}/2,000 \text{ lb} = 0.58 \text{ ton VOC/yr} \\
&= 0.58 \text{ ton VOC/yr} \\
E_{\text{toluene}} &= Q * y_{\text{toluene}} * \frac{1}{C} * MW_{\text{toluene}} * \left(1 - \frac{\text{DRE}}{100}\right) \\
&= 200 \text{ scf} * 0.01 \text{ scf toluene/scf} * \frac{1 \text{ lb-mole toluene}}{379 \text{ scf toluene}} * \\
&= \frac{92.13 \text{ lb toluene}}{\text{lb-mole toluene}} * \left(1 - \frac{98}{100}\right) = 0.0097 \text{ lb toluene/hr} \\
&= 0.0097 \text{ lb toluene/hr} * 8,760 \text{ hr/yr} = 85 \text{ lb toluene/yr} \\
&= 85 \text{ lb toluene/yr} * \text{ton}/2,000 \text{ lb} = 0.042 \text{ ton toluene/yr} \\
&= 0.042 \text{ ton toluene/yr}
\end{aligned}$$

**4.4 EMISSION CALCULATIONS USING STACK SAMPLING DATA**

Stack sampling test reports often provide emissions data in terms of lb/hr or mg/m<sup>3</sup>. Annual emissions may be calculated from these data using Equation 10.4-16. Stack tests performed under a proposed permit condition or a maximum emissions rate are likely to be higher than the emissions which would result under normal operating conditions. The emission testing should only be completed after the purpose of the testing is known. For example, emission testing for particulate emissions may be different than emission testing for New Source Performance Standards (NSPS) because the back-half catch portion of the sampling train (where condensable PM is caught) is not considered in the NSPS limits.

An example summary of a stack test is shown in Table 10.4-2. The table shows the results of three different sampling runs conducted during one test event. Pollutant concentration is multiplied by the exhaust gas volumetric flow rate to determine the emission rate in pounds per hour, as shown in Equation 10.4-16 and Example 10.4-20.

$$E_x = C_x * Q/35.3 * 60/454,000 \quad (10.4-16)$$

where:

$$E_x = \text{hourly emissions in lb/hr of pollutant x}$$

$C_x$	=	stack gas concentration, mg/m <sup>3</sup>
$Q$	=	stack gas volumetric flow rate, scfm
35.3	=	conversion factor, 35.3 ft <sup>3</sup> /m <sup>3</sup>
60	=	60 min/hr
454,000	=	conversion factor, 454,000 mg per pound

**TABLE 10.4-2****TEST RESULTS**

Parameter	Symbol	Run 1	Run 2	Run 3
Volumetric flow rate (scfm)	$Q$	300	292	297
Concentration of H <sub>2</sub> S (mg/m <sup>3</sup> )	$C_{H_2S}$	652	665	657
H <sub>2</sub> S emission rate (lb/hr)	$E_{H_2S}$	0.73	0.73	0.73

Example 10.4-20

H<sub>2</sub>S emissions are calculated using Equation 10.4-16 and the stack sampling data for Run 1 (presented in Table 10.4-2 are shown below). The unit is operated 8,760 hours per year.

$$\begin{aligned}
 E_{H_2S} &= C_{H_2S} * Q / 35.3 * 60 / 454,000 \\
 &= 652 \text{ mg/m}^3 * 300 \text{ scf/min} / (35.3 \text{ ft}^3/\text{m}^3) * (60 \text{ min/hr}) / (454,000 \text{ mg/lb}) \\
 &= 0.73 \text{ lb H}_2\text{S/hr} \\
 &= 0.73 \text{ lb H}_2\text{S/hr} * 8,760 \text{ hrs/yr} = 6,415 \text{ lb H}_2\text{S/yr} \\
 &= 6,415 \text{ lbs H}_2\text{S/yr} * \frac{\text{ton}}{2,000 \text{ lb}} = 3.2 \text{ ton H}_2\text{S/yr} \\
 &= 3.2 \text{ ton H}_2\text{S/yr}
 \end{aligned}$$

# 5

## ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

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Alternative methods for estimating emissions from oil and gas field processing operations are presented in this section. Table 10.5-1 lists the variables used in Equations 10.5-1 through 10.5-6.

In addition, equipment and emissions from off-shore operations, although not specifically addressed in this document, are believed to be similar to those from on-shore operations. Preferred and alternative emission estimation methodologies for off-shore sources are, therefore, expected to be the same as for on-shore sources. Depending on the purpose of the emission inventory, the inventory preparer should also consider inclusion of emissions from these source types.

### 5.1 EMISSION CALCULATIONS USING EMISSION FACTORS

Emission factors are commonly used to calculate emissions from oil and gas field processing operations. EPA maintains a compilation of emission factors in *AP-42* for criteria pollutants and HAPs (*AP-42, 5th Edition*, January 1995). Emission factors for equipment leaks may be found in *Protocol for Equipment Leak Emission Estimates* (EPA-453/R-95-017, 1995) and *Calculation Workbook for Oil and Gas Production Equipment Fugitive Emissions* (API, 1996). The Factor Information and Retrieval system (FIRE) (EPA, 1998) is a database containing AP-42 emission factors as well as other emission factors that may be found in EPA documents such as the “Locating and Estimating” series for toxic pollutants. In addition, manufacturers often provide emission factors for specific pieces of equipment.

Currently, emission factors are available as an alternative method for the following types of sources found in oil and gas field processing operations:

- SO<sub>2</sub> emissions from gas sweetening amine units venting to a smokeless flare or tail gas incinerator;
- SO<sub>2</sub> emissions from Claus sulfur recovery units; and

**TABLE 10.5-1****LIST OF VARIABLES AND SYMBOLS**

Variable	Symbol	Units
Emissions	$E_x$	Typically lb/hr of pollutant x
Emission factor	$EF_x$	Various
Activity, production or flow rate	$Q$	Various
Volume of fuel fired	$V$	Various
Heating value of the fuel	$H$	Various
Pollutant concentration	$C_x$	mg/m <sup>3</sup> or ppmvd
Rich sample pollutant x concentration	$C_i$	Various
Lean sample pollutant x concentration	$C_o$	Various
Molecular weight of pollutant	MW	lb/lb-mole
Molar volume of ideal gas	$C$	scf/lb-mole
Annual emissions of pollutant x	$E_{tpy,x}$	ton/yr
Annual operating hours	OpHrs	hour/yr
Gas/oil ratio	GOR	scf/ Stock tank barrel (STB)
API gravity	$\gamma_o$	API degrees
Solution gas specific gravity at actual temperature and pressure	$\gamma_g$	Dimensionless
Dissolved gas specific gravity at 100 psig	$\gamma_{gc}$	Dimensionless
Stock tank oil specific gravity	$\gamma_{os}$	Dimensionless
Operating pressure	$P$	Psia

**TABLE 10.5-1****CONTINUED**

Variable	Symbol	Units
Operating temperature	T	Various
Molecular weight of vapor	MW <sub>v</sub>	lb/lb-mole
Mass fraction	X <sub>x</sub>	lb x/total lb
Days per year operation	D	Days/year

- Pneumatic devices.

Much work has been done to develop emission factors for HAPs and AP-42 revisions have included these factors (EPA, 1995a,b). In addition, many states have developed their own HAP emission factors for certain source categories and require their use in any inventories including HAPs. Refer to Chapter 1 of Volume II for a complete discussion of available information sources for locating, developing, and using emission factors as an estimation technique.

Emission factors developed from measurements for a specific source may sometimes be used to estimate emissions at other sites. For example, a company may have several units of similar model and size; if emissions were measured from one unit, an emission factor could be developed and applied to other similar units. It is advisable to consult with state/local agencies or the EPA prior to selection of an emission factor.

The basic equation for using an emission factor to calculate emissions is the following:

$$E_x = EF_x * Q \quad (10.5-1)$$

where:

$$\begin{array}{lll} E_x & = & \text{Emissions of pollutant x} \\ EF_x & = & \text{Emission factor of pollutant x} \\ Q & = & \text{Activity or production rate} \end{array}$$

Depending on the emission factor, activity rate, and desired emissions units, additional variables may need to be factored into the equation, such as sulfur content of the fuel, hours per year of



operation, and conversion from pounds to tons. For some sources (e.g., combustion sources), emission factors may be based on the Btu fired rather than volume of fuel fired. The actual Btu firing rate can be calculated based on the volume of fuel fired and the heating value of the fuel using the following equation:

$$Q = V * H \quad (10.5-2)$$

where:

Q	=	Activity or production rate to be used in equation 10.5-1
V	=	Volume of fuel fired
H	=	Heating value of the fuel

Calculations using emission factors are presented in Examples 10.5-1 through 10.5-3.

The EPEC model uses the emission factor method for estimating VOC, HAP, and criteria pollutant emissions from heater treaters and flares. In some cases, users have the choice of applying GRI or EPA AP-42 emission factors.

The GRI-HAPCalc model also uses the emission factor method to estimate HAP as well as criteria pollutant emissions from gas sweetening amine units. The gas sweetening emission factors are based on GRI field test data.

In all cases, it is advisable to consult with the state/local agencies or the EPA prior to selection of an emission factor.

#### Example 10.5-1

Example 10.5-1 shows how potential hourly SO<sub>2</sub> emissions may be calculated for a smokeless flare on an amine gas sweetening process with no sulfur recovery or sulfuric acid production present. The SO<sub>2</sub> emission factor is from AP-42, Table 5.3-1. H<sub>2</sub>S content of the inlet gas is assumed to be 2.5% by volume, and the gas processing rate is assumed to be 200 scf/hr for 8,760 hours per year.

EF <sub>SO<sub>2</sub></sub>	=	1,685 * S lb/10 <sup>6</sup> scf gas processed
S	=	H <sub>2</sub> S content of the sour gas entering the gas sweetening plant (volume %)
	=	2.5
Q	=	200 scf/hr

Example 10.5-1 (Continued)

$$\begin{aligned}
 E_{\text{SO}_2} &= EF_{\text{SO}_2} * S * \text{gas processing rate} \\
 &= 1,685 * 2.5 * 200 = 842,500 \text{ lb-scf/hr} \cdot 10^6 \text{ scf} \\
 &= 842,500 \text{ lb-scf/hr} \cdot 10^6 \text{ scf} * 10^6 \text{ scf} / 1,000,000 \text{ scf} = 0.8425 \text{ lb/hr} \\
 &= 0.8425 \text{ lb/hr} * 8,760 \text{ hr/yr} = 7,380 \text{ lb/yr} \\
 &= 7,380 \text{ lb/yr} * \text{ton} / 2,000 \text{ lb} = 3.69 \text{ ton/yr} \\
 &= 3.69 \text{ ton/yr}
 \end{aligned}$$

Example 10.5-2

Example 10.5-2 estimates SO<sub>2</sub> emissions from an uncontrolled 3-stage Claus sulfur recovery unit using emission factors. The SO<sub>2</sub> emission factor is from AP-42, Table 8.13-1. The unit produces 550 tons per year of sulfur.

$$\begin{aligned}
 EF_{\text{SO}_2} &= 188 \text{ lb/ton sulfur produced} \\
 Q &= 550 \text{ ton/yr} \\
 E_{\text{SO}_2} &= EF_{\text{SO}_2} * Q \\
 &= 188 \text{ lb/ton sulfur} * 550 \text{ ton sulfur/yr} = 103,400 \text{ lb SO}_2\text{/yr} \\
 &= 103,400 \text{ lb SO}_2\text{/yr} * \frac{\text{ton}}{2,000 \text{ lb}} = 51.7 \text{ ton SO}_2\text{/yr} \\
 &= 51.7 \text{ ton SO}_2\text{/yr}
 \end{aligned}$$

Example 10.5-3

Example 10.5-3 uses emission factors to estimate CH<sub>4</sub> emissions from pneumatic devices. The site estimates a total of 85,000 pneumatic devices. The emission factor is from “Methane Emissions from the U.S. Petroleum Industry” (EPA, 1996).

$$\begin{aligned}
 Q &= 85,000 \text{ devices} \\
 EF_{\text{CH}_4} &= 345 \text{ scf CH}_4\text{ /day/device} \\
 E_{\text{CH}_4} &= Q * EF_{\text{CH}_4}
 \end{aligned}$$

Example 10.5-3 (Continued)

$$\begin{aligned}
 &= 85,000 \text{ devices} * 345 \text{ scf CH}_4/\text{day/device} \\
 &= 29,325,000 \text{ scf CH}_4/\text{day} * \frac{1 \text{ lb mole CH}_4}{379 \text{ scf}} * \\
 &\quad \frac{16 \text{ lb CH}_4}{1 \text{ lb-mole CH}_4} = 4,836 \text{ lb CH}_4/\text{day} \\
 &= 4,836 \text{ lb CH}_4/\text{day} * 365 \text{ days/yr} = 1,765,110 \text{ lb CH}_4/\text{yr} \\
 &= 1,765,110 \text{ lb CH}_4/\text{yr} * \frac{\text{ton}}{2,000 \text{ lb}} = 883 \text{ ton CH}_4/\text{yr} \\
 &= 883 \text{ ton CH}_4/\text{yr}
 \end{aligned}$$

## 5.2 EMISSION CALCULATIONS USING STACK SAMPLING DATA

Stack sampling test reports often provide emissions data in terms of lb/hr or mg/m<sup>3</sup>. Annual emissions may be calculated from these data using Equations 10.5-3 or 10.5-4. Stack tests performed under a proposed permit condition or a maximum emissions rate are likely to be higher than the emissions which would result under normal operating conditions. The emission testing should only be completed after the purpose of the testing is known. For example, emission testing for particulate emissions may be different than emission testing for New Source Performance Standards (NSPS) because the back-half catch portion of the sampling train (where condensable PM is caught) is not considered in the NSPS limits.

### 5.2.1 STACK SAMPLING DATA FOR GAS SWEETENING PROCESSES

This section shows how to calculate emissions in lb/hr based on stack sampling data. Calculations involved in determining H<sub>2</sub>S emissions from EPA Method 11 data are used as an example. The only available methods for sampling H<sub>2</sub>S emissions are EPA Method 11, a stainless steel bomb or a portable gas chromatograph.

An example summary of a Method 11 test is shown in Table 10.5-2. The table shows the results of three different sampling runs conducted during one test event. Pollutant concentration is

multiplied by the exhaust gas volumetric flow rate to determine the emission rate in pounds per hour, as shown in Equation 10.5-3 and Example 10.5-4.

$$E_x = C_x * Q/35.3 * 60/454,000 \quad (10.5-3)$$

where:

$E_x$	=	hourly emissions in lb/hr of pollutant x
$C_x$	=	stack gas concentration, mg/m <sup>3</sup>
$Q$	=	stack gas volumetric flow rate, scfm
35.3	=	conversion factor, 35.3 ft <sup>3</sup> /m <sup>3</sup>
60	=	60 min/hr
454,000	=	conversion factor, 454,000 mg per pound

**TABLE 10.5-2**

**TEST RESULTS - METHOD 11**

Parameter	Symbol	Run 1	Run 2	Run 3
Volumetric flow rate (scfm)	Q	300	292	297
Concentration of H <sub>2</sub> S (mg/m <sup>3</sup> )	C <sub>H<sub>2</sub>S</sub>	652	665	657
H <sub>2</sub> S emission rate (lb/hr)	E <sub>H<sub>2</sub>S</sub>	0.73	0.73	0.73

Example 10.5-4

H<sub>2</sub>S emissions are calculated using Equation 10.5-3 and the stack sampling data for Run 1 (presented in Table 10.5-2 are shown below). The unit is operated 8,760 hours per year.

$$\begin{aligned}
 E_{H_2S} &= C_{H_2S} * Q/35.3 * 60/454,000 \\
 &= 652 \text{ mg/m}^3 * 300 \text{ scf/min}/(35.3 \text{ ft}^3/\text{m}^3) * (60 \text{ min/hr})/(454,000 \text{ mg/lb}) \\
 &= 0.73 \text{ lb H}_2\text{S/hr} \\
 &= 0.73 \text{ lb H}_2\text{S/hr} * 8,760 \text{ hrs/yr} = 6,415 \text{ lb H}_2\text{S/yr} \\
 &= 6,415 \text{ lbs H}_2\text{S/yr} * \frac{\text{ton}}{2,000 \text{ lb}} = 3.2 \text{ ton H}_2\text{S/yr} \\
 &= 3.2 \text{ ton H}_2\text{S/yr}
 \end{aligned}$$

### 5.2.2 THE RICH/LEAN METHOD FOR GLYCOL DEHYDRATORS AND GAS SWEETENING AMINE UNITS

The rich/lean method can be used to estimate emissions from glycol dehydrators and gas sweetening amine units. The rich/lean method utilizes rich and lean sample data by applying them to either glycol or amine circulation rates. For glycol dehydrators, a rich glycol sample is obtained prior to the reboiler and after any flash tank. A lean glycol sample is taken prior to the contact tower (Boyer and Brodnax, 1996). The following equation can be used to calculate emissions from either glycol dehydrators or gas sweetening amine units venting to the atmosphere:

$$E_x = (C_i - C_o) * Q \quad (10.5-4)$$

where:

$E_x$	=	Emissions of pollutant x
$C_i$	=	Rich sample pollutant x concentration
$C_o$	=	Lean sample pollutant x concentration
$Q$	=	Glycol or amine circulation rate

Examples 10.5-5 and 10.5-6 illustrate the use of this equation.

The EPEC model incorporates the Rich/Lean emissions estimation method for both glycol dehydrators and gas sweetening amine units. The GLYCalc model also provides users the option of applying the Rich/Lean method to estimate emissions from glycol dehydrators.

#### Example 10.5-5

Example 10.5-5 estimates benzene emissions from a glycol dehydrator with a glycol circulation rate of 5 gpm. Sample analyses indicate a rich glycol benzene concentration prior to the reboiler of 800 mg/L and a lean glycol benzene concentration prior to the contact tower of 100 mg/L. The dehydrator operates 8,760 hours per year.

$C_i$	=	800 mg/L
$C_o$	=	100 mg/L
$Q$	=	5 gal/min
$E_{\text{benzene}}$	=	$(C_i - C_o) * Q$

Example 10.5-5 (Continued)

$$\begin{aligned}
 &= (800 \text{ mg/L} - 100 \text{ mg/L}) * 5 \text{ gal/min} * \frac{1,000 \text{ L}}{264 \text{ gal}} \\
 &\quad * \frac{\text{lb}}{454,000 \text{ mg}} * 60 \text{ min/hr} = 1.75 \text{ lb benzene/hr} \\
 &= 1.75 \text{ lb benzene/hr} * \frac{8,760 \text{ hr}}{\text{yr}} = 15,348 \text{ lb benzene/yr} \\
 &= 15,348 \text{ lb benzene/yr} * \frac{\text{ton}}{2,000 \text{ lb}} = 7.67 \text{ ton benzene/yr} \\
 &= 7.67 \text{ ton benzene/yr}
 \end{aligned}$$

Example 10.5-6

Example 10.5-6 estimates ethylbenzene emissions from a gas sweetening amine unit with an amine circulation rate of 8 gpm. Sample analyses indicate a rich amine ethylbenzene concentration of 600 mg/L and a lean amine ethylbenzene concentration of 300 mg/L. The amine unit operates 8,760 hours per year.

$$\begin{aligned}
 C_i &= 600 \text{ mg/L} \\
 C_o &= 300 \text{ mg/L} \\
 Q &= 8 \text{ gal/min} \\
 E_{\text{ethylbenzene}} &= (C_i - C_o) * Q \\
 &= (600 \text{ mg/L} - 300 \text{ mg/L}) * 8 \text{ gal/min} * \frac{1,000 \text{ L}}{264 \text{ gal}} \\
 &\quad * \frac{\text{lb}}{454,000 \text{ mg}} * 60 \text{ min/hr} = 1.20 \text{ lb ethylbenzene/hr} \\
 &= 1.20 \text{ lb ethylbenzene/hr} * \frac{8,760 \text{ hr}}{\text{yr}} = 10,525 \text{ lb ethylbenzene/yr} \\
 &= 10,525 \text{ lb ethylbenzene/yr} * \frac{\text{ton}}{2,000 \text{ lb}} = 5.26 \text{ ton ethylbenzene/yr} \\
 &= 5.26 \text{ ton ethylbenzene/yr}
 \end{aligned}$$

## 5.3 EMISSION EQUATIONS FOR FLASH LOSSES

The dissolved Gas Oil Ratio (GOR) can also be used as an alternative method to estimate flash losses. The GOR can be estimated using either the Vazquez-Beggs Correlation or the Rollins, McCain, Creeger Correlation. Both techniques are detailed below (TNRCC, 1996).

### 5.3.1 VAZQUEZ-BEGGS CORRELATION

The Vazquez-Beggs correlation is an empirical correlation equation based on laboratory measured pressure-volume-temperature (PVT) data and is a function of pressure, temperature, oil gravity, and gas gravity (Martino, 1997). The Vazquez-Beggs correlation is valid for liquids with API gravity ranging between 15 and 68 degrees. The Vazquez-Beggs correlation is valid only within a set range of values. These values are listed below.

Parameters	Range
Vessel operating pressure, P	50 to 5250 (psia)
Vessel operating temperature, T	70 to 295 (degrees F)
Vessel gas/oil ratio, GOR	20 to 2070 (scf/STB)
API gravity, $\gamma_o$	16 to 58 API
Gas specific gravity at actual temperature and pressure, $\gamma_g$	0.56 to 1.18

The Vazquez-Beggs solution gas ratio correlation for a bubble point crude is shown below:

$$\text{GOR} = C_1 * \gamma_{gc} * P^{C_2} * \exp \left[ \frac{C_3 * \gamma_o}{T + 460} \right] \quad (10.5-7)$$

where:

GOR	=	Solution gas/oil ratio in vessel liquid, units are standard cubic feet per stock tank barrel (scf/STB)
$C_1, C_2, C_3$	=	Empirical constants shown in table below
$\gamma_{gc}$	=	Dissolved gas specific gravity at 100 psig (See equation 10.5-8)
P	=	Vessel operating pressure, psia
exp	=	2.718, the base “e” of the natural log system
$\gamma_o$	=	API gravity of stock-tank liquid
T	=	Vessel operating temperature, degrees Fahrenheit

Coefficient	API ≤ 30	API > 30
C1	0.0362	0.0178
C2	1.0937	1.1870
C3	25.7240	23.9310

If the gas specific gravity was not taken at 100 psig then, the gas specific gravity, for any pressure and temperature, may be referenced to 100 psig by using the following equation:

$$\gamma_{gc} = \gamma_g * \left[ 1.0 + \left( 5.912 \times 10^{-5} * \gamma_o * T * \log \left[ \frac{P}{114.7} \right] \right) \right] \quad (10.5-8)$$

where:

$\gamma_{gc}$	=	Dissolved gas specific gravity at 100 psig
$\gamma_g$	=	Solution gas specific gravity at actual separator pressure and temperature
P	=	Vessel operating pressure, psia
$\gamma_o$	=	API gravity of stock tank liquid
T	=	Vessel operating temperature, degrees Fahrenheit
log	=	10, the base "10" of the standard log system

### 5.3.2 ROLLINS, MCCAIN, CREEGER CORRELATION

The Rollins, McCain, Creeger correlation is based on 301 black oil samples and is a function of the oil specific gravity, separator gas specific gravity, and separator temperature and pressure (Martino, 1997). The Rollins, McCain, Creeger correlation is applicable to oil with an API gravity range of 20 to 50 degrees.

The Rollins, McCain, Creeger correlation is valid within the following range of values:

Parameter	Range
Vessel gas/oil ratio, GOR	≥ 100.0 (scf/STB)
Vessel operating pressure, P	30 to 300 (psia)
Vessel operating temperature, T	65 to 140 (degrees F)
Stock tank oil specific gravity, $\gamma_{os}$	0.934 to 0.780



The following equation can be used to estimate GOR:

$$\log(\text{GOR}) = 0.4896 - 4.916 * \log(\gamma_{\text{os}}) + 3.469 * \log(\gamma_{\text{g}}) + 1.501 * \log(P) - 0.9213 * \log(T) \quad (10.5-9)$$

where:

GOR	=	Solution gas/oil ratio in vessel liquid, scf/STB
$\gamma_{\text{os}}$	=	Stock tank oil specific gravity
$\gamma_{\text{g}}$	=	Vessel gas specific gravity
P	=	Vessel operating pressure, psia
T	=	Vessel operating temperature, degrees Fahrenheit

The following equation can be used to estimate  $\gamma_{\text{os}}$ :

$$\gamma_{\text{os}} = 141.5/[131.5 + \gamma_{\text{o}}]$$

where:

$\gamma_{\text{os}}$	=	Stock tank oil specific gravity
$\gamma_{\text{o}}$	=	API gravity of stock tank liquid, API degrees

The EPEC model incorporates both the Vazquez-Beggs and the Rollins, McCain, Creeger correlations for estimating the dissolved gas oil ratio. In all cases, it is advisable to consult with state/local agencies or the EPA prior to selection of an emission estimation method.

Once the GOR has been found, the VOC emissions can be calculated as follows:

$$E_{\text{VOC}} = Q * \text{GOR} * 1/C * \text{MW}_{\text{v}} * X_{\text{VOC}} * D \quad (10.5-10)$$

where:

$E_{\text{VOC}}$	=	VOC emissions lb/year
Q	=	Volume of oil processed, bbl/day
GOR	=	Dissolved gas/oil ratio, scf/STB
C	=	Molar volume of ideal gas, 379 scf/lb-mole at 60 degrees Fahrenheit and 1 atmosphere
$\text{MW}_{\text{v}}$	=	Vapor Molecular weight, lb/lb-mole
$X_{\text{VOC}}$	=	Mass fraction of VOC in vapor, lb VOC/lb vapor
D	=	Days per year of operation

Examples 10.5-8 and 10.5-9 illustrate the use of equations 10.5-7 through 10.5-10.

### Example 10.5-8

Example 10.5-8 uses the Vazquez-Beggs correlation to calculate flash losses resulting from oil entering a storage tank from a separator operating at 300 psia and 200°F. The API gravity of the oil is 30 API, the dissolved gas specific gravity at actual conditions is 0.75.

The oil transfer rate is 120 STB/day, the vapor molecular weight is 50 lb/lb-mole and the mass fraction of VOC in the vapor is 0.9. This source operates 365 days/yr.

$$\begin{aligned}
 P &= 300 \text{ psia} \\
 T &= 200^\circ\text{F} \\
 \gamma_o &= 30 \\
 \gamma_g &= 0.75 \\
 \gamma_{gc} &= \gamma_g * [1.0 + (5.912 \times 10^{-5} * \gamma_o * T * \log (P/114.7))] \\
 &= 0.75 * [1.0 + (5.912 \times 10^{-5} * 30 * 200 * \log (300/114.7))] \\
 &= 0.86 \\
 C_1 &= 0.0362 \text{ at 30 API} \\
 C_2 &= 1.0937 \text{ at 30 API} \\
 C_3 &= 25.7240 \text{ at 30 API} \\
 MW &= 50 \text{ lb/lb-mole} \\
 Q &= 120 \text{ STB/day} \\
 X_{VOC} &= 0.9 \\
 C &= 379 \text{ scf/lb-mole @ } 60^\circ\text{F, 1 atm} \\
 GOR &= C_1 * \gamma_{gc} * P^{C_2} * \exp [C_3 * \gamma_o / (T + 460)] \\
 &= 0.0362 * 0.86 * (300)^{1.0937} * \exp [25.7240 * 30 / (200 + 460)] \\
 &= 51.31 \text{ scf/STB} \\
 E_{VOC} &= Q * GOR * (1/C) * MW * X_{VOC} \\
 &= 120 \text{ STB/day} * 51.31 \text{ scf/STB} * (\text{lb-mole}/379 \text{ scf}) * 50 \text{ lb/lb-mole} * 0.9 \text{ lb VOC/lb} \\
 &= 731.1 \text{ lb VOC/day} * 365 \text{ days/yr} \\
 &= 266,851 \text{ lb VOC/yr} * \text{ton}/2,000 \text{ lb} \\
 &= 133 \text{ ton VOC/yr}
 \end{aligned}$$

Gas analysis indicates benzene content is 5% of VOC by weight.

$$\begin{aligned}
 E_{\text{benzene}} &= E_{VOC} * X_{\text{benzene}} \\
 &= 266,851 \text{ lb VOC/yr} * 0.05 \text{ lb benzene/lb VOC} \\
 &= 13,343 \text{ lb benzene/yr} * \text{ton}/2,000 \text{ lb} \\
 &= 6.7 \text{ ton benzene/yr}
 \end{aligned}$$

Example 10.5-9

Example 10.5-9 uses the Rollins, McCain, Creeger correlation to calculate flash losses resulting from oil entering a storage tank from a gun barrel operating at 300 psia and 200°F. The API gravity of the oil is 30 API degrees, the dissolved gas specific gravity at actual conditions is 0.75. The oil transfer rate is 50 STB/day, the vapor molecular weight is 50 lb/lb-mole and the mass fraction of VOC in vapor is 0.85.

$$\begin{aligned}
 P &= 300 \text{ psia} \\
 T &= 200^\circ\text{F} \\
 \gamma_o &= 30 \\
 \gamma_g &= 0.75 @ 300 \text{ psia} \\
 MW &= 50 \text{ lb/lb-mole} \\
 Q &= 120 \text{ STB/day} \\
 X_{\text{VOC}} &= 0.85 \\
 C &= 379 \text{ scf/lb-mole @ } 60^\circ\text{F, 1 atm} \\
 \gamma_{os} &= 141.5/[131.5 + \gamma_o] \\
 &= 141.5/[131.5 + 30] \\
 &= 0.876 \\
 \log(\text{GOR}) &= 0.4896 - 4.916 * \log(\gamma_{os}) + 3.469 * \log(\gamma_g) + 1.501 * \log(P) - 0.9213 * \log(T) \\
 &= 0.4896 - 4.916 * \log(0.876) + 3.469 * \log(0.75) + 1.501 * \log(300) - 0.9213 * \log(200) \\
 &= 1.94 \\
 \text{GOR} &= \log^{-1}(1.94) \\
 &= 86.5 \text{ scf/STB} \\
 E_{\text{VOC}} &= Q * \text{GOR} * (1/C) * MW * X_{\text{VOC}} \\
 &= 50 \text{ STB/day} * 86.5 \text{ scf/STB} * (\text{lb-mole}/379 \text{ scf}) * 50 \text{ lb/lb-mole} * 0.85 \text{ lb VOC/lb} \\
 &= 485 \text{ lb VOC/day} * 365 \text{ day/yr} = 177,023 \text{ lb/yr} \\
 &= 177,023 \text{ lb/yr} * \text{ton}/2,000 \text{ lb} \\
 &= 89 \text{ ton VOC/yr}
 \end{aligned}$$

Gas analysis indicates benzene content is 10% of VOC by weight.

$$\begin{aligned}
 E_{\text{benzene}} &= E_{\text{VOC}} * X_{\text{benzene}} \\
 &= 177,023 \text{ lb VOC/yr} * 0.10 \text{ lb benzene/lb VOC} \\
 &= 17,702 \text{ lb benzene/yr} * \text{ton}/2,000 \text{ lb} \\
 &= 8.85 \text{ ton benzene/yr}
 \end{aligned}$$

# 6

## QUALITY ASSURANCE/QUALITY CONTROL

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The consistent use of standardized methods and procedures is essential in the compilation of reliable emission inventories. QA and QC of an inventory is accomplished through a set of procedures that ensure the quality and reliability of data collection and analysis. These procedures include the use of appropriate emission estimation techniques, applicable and reasonable assumptions, accuracy/logic checks of computer models, checks of calculations, and data reliability checks. Figure 10.6-1 provides an example completeness checklist that could aid the inventory preparer at an oil and gas field production and processing facility. Volume VI, *QA Procedures*, of this series describes additional QA/QC methods and tools for performing these procedures.

Volume II, Chapter 1, *Introduction to Stationary Point Source Emission Inventory Development*, also presents recommended standard procedures to follow to ensure that the reported inventory data are complete and accurate. This section discusses the use of QC checklists, QA/QC procedures for specific emission estimation methods (e.g., emission factors), and the application of the Data Attribute Rating System (DARS).

### 6.1 GENERAL FACTORS INVOLVED IN EMISSION ESTIMATION TECHNIQUES

#### 6.1.1 EMISSION FACTORS

The use of emission factors is straightforward when the relationship between process data and emissions is direct and relatively uncomplicated. When using emission factors, the user should be aware of the quality indicator associated with the value. Emission factors published within EPA documents and electronic tools have a quality rating applied to them. The lower the quality indicator, the less confidence EPA has in the data used to develop the factor and the more cautious the user should be using the emission estimate. When an emission factor for a specific source or category may not provide a reasonably adequate emission estimate, it is always better to rely on actual stack test data, where available. The reliability and uncertainty of using emission factors as

Item	Y/N	Corrective Action (Complete if "N"; Describe, Sign, and Date)
Have emissions from all sources been included? Potential sources include external flame burners/boilers, IC engines/turbines, flares, equipment leaks, glycol dehydrators, storage tanks, process piping, loading losses, flash losses, sulfur recovery units, heater treaters, blowout, separators, well heads, pipeline, pump stations, gas sweetening units, emergency and process vents, pigging operations, and pneumatic devices.		
Has an emission estimating technique been identified for each source?		
If toxic emissions are to be calculated using testing data, are the test methods approved?		
If toxic emissions are to be calculated using emission factors, are the emission factors from <i>AP-42</i> or FIRE?		
Have stack parameters been provided for each stack or vent that emits criteria or toxic air pollutants?		
If required by the state, has a site diagram been included with the emissions inventory? This should be a detailed plant drawing showing the location of sources/stacks with ID numbers for all processes, control equipment, and exhaust points.		
Have examples of all calculations been included?		
Have all assumptions been documented?		
Have references for all calculation methods been included?		
Have all conversions and units been reviewed and checked for accuracy?		

FIGURE 10.6-1

**EXAMPLE EMISSION INVENTORY CHECKLIST FOR  
OIL AND GAS FIELD PRODUCTION AND PROCESSING OPERATIONS**

an emission estimation technique are discussed in detail in the QA/QC section of Chapter 1 of this volume and Chapter 4 of Volume VI.

### 6.1.2 EMISSION MODELS AND ENGINEERING EQUATIONS

The level of effort for using models and engineering equations is related to the complexity of the equations, the types of data that must be collected, and the diversity of products manufactured at a facility. Typically, the use of emission models involves making one or more conservative assumptions. As a result, their use may result in an overestimation of emissions. However, the accuracy and reliability of models can be improved by ensuring that data collected for emission calculations (e.g., material speciation data) are of the highest possible quality.

### 6.1.3 TESTING

Stack tests must meet quality objectives. Test data must be reviewed to ensure that the test was conducted under normal operating conditions, or under maximum operating conditions in some states, and that the data were generated according to an acceptable method for each pollutant of interest. Calculation and interpretation of accuracy for stack testing methods are described in detail in *Quality Assurance Handbook for Air Pollution Measurements Systems: Volume III, Stationary Source Specific Methods (Interim Edition)* (EPA, 1994b).

The acceptable criteria, limits, and values for each control parameter associated with manual sampling methods, such as dry gas meter calibration and leak rates, are summarized in tabular format in the QA/QC section of Chapter 1 of this volume. QC procedures for all instruments used to continuously collect emissions data are similar. The primary control check for precision of the continuous monitors is daily analysis of control standards.

## 6.2 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

One measure of emission inventory data quality is the DARS score. Four examples are given here to illustrate DARS scoring using the preferred and alternative methods. DARS provides a numerical ranking on a scale of 0 to 1.0 for individual attributes of the emission factor and the activity data. Each score is based on what is known about the factor and activity data, such as the specificity to the source category and the measurement technique employed. The composite attribute score for the emissions estimate can be viewed as a statement of the confidence that can be placed in the data. For a complete discussion of DARS and other rating systems, see the *QA Procedures* (Volume VI, Chapter 4), and the QA/QC section of Chapter 1 of this volume.

Each of the examples below is hypothetical. A range is given where appropriate to cover different situations. Table 10.6-1 gives a set of scores for an estimate made with an *AP-42* emission factor. The activity data are assumed to be measured directly or indirectly. Table 10.6-2 shows scores

**TABLE 10.6-1****DARS SCORES: EMISSION FACTORS (EF)**

<b>Attribute</b>	<b>Factor Score</b>	<b>Activity Score</b>	<b>Emissions Score</b>	<b>Factor Assumptions</b>	<b>Activity Assumptions</b>
Measurement/ Method	0.90	0.80 - 1.0	0.72 - 0.90	Factor is based on intermittent measurements of intended pollutant and representative sampling over a range of loads.	Lower score reflects an activity rate derived from a surrogate that is indirectly related to the activity data (rather than a surrogate that has been directly related and measured); upper score reflects direct continuous measurement of activity.
Source Specificity	0.90	0.90	0.81	Factor was developed for a subset or a superset of the intended source category. Expected variability is low.	Activity data are very closely correlated to the emission activity.
Spatial Congruity	0.90	1.0	0.90	Factor was developed for a similar source.	Activity data are developed for and specific to the

TABLE 10.6-1

(CONTINUED)

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Spatial Congruity (Continued)				Spatial variability is low.	source being inventoried.
Temporal Congruity	0.70	0.90	0.63	Factor was developed for a different period where the temporal variability is expected to be moderate to low.	Activity data are representative of the same temporal period as the inventory, but are based on an average of several repeated periods (activity data are an average of three years, inventory is for one year).
Composite Scores	0.85	0.90 - 0.95	0.76 - 0.81		



**TABLE 10.6-2****DARS SCORES: EMISSION MODELS AND ENGINEERING EQUATIONS**

<b>Attribute</b>	<b>Factor Score</b>	<b>Activity Score</b>	<b>Emissions Score</b>	<b>Factor Assumptions</b>	<b>Activity Assumptions</b>
Measurement/ Method	0.30	0.30 - 1.0	0.09 - 0.30	Factors (inputs to model or equation) are based on material balance, all/most end-points accounted for.	Lower score reflects an activity rate derived from engineering or physical principles. Upper score reflects direct, continuous measurement of activity.
Source Specificity	0.90 - 1.0	0.70 - 1.0	0.63 - 1.0	Lower score reflects inputs developed for a subset or superset of the intended category. Upper score reflects inputs developed specifically for the intended source.	Lower score reflects activity data for a similar process that is highly correlated to the emissions process. Upper score reflects activity data that represent the emission process exactly.
Spatial Congruity	1.0	1.0	1.0	Inputs were developed for and specific	Activity data are developed for and specific to the

**TABLE 10.6-2****(CONTINUED)**

<b>Attribute</b>	<b>Factor Score</b>	<b>Activity Score</b>	<b>Emissions Score</b>	<b>Factor Assumptions</b>	<b>Activity Assumptions</b>
Spatial Congruity (Continued)				to the given spatial scale.	source being inventoried.
Temporal Congruity	1.0	1.0	1.0	Model inputs were developed for and are applicable to the temporal period represented in the inventory.	Activity data are specific for the temporal period represented in the inventory.
Composite Scores	0.80 - 0.83	0.75 - 1.0	0.68 - .083		

developed from the use of emission models. Table 10.6-3 demonstrates scores determined for testing data.

These examples are given as an illustration of the relative quality of each method. If the same analysis were done for an actual site, the scores could be different but the relative ranking of methods should stay the same. Note, however, that if the source is not truly a member of the population used to develop the EPA correlation equations or the emission factors, these approaches are less appropriate and the DARS scores will drop.

If sufficient data are available, the uncertainty in the estimate should be evaluated. Qualitative and quantitative methods for conducting uncertainty analyses are described in the *QA Procedures* (Volume VI, Chapter 4).

TABLE 10.6-3

**DARS SCORES: STACK SAMPLING**

<b>Attribute</b>	<b>Factor Score</b>	<b>Activity Score</b>	<b>Emissions Score</b>	<b>Factor Assumptions</b>	<b>Activity Assumptions</b>
Measurement/ Method	0.70 - 0.90	0.90 - 1.0	0.63 - 0.90	Lower score reflects a small number of tests at typical loads; upper score represents numerous tests over a range of loads.	Lower score reflects direct, intermittent measurement of activity. Upper score reflects direct, continuous measurement of activity.
Source Specificity	1.0	1.0	1.0	Factor is developed specifically for the intended source.	Activity data represents the emission process exactly.
Spatial Congruity	1.0	1.0	1.0	Factor is developed for and is specific to the given spatial scale.	Activity data are developed for and specific to the inventory area.
Temporal Congruity	0.70 - 1.0	0.70 - 1.0	0.49 - 1.0	Lower score reflects a factor developed for a shorter time period with moderate to low temporal variability; upper score	Lower score reflects activity data representative of a short period of time; upper score represents activity data specific for the

**TABLE 10.6-3****(CONTINUED)**

<b>Attribute</b>	<b>Factor Score</b>	<b>Activity Score</b>	<b>Emissions Score</b>	<b>Factor Assumptions</b>	<b>Activity Assumptions</b>
Temporal Congruity (Continued)				reflects a factor developed for and applicable to the same temporal scale.	temporal period represented in the inventory.
Composite Scores	0.85 - 0.98	0.90 - 1.0	0.78 - 0.98		

# 7

## DATA CODING PROCEDURES

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This section describes the methods and codes available for characterizing emission sources at oil and gas field production and processing operations. Consistent categorization and coding will result in greater uniformity among inventories. In addition, the procedures described here will assist the reader who is preparing data for input to the Aerometric Information Retrieval System (AIRS) or a similar database management system. For example, the use of the Source Classification Codes (SCCs) provided in Table 10.7-1 are recommended for describing oil and gas field production and processing operations. Refer to the CHIEF for a complete listing of SCCs.

### 7.1 SOURCE CLASSIFICATION CODES

SCCs for oil and gas field production and processing operations are presented in Table 10.7-1. A brief description of each source listed in the table is given below.

#### 7.1.1 PROCESS OPERATIONS

Process operations consist of well operations, separation, drilling, heating, sweetening, sulfur recovery, glycol dehydration, reboiler, and equipment leaks. The SCCs that correspond to these activities appear in Table 10.7-1 under the Oil Production, Natural Gas Production, Natural Gas Processing, Liquid Waste Treatment, Process Heaters, and Steam Generators source descriptions.

#### 7.1.2 IN-PROCESS FUEL USE

In-process fuel use consists of internal combustion engines. The SCCs that correspond to these activities appear in Table 10.7-1 under the Internal Combustion Engines and Control Device Fuel source descriptions.

#### 7.1.3 STORAGE TANKS

At oil and gas field production and processing facilities oil is stored in fixed roof, floating roof, or underground storage tanks. The SCCs that correspond to these activities appear in Table 10.7-1 under the Fixed Roof 67,000 Barrel Fuel Tanks: Standing Losses, Fixed Roof 250,000 Barrel Fuel Tanks: Standing Losses, Fixed Roof Fuel Tanks: Working Losses, Floating Roof 67,000 Barrel Fuel Tanks: Standing Losses, Floating Roof 250,000 Barrel Fuel Tanks: Standing Losses,

**TABLE 10.7-1****SOURCE CLASSIFICATION CODES FOR OIL AND GAS PRODUCTION**

Source Description	Process Description	SCC	Units
Process Emissions			
Oil Production	Miscellaneous Well: General	3-10-001-02	Wells/Year in Operation
	Wells: Rod Pumps	3-10-001-03	Wells/Year in Operation
	Crude Oil Sumps	3-10-001-04	Square Feet Sump Area/Year
	Crude Oil Pits	3-10-001-05	Square Feet Sump Area/Year
	Enhanced Wells, Water Reinjection	3-10-001-06	1000 Gallons Water
	Oil/Gas/Water/Separation	3-10-001-07	1000 Gallons Crude Transfer
	Evaporation from Liquid Leaks into Oil Well Cellars	3-10-001-08	Square Feet of Surface Area
	Site Preparation	3-10-001-21	100 Acres Prepared
	Drilling and Well Completion	3-10-001-22	Wells/Year Drilled
	Wellhead Casing Vents	3-10-001-23	Wells/Year in Operation
	Valves - General	3-10-001-24	1000 Barrels Oil Produced
	Relief Valves	3-10-001-25	1000 Barrels Oil Produced
	Pump Seals	3-10-001-26	1000 Barrels Oil Produced
	Flanges and Connections	3-10-001-27	1000 Barrels Oil Produced
	Oil Heating	3-10-001-28	1000 Barrels Oil Produced
	Gas/Liquid Separation	3-10-001-29	1000 Barrels Oil Produced
	Atmospheric Wash Tank (Second Stage of Gas-Oil Separation): Flashing Loss	3-10-001-32	1000 Gallons of Crude Oil Processed
	Waste Sumps - Primary Light Crude	3-10-001-40	1000 Barrels Oil Produced
	Waste Sumps - Primary Heavy Crude	3-10-001-41	1000 Barrels Oil Produced
	Waste Sumps - Secondary Light Crude	3-10-001-42	1000 Barrels Oil Produced
	Waste Sumps - Secondary Heavy Crude	3-10-001-43	1000 Barrels Oil Produced

TABLE 10.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
Oil Production (Continued)	Waste Sumps - Tertiary Light Crude	3-10-001-44	1000 Barrels Oil Produced
	Waste Sumps - Tertiary Heavy Crude	3-10-001-45	1000 Barrels Oil Produced
	Gathering Lines	3-10-001-46	1000 Miles of Pipeline
	Flares	3-10-001-60	1000 Barrels Oil Produced
	Processing Operations: Not Classified	3-10-001-99	1000 Barrels Produced
Natural Gas Production	Gas Sweetening: Amine	3-10-002-01	Million Cubic Feet Sour Gas Produced
	Gas Stripping Operations	3-10-002-02	Million Cubic Feet Gas Produced
	Compressor Operation	3-10-002-03	Million Cubic Feet Gas Processed
	Well Vents	3-10-002-04	Million Cubic Feet Gas Produced
	Flares	3-10-002-05	Million Cubic Feet Gas Produced
	Gas Lift	3-10-002-06	Million Cubic Feet Gas Produced
	Valves - General	3-10-002-07	Million Cubic Feet Gas Produced
	Sulfur Recovery Unit	3-10-002-08	Tons 100% Sulfur
	Site Preparation	3-10-002-21	100 Acres Prepared
	Drilling and Well Completion	3-10-002-22	Wells/Year Drilled
	Relief Valves	3-10-002-23	Million Cubic Feet Gas Produced
	Pump Seals	3-10-002-24	Million Cubic Feet Gas Produced
	Compressor Seals	3-10-002-25	Million Cubic Feet Gas Produced
	Flanges and Connections	3-10-002-26	Million Cubic Feet Gas Produced
	Glycol Dehydrator Reboiler Still Stack	3-10-002-27	Million Cubic Feet Gas Produced
	Glycol Dehydrator Reboiler Burner	3-10-002-28	Million Cubic Feet Gas Produced
	Gathering Lines	3-10-002-29	Million Cubic Feet Gas Produced
	Hydrocarbon Skimmer	3-10-002-30	Million Cubic Feet Gas Produced



**TABLE 10.7-1****(CONTINUED)**

<b>Source Description</b>	<b>Process Description</b>	<b>SCC</b>	<b>Units</b>
Natural Gas Processing	Glycol Dehydrators: Reboiler Still Vent: Triethylene Glycol	3-10-003-01	Million Cubic Feet Gas Produced
	Glycol Dehydrators: Reboiler Burner Stack: Triethylene Glycol	3-10-003-02	Million Cubic Feet Gas Produced
	Glycol Dehydrators: Phase Separator Vent: Triethylene Glycol	3-10-003-03	Million Cubic Feet Gas Produced
	Glycol Dehydrators: Ethylene Glycol: General	3-10-003-04	Million Cubic Feet Gas Produced
	Gas Sweetening: Amine Process	3-10-003-05	Million Cubic Feet Gas Produced
	Process Valves	3-10-003-06	Million Cubic Feet Gas Produced
	Relief Valves	3-10-003-07	Million Cubic Feet Gas Produced
	Open-ended Lines	3-10-003-08	Million Cubic Feet Gas Produced
	Compressor Seals	3-10-003-09	Million Cubic Feet Gas Produced
	Pump Seals	3-10-003-10	Million Cubic Feet Gas Produced
	Ranges and Connections	3-10-003-11	Million Cubic Feet Gas Produced
Liquid Waste Treatment	Flotation Units	3-10-005-01	Barrels Waste Liquid
	Liquid - Liquid Separator	3-10-005-02	Barrels Waste Liquid
	Oil - Water Separator	3-10-005-03	Barrels Waste Liquid
	Oil-Sludge-Waste Water Pit	3-10-005-04	Barrels Waste Liquid
	Sand Filter Operation	3-10-005-05	Barrels Waste Liquid
	Oil-Water Separation Wastewater Holding Tanks	3-10-005-06	Square Feet of Surface Area
Process Heaters	Distillate Oil	3-10-004-01	1000 Gallons Burned
	Residual Oil	3-10-004-02	1000 Gallons Burned
	Crude Oil	3-10-004-03	1000 Gallons Burned
	Natural Gas	3-10-004-04	Million Cubic Feet Burned
	Process Gas	3-10-004-05	Million Cubic Feet Burned

TABLE 10.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
Steam Generators	Distillate Oil	3-10-004-11	1000 Gallons Burned
	Residual Oil	3-10-004-12	1000 Gallons Burned
	Crude Oil	3-10-004-13	1000 Gallons Burned
	Natural Gas	3-10-004-14	Million Cubic Feet Burned
	Process Gas	3-10-004-15	Million Cubic Feet Burned
In-Process Fuel Use			
Internal Combustion Engines	Gas Turbines	2-02-002-01	Lb/MMBtu
	2-Cycle Lean Burn	2-02-002-52	Lb/MMBtu
	4-Cycle Lean Burn	2-02-002-53	Lb/MMBtu
	4-Cycle Rich Burn	2-02-002-54	Lb/MMBtu
Storage Tanks			
Fixed Roof 67,000 Barrel Fuel Tanks: Standing Losses	Grade 6 Oil	4-03-010-25	1000 Gallons Storage Capacity
	Grade 5 Oil	4-03-010-26	1000 Gallons Storage Capacity
	Grade 4 Oil	4-03-010-27	1000 Gallons Storage Capacity
	Grade 2 Oil	4-03-010-28	1000 Gallons Storage Capacity
	Grade 1 Oil	4-03-010-29	1000 Gallons Storage Capacity
Fixed Roof 250,000 Barrel Fuel Tanks: Standing Losses	Grade 6 Oil	4-03-010-65	1000 Gallons Storage Capacity
	Grade 5 Oil	4-03-010-66	1000 Gallons Storage Capacity
	Grade 4 Oil	4-03-010-67	1000 Gallons Storage Capacity
	Grade 2 Oil	4-03-010-68	1000 Gallons Storage Capacity
	Grade 1 Oil	4-03-010-69	1000 Gallons Storage Capacity
Fixed Roof Fuel Tanks: Working Losses	Grade 6 Oil	4-03-010-75	1000 Gallons Throughput
	Grade 5 Oil	4-03-010-76	1000 Gallons Throughput
	Grade 4 Oil	4-03-010-77	1000 Gallons Throughput
	Grade 2 Oil	4-03-010-78	1000 Gallons Throughput
	Grade 1 Oil	4-03-010-79	1000 Gallons Throughput

TABLE 10.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
Floating Roof 67,000 Barrel Fuel Tanks: Standing Losses	Grade 6 Oil	4-03-011-25	1000 Gallons Storage Capacity
	Grade 5 Oil	4-03-011-26	1000 Gallons Storage Capacity
	Grade 4 Oil	4-03-011-27	1000 Gallons Storage Capacity
	Grade 2 Oil	4-03-011-28	1000 Gallons Storage Capacity
	Grade 1 Oil	4-03-011-29	1000 Gallons Storage Capacity
Floating Roof 250,000 Barrel Fuel Tanks: Standing Losses	Grade 6 Oil	4-03-011-65	1000 Gallons Storage Capacity
	Grade 5 Oil	4-03-011-66	1000 Gallons Storage Capacity
	Grade 4 Oil	4-03-011-67	1000 Gallons Storage Capacity
	Grade 2 Oil	4-03-011-68	1000 Gallons Storage Capacity
	Grade 1 Oil	4-03-011-69	1000 Gallons Storage Capacity
Floating Roof Fuel Tanks: Working Losses	Grade 6 Oil	4-03-011-75	1000 Gallons Throughput
	Grade 5 Oil	4-03-011-76	1000 Gallons Throughput
	Grade 4 Oil	4-03-011-77	1000 Gallons Throughput
	Grade 2 Oil	4-03-011-78	1000 Gallons Throughput
	Grade 1 Oil	4-03-011-79	1000 Gallons Throughput
Bulk Plants			
Oil Field Storage of Crude	Fixed Roof Tank: Breathing Loss	4-04-003-01	1000 Gallons Storage Capacity
	Fixed Roof Tank: Working Loss	4-04-003-02	1000 Gallons Throughput
	External Floating Roof Tank with Primary Seals: Standing Loss	4-04-003-03	1000 Gallons Storage Capacity
	External Floating Roof Tank with Secondary Seals: Standing Loss	4-04-003-04	1000 Gallons Storage Capacity
	Internal Floating Roof Tank: Standing Loss	4-04-003-05	1000 Gallons Storage Capacity
Underground Tanks	Crude Oil RVP 5: Breathing Loss	4-04-004-07	1000 Gallons Storage Capacity

TABLE 10.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
Underground Tanks (Continued)	Crude Oil RVP 5: Working Loss	4-04-004-08	1000 Gallons Throughput
Fugitive Emissions			
Oil Production	Complete Well	3-10-001-01	Wells/Year in Operation
	Compressor Seals	3-10-001-30	Number of Seals
	Drains	3-10-001-31	Number of Drains
	Miscellaneous Fugitive Emissions	3-10--888-01 to -04	Process Unit - Year
	Miscellaneous Fugitive Emissions - Oil	3-10-888-05	1000 Barrels Feed Produced
Natural Gas Production	Valves	3-10-002-07	Million Cubic Feet Gas Produced
	Drains	3-10-002-31	Number of Drains
	Miscellaneous Fugitive Emissions - Gas	3-10-888-11	Million Cubic Feet Produced
Control Device Fuel			
Control Device Fuel	Afterburners - Distillate Oil No. 2	3-06-099-01	1000 Gallons Burned
Transportation and Marketing			
Tank Cars and Trucks	Gasoline: Submerged Loading, Normal Service	4-06-001-31	1000 Gallons Transferred
	Crude Oil: Submerged Loading, Normal Service	4-06-001-32	1000 Gallons Transferred
	Gasoline: Splash Loading, Normal Service	4-06-001-36	1000 Gallons Transferred
	Crude Oil: Splash Loading, Normal Service	4-06-001-37	1000 Gallons Transferred
	Gasoline: Submerged Loading, Balanced Service	4-06-001-41	1000 Gallons Transferred
	Crude Oil: Submerged Loading, Balanced Service	4-06-001-42	1000 Gallons Transferred

**TABLE 10.7-1****(CONTINUED)**

<b>Source Description</b>	<b>Process Description</b>	<b>SCC</b>	<b>Units</b>
Tank Cars and Trucks (Continued)	Gasoline: Splash Loading, Balanced Service	4-06-001-44	1000 Gallons Transferred
	Crude Oil: Splash Loading, Balanced Service	4-06-001-45	1000 Gallons Transferred
	Gasoline: Submerged Loading, Clean Trucks	4-06-001-47	1000 Gallons Transferred
	Crude Oil: Submerged Loading, Clean Trucks	4-06-001-48	1000 Gallons Transferred
Marine Vessels	Crude Oil: Loading Tankers	4-06-002-43	1000 Gallons Transferred
	Crude Oil: Loading Barges	4-06-002-48	1000 Gallons Transferred

Floating Roof Fuel Tanks: Working Losses, Oil Field Storage of Crude, and Underground Tanks source descriptions.

#### **7.1.4 FUGITIVE SOURCES**

Fugitive sources consist of wells, equipment leaks, and other miscellaneous sources. The SCCs that correspond to these activities appear in Table 10.7-1 under the Oil Production and the Natural Gas Production source descriptions.

#### **7.1.5 TRANSPORTATION AND MARKETING**

Transportation and marketing consists of loading materials onto trucks, barges, and tankers. The SCCs that correspond to these activities appear in Table 10.7-1 under the Tank Cars and Trucks and Marine Vessels source descriptions.

### **7.2 AIRS CONTROL DEVICE CODES**

Control device codes applicable to oil and gas field production and processing operations are presented in Table 10.7-2. These should be used to enter the type of applicable emission control device into the AIRS Facility Subsystem (AFS). The "099" control code may be used for miscellaneous control devices that do not have a unique identification code.

**TABLE 10.7-2**  
**AIRS CONTROL DEVICE CODES**

<b>Control Device</b>	<b>Code</b>
Gas Scrubber	013
Catalytic Afterburner	019
Catalytic Afterburner with Heat Exchanger	020
Direct Flame Afterburner	021
Direct Flame Afterburner with Heat Exchanger	022
Flaring	023
Sulfur Plant	045
Process Change	046
Vapor Recovery System	047
Catalytic Reduction	065
Tube and Shell Condenser	072
Refrigerated Condenser	073
Barometric Condenser	074
Conservation Vent	088
Bottom Filling	089
Conversion to Variable Vapor Space Tank	090
Conversion to Floating Roof Tank	091
Conversion to Pressurized Tank	092
Submerged Filling	093
Underground Tank	094
White Paint	095
Miscellaneous Control Devices	099

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# **APPENDIX A**

## **EXAMPLE DATA COLLECTION FORMS**

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**EXAMPLE DATA COLLECTION FORMS INSTRUCTIONS -  
OIL AND NATURAL GAS FIELD PRODUCTION AND PROCESSING OPERATIONS  
MANUFACTURING FACILITIES**

1. These forms may be used as a work sheet to aid the plant engineer in collecting the information necessary to calculate emissions from oil and natural gas field production and processing operations. The information requested on the forms relate to the methods (described in Sections 3, 4, and 5) for quantifying emissions. These forms may also be used by the regulatory agency to assist in area wide inventory preparation.
2. The completed forms should be maintained in a reference file by the plant engineer with other supporting documentation.
3. If the information requested is unknown, write "unknown" in the blank. If the information requested does not apply to a particular unit or process, write "NA" in the blank.
4. If you want to modify the form to better serve your needs, an electronic copy of the form may be obtained through the EIIP on the Clearinghouse for Inventories and Emission Factors (CHIEF) system.
5. Collect all Manufacturer's Technical Data Sheets (TDSs) for all materials containing potential air contaminants that are used at the facility.
6. The plant engineer should maintain all material usage information and TDSs in a reference file.

**EXAMPLE DATA COLLECTION FORM****FORM A: GENERAL INFORMATION**

Facility/Plant Name: \_\_\_\_\_

SIC Code: \_\_\_\_\_

SCC: \_\_\_\_\_

SCC Description: \_\_\_\_\_

Location: \_\_\_\_\_

County: \_\_\_\_\_

City: \_\_\_\_\_

State: \_\_\_\_\_

Plant Geographical coordinates:

Latitude: \_\_\_\_\_

Longitude: \_\_\_\_\_

UTM Zone: \_\_\_\_\_

UTM Easting: \_\_\_\_\_

UTM Northing: \_\_\_\_\_

Contact Name: \_\_\_\_\_

Title: \_\_\_\_\_

Telephone Number: \_\_\_\_\_

**EXAMPLE DATA COLLECTION FORM****FORM B: SOURCE INFORMATION**

Unit ID:

Permit No.:

Location:

Unit Description:

Manufacturer:

Date Installed:

Date Modified:

Operating Schedule:

Hours/Day:

Days/Week:

Weeks/Year:



**EXAMPLE DATA COLLECTION FORM****FORM C: CONTROL DEVICE INFORMATION**

Unit ID: \_\_\_\_\_

Permit No.: \_\_\_\_\_

Location: \_\_\_\_\_

Pollutant Controlled: \_\_\_\_\_

Control Efficiency (Indicate source of information): \_\_\_\_\_

Type of Control Device:

☐ Baghouse☐ Carbon Adsorber☐ Condenser☐ Flare☐ Scrubbers (indicate type) \_\_\_\_\_☐ Thermal Incinerator☐ Other (indicate type) \_\_\_\_\_

Manufacturer: \_\_\_\_\_

Date Installed: \_\_\_\_\_

Date Modified: \_\_\_\_\_

Operating Schedule: \_\_\_\_\_

Hours/Day: \_\_\_\_\_

Days/Week: \_\_\_\_\_

Weeks/Year: \_\_\_\_\_

Source(s) Linked to this Control Device: \_\_\_\_\_

**EXAMPLE DATA COLLECTION FORM****FORM D: STACK INFORMATION**

Stack ID:

Unit ID:

Stack (Release) Height (ft):

Stack Diameter (inch):

Stack Gas Temperature (°F):

Stack Gas Velocity (ft/sec):

Stack Gas Flow Rate (ascf/min):

Source(s) Linked to this Stack:

## FORM E: PRODUCTION INFORMATION

[illegible]

**EXAMPLE DATA COLLECTION FORM****FORM F: DATA NEEDED FOR EMISSIONS FROM COMBUSTION OPERATIONS**

Unit ID No.:	Fuel A	Fuel B	Fuel C	Comments
Fuel Type:				
Sulfur Content (%):				
Heating Value of Fuel (MMBtu/MMscf or MMBtu/Mgal):				
Maximum Hourly Fuel Use (units):				
Total Annual Fuel Use (units):				
Maximum Capacity (Million Btu/hr):				

Note: Complete this form for each unit.

**EXAMPLE DATA COLLECTION FORM**

**FORM G: DATA FOR EMERGENCY AND PROCESS VENTS, GAS ACTUATED PUMPS, PRESSURE/LEVEL CONTROLLERS, BLOWDOWN, WELL BLOWOUTS, WELL TESTING, TRANSPORTATION LOADING LOSS, AND STORAGE TANK FLASH LOSS EMISSIONS**

<b>Equipment ID</b>	<b>Volume of Gas Processed (scf/yr)</b>	<b>Molecular Weight of Gas</b>	<b>VOC Mass Fraction in Gas</b>	<b>VOC Constituent</b>	<b>VOC Constituent Mass Fraction in VOC</b>

## FORM H: DATA FOR GAS SWEETENING/FLARE EMISSIONS

[illegible]

[illegible]

---

[illegible]



## FORM K: DATA NEEDED FOR LOADING LIQUID MATERIALS INTO TANK TRUCKS AND TANK CARS

[illegible]

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[illegible]

## EXAMPLE DATA COLLECTION FORM

## FORM M: EMISSION RESULTS

Equipment ID: \_\_\_\_\_

Pollutant	Emission Estimation Method <sup>b</sup>	Emissions	Emissions Units	Emission Factor <sup>c</sup>	Emission Factor Units	Comments

<sup>a</sup> Pollutants include VOCs, PM/PM<sub>10</sub>, H<sub>2</sub>S, SO<sub>2</sub>, NO<sub>x</sub>, CO<sub>2</sub>, CH<sub>4</sub>, CO, and HAPs (list individually).

<sup>b</sup> Use the following codes to indicate which emission estimation method is used for each pollutant:

Emission Factor = EF

Mass Balance = MB

Other Method (indicate) = O

Emission Model = EM

Engineering Equation = EE

Stack Test = ST

Continuous Emission Monitoring Systems = (CEMS)

<sup>c</sup> Where applicable, enter the emission factor and provide full citation of the reference or source of information from where the emission factor came. Include edition, version, table and page numbers if AP-42 is used.

## **APPENDIX B**

# **LADEQ GUIDELINES AND INSPECTION CHECKLIST FOR GRI-GLYCALC MODEL**

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**LADEQ GUIDELINES FOR GRI-GLYCALC MODEL<sup>1</sup>**

Process Parameter	Guidelines
A. Wet Gas	
1. Temperature	Range: 80°F to 120°F
2. Pressure	Range: 850 psig to 1,400 psig
3. Water content	Always saturated
4. All data	Based on actual information
5. Sample	Must be obtained at inlet for analysis and include BTEX analysis
6. Composition	Always check composition if benzene mole % is less than 0.03; if below 0.03%, the sample may have been taken in the wrong location.
B. Dry Gas	
1. Flow rate	Range: 1.0 to 500 MMscf/day
2. Water content	Range: 2.0 to 7.0 lb H <sub>2</sub> O/MMscf (never over 7.0)
C. Lean Glycol	
1. Circulation rate	Obtain from chart with strokes per minute information (gpm)
2. Water content	Range: 0.1 to 0.5 wt%
3. Lean glycol	Always use 3.0 gal/lb H <sub>2</sub> O
4. Pump type	Electric or gas driven with meter on electric pump
5. Pump gas ratio	Obtain from chart called gas composition
D. Flash Tank (Separator):	
1. Temperature	Range: 100.0 to 150.0°F
2. Pressure	Range: 30 to 70 psig
3. All data	Obtained from actual data at facility
E. Stripping gas	Normally none
F. Control device (if applicable)	
1. Condenser temperature	Range: 80 to 200°F; if steam is coming out, use 200°F; if water cooled, use 80°F
2. Condenser pressure	Always use 14.7 psia

<sup>1</sup> These guidelines are used by the Louisiana Department of Environmental Quality (LADEQ) and are based on data collected from the field.

**LADEQ GLYCOL INSPECTION CHECKLIST**

July 17, 1998

**MEMORANDUM**

TO: Regional Coordinators  
Air Quality Compliance Division

FROM: Mike Algero  
Surveillance Program Manager  
Air Quality Compliance Division

SUBJECT: Glycol Inspection Checklist

The Air Quality Engineering Section has developed the following checklist for glycol units. Please review it with you staff.

When glycol dehydrators are inspected by your staff, the following information is needed to evaluate compliance using the Glycalc software.

1. Inlet wet gas flow rate and composition (speciated for BTEX).
2. Temperature and pressure of glycol contact tower.
3. Glycol circulation - obtained by timing strokes of the glycol pump and converting to flow rate using pump vendor information obtained from facility. If circulation cannot be determined this way, then facility must provide other means of measuring flow, if Glycalc is to be used.
4. If the unit is controlled with a condenser, documentation that the annual average temperature of the condenser outlet is less than 110°F (as specified in 2116.F.3).

Please contact me if you have any questions.

MA/vh

**VOLUME II: CHAPTER 11**

# **PREFERRED AND ALTERNATIVE METHODS FOR ESTIMATING AIR EMISSIONS FROM PLASTIC PRODUCTS MANUFACTURING**

**December 1998**



Prepared by:  
Eastern Research Group, Inc.

Prepared for:  
Point Sources Committee  
Emission Inventory Improvement Program



## **DISCLAIMER**

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

## ACKNOWLEDGMENT

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# 1

## INTRODUCTION

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The purposes of the preferred methods guidelines are to describe emission estimation techniques for point sources in a clear and unambiguous manner and to provide concise example calculations to aid regulatory and non-regulatory personnel in the preparation of emission inventories. This chapter describes the procedures and recommended approaches for estimating air emissions from plastic products manufacturing operations.

Section 2 of this chapter contains a general description of the plastic products manufacturing source category, identifies common emission sources, and contains an overview of available air pollution control technologies. Section 3 of this chapter provides an overview of available emission estimation methods. It should be noted that the use of site-specific emissions data is usually preferred over the use of industry-averaged data. However, depending upon available resources, obtaining site-specific data may not be cost effective.

Section 4 presents the preferred emission estimation methods for plastic products manufacturing and Section 5 presents alternative emission estimation techniques. Quality assurance and quality control procedures associated with the emission estimation methods are described in Section 6. Section 7 contains data coding procedures used for data input and storage. Some states use their own unique identification codes, so non-regulatory personnel developing an inventory should contact individual state agencies to determine the appropriate coding scheme to use. References cited in this document are provided in Section 8 and other useful information on this topic may be found in the references listed in Section 9 (Bibliography). Appendix A contains an example data collection form for plastic products manufacturing sources and may be revised to fit individual user's needs.

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# 2

## SOURCE CATEGORY DESCRIPTION

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### 2.1 PROCESS DESCRIPTION

Plastic products manufacturing involves molding, forming, shaping, or otherwise altering plastic resins or plastic materials to produce an intermediate or final product. This manufacturing industry is also commonly referred to as plastics processing or polymer processing. The manufacture of resins is not a part of plastic products manufacturing; however, some facilities manufacture resins at the same site as where the resins are processed.<sup>1</sup> This chapter will not address the manufacture of resins because it is not an activity inherent to plastic products manufacturing.

Solid and foamed plastic products are manufactured using plastic resins or solid plastic chips as the starting material. Most plastic products are manufactured by mixing plastic resins with additives, applying heat or pressure to the mixture, and shaping the mixture to form the desired product.

Section 2.1.1 describes the different types of plastics used by plastic products manufacturing facilities in the United States. Section 2.1.2 describes the major manufacturing techniques used to process plastic products.

#### 2.1.1 TYPES OF PLASTICS

Plastic products can be fabricated into a solid or foam state. The basic properties of a plastic product are influenced and limited by the physical and chemical characteristics of the plastic resin from which it is made.

Plastic resins are generally defined by their rheology, or ability to flow under heat or pressure. Thermoplastic resins (or dry blends) and thermoset resins are the two major classes of resins that are used to manufacture plastic products. Although most resins fall into one of these two classes of resins, some resins can be classified as both a thermoplastic and thermoset resin.

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<sup>1</sup> A polymer is a high-molecular-weight organic compound, natural or synthetic, whose structure can be represented by a repeated small unit, the monomer. A resin is a solid or semisolid organic product usually of high molecular weight and no definite melting point. Most resins are polymers (The Society of the Plastics Industry, 1991).



***Thermoplastics***

Thermoplastic resins (or thermoplastics) are plastic resins that will repeatedly become soft when heated and hard when cooled. Thermoplastics do not normally undergo a chemical change during forming. Plastic products manufacturing facilities usually purchase and use thermoplastics in solid pellet form for processing. An economic advantage of products made from thermoplastics is that they can be easily remanufactured or reprocessed.

Thermoplastics account for the major share of domestic polymer production. The following six thermoplastics are processed in the largest quantities in the United States:

- Low-density polyethylene;
- High-density polyethylene;
- Polyvinyl chloride;
- Polypropylene;
- Polystyrene; and
- Linear low-density polyethylene.

***Thermosets***

Thermoset resins (or thermosets) undergo a chemical reaction and become permanently solid when heated, pressurized, or reacted with a hardening agent. Thermosets are usually available in liquid or powder form for processing. Unlike thermoplastics, thermosets cannot be easily remelted or refabricated. However, scraps from thermoset processing operations can be used as fillers for other products.

Some widely used thermosets include:

- Epoxy;
- Phenolic;
- Unsaturated polyester; and
- Urea.

***Foamed Plastics***

Foamed plastics (or foams) have a unique cellular structure that is different from solid plastics. For this reason, foams are often called “cellular plastics.” Foams, which are rigid, semi-rigid, or flexible, can be manufactured with thermoplastic or thermoset resins. Many of the manufacturing techniques used to fabricate solid plastic products are also used to make foam products. The process used to manufacture foams influences the properties of the final foam product.

Some typical foams include:

- Polystyrene foam;
- Polyurethane foam; and
- Polyethylene foam.

A detailed description of foam processing is provided in Section 2.1.2.

Table 11.2-1 lists ten plastics that are processed in the largest quantities in the United States (The Society of the Plastics Industry, 1991 and 1996). It also presents common applications and typical manufacturing techniques used for each plastic type.

**2.1.2 MANUFACTURING TECHNIQUES**

Solid and foamed plastic products are manufactured by a variety of methods. The choice of manufacturing techniques used to process a plastic product depends largely on whether the resin is a thermoplastic or thermoset, and the dimensions, shape, or physical qualities of the desired product.

This section describes the major manufacturing techniques used to fabricate intermediate and final plastic products. Extrusion is the most widely used processing technique, followed by injection molding, blow molding, and foam processing (Midwest Research Institute, 1993). These four manufacturing techniques, in addition to lamination, coating, and finishing operations, are described below.

***Extrusion***

The extrusion process is a common technique used to form thermoplastic materials into long plastic shapes including pipes, tubes, coated wires, coated cables, rods, and continuous sheets

TABLE 11.2-1

## COMMON APPLICATIONS AND MANUFACTURING TECHNIQUES FOR SELECTED PLASTICS

Plastic Type	Common Applications	Typical Processing Methods	1995 Production <sup>a</sup>
<b>Thermoplastics</b>			
Polyethylene	Packaging, housewares, toys and communications equipment	Extrusion, compression molding, injection molding, blow molding, foam processing	25,097 <sup>b</sup>
Polypropylene	Packaging, automotive, appliance, and carpeting	Extrusion, compression molding, injection molding, blow molding	10,890
Polystyrene	Consumer and institutional products (egg cartons, business machines, pallets), electrical/electronic uses, and building construction	General molding, compression molding, expandable bead molding, extrusion, injection molding	5,656
Polyvinyl Chloride	Building/construction, packaging, consumer and institutional products, and electrical/electronic uses	Extrusion, injection molding, calendaring, foam processing	12,295
Saturated Polyester	Packaging, automotive, electrical, and consumer markets	Film and sheet processing, blow molding, injection molding	3,785
<b>Thermosets</b>			
Epoxy	Protective coatings, bonding adhesives, building and construction, and electrical uses	Adhesive, bonding, lamination, transfer molding, injection molding, foam processing	632
Phenolic	Adhesives, casting resins, potting compounds, laminating resins, and electrical uses	Adhesive bonding, lamination, compression molding, transfer molding, foam processing	3,204
Polyurethanes	Automotive industry, transportation, carpet underlay, furniture (foam cushion), and construction markets	Flexible foam processing, rigid foam processing, reaction injection molding	4,269 <sup>c</sup>
Unsaturated Polyester	Transportation, appliances, electrical, and construction markets	Reinforced plastics processing, general molding	1,577
Urea-Formaldehyde	Laminates and chemically resistant coatings, rigid electrical and decorative products	Compression molding, transfer molding, lamination	1,816

<sup>a</sup> Millions of pounds<sup>b</sup> Low and high density<sup>c</sup> Market data for 1994

Source: The Society of the Plastics Industry, 1996 and 1991.

and films. The types of extrusion methods are as diverse as the products that can be fabricated by extrusion. Extrusion methods include blown film, sheet extrusion, cast film, extrusion coating, profile extrusion, pipe and tubing extrusion, wire and cable coating, and fiber extrusion.

In most extrusion operations, dry resin material is poured into a hopper, which directs the resin material into the feed throat of the extruding machine where the resin is heated. A large continuously revolving screw encased in a long heating chamber then carries the heated resin down the length of the screw toward a die (orifice) at the end of the chamber. The revolving screw forces the fluidized resin material through the die which has the shape of the cross section of the final plastic product. After the resin material exits the die, it may be wound into a roll, or transported on rollers or a conveyor belt where it is cooled by air or water immersion.

### ***Molding***

In most molding operations, the forming of the intermediate or final plastic product takes place in a closed mold. Molding methods vary depending on resin type, raw materials, desired plastic product shape, and other factors. Some of the more typical molding methods include injection, blow, general, rotational, transfer, reaction injection, and compression injection. This section will describe the three most prevalent molding methods currently used in the United States.

**Injection Molding.** Injection molding is one of the more common methods used to mold thermoplastics; however, this method can also be used to mold thermosets. The injection molding process is similar to the extrusion method except that in injection molding, the molten material is injected into a mold rather than forced through a die.

Plastic pellets are fed into a heating chamber and are pushed along by a plunger until they are homogenized and fluidized. The fluid plastic is then injected (forced under high pressure) through a nozzle into a relatively cold mold. The fluid plastic conforms to the shape of the clamped mold, which is released once the plastic solidifies. The reciprocating screw injection machine, which serves as both a plasticizer and injection ram, is the most common machine used for injection molding.

Reaction injection molding is a recently developed injection molding technology that mixes liquid plastic (i.e., polyols and isocyanates) at low temperatures before injecting the liquid plastic into a mold. Unlike standard injection molding, an exothermic reaction takes place in reaction injection molding; therefore reaction injection molding requires substantially less energy than traditional injection molding (The Society of the Plastics Industry, 1996).

**Blow Molding.** Blow molding is used to manufacture bottles and other hollow or lightweight objects. The basic technique of blow molding is to stretch and form plastic material against a mold, usually by air pressure. The extrusion blow molding method extrudes fluid plastic into a

parison (a free-blown form shaped like a tube) before molding the final product. The parison is directed between two halves of a mold, then air pressure expands the parison and forces it to conform to the contour of the mold. The injection blow molding method is similar to extrusion blow molding, except that the parison is injection-molded rather than extruded.

**Compression Molding.** Compression molding is a common method for forming thermosets and is rarely used for thermoplastics, except with a few specialized processes. In compression molding, a premixed plastic mixture or preformed plastic part is placed in an open mold cavity. As the heated mold is closed, the plastic mixture spreads throughout the mold. The mixture in the mold is pressurized and heated until it undergoes a chemical change that hardens the mixture into the desired shape.

**Transfer Molding.** Transfer molding is a process similar to compression molding that is used for thermoplastics. However, unlike compression molding, a hydraulic plunger forces the heated plastic mixture into a closed hot mold where it solidifies.

### ***Lamination***

Lamination is the binding and fusing of multiple layers with heat and pressure. All thermosets can be used as laminating binders; however, phenolic is the most common binder used in lamination.

Most laminating operations involve the following three basic steps: impregnation, drying, and pressing. First, a web of paper, fabric, or other material is impregnated with a resin solution by continuously feeding it through a dip tank. Next, excess resin is removed and the web is dried. The drying, which takes place in an oven, vaporizes the solvent and helps increase the molecular weight of the resin via additional chemical reactions. Usually the web sheeting is cut and placed in multiple layers. Finally, a hydraulic press compacts the layers of sheets at pressures ranging from 1,400 Kilopascals (kPa) to 12,000 kPa under temperature conditions of 140 to 180 °C (EPA, 1978).

### ***Coating***

A variety of methods are available to coat objects, web materials, and other substrates with plastic. Some of the more common methods are included in this discussion. For a detailed discussion on coating operations and estimating emissions from associated activities, please see Chapter 7 in this series, *Preferred and Alternative Methods for Estimating Emissions from Surface Coating Operations*.

Calender coating involves the production of plastic sheets that are then pressed between heated rollers against a web of material. The heat and pressure bond the plastic to the web substrate.

In dip coating, a part is dipped or immersed in a resin solution. After the part is removed from the solution and excess coating is drained, the part is air-dried or baked. This coating method is useful for irregularly shaped parts. In flow coating, a method similar to dip coating, plastic coating is poured or sprayed on the part and allowed to drain by gravity.

Roll coating is another common method that is often used for web substrates. A controlled amount of resin is applied to the web as it passes over and between a series of rollers. In knife-over-roll coating, a coating knife controls the thickness of the coating that is applied to the web substrate as it passes over a roller. The coating thickness is regulated by the distance between the coating knife edge and the surface of the web material.

### ***Foam Processing***

Many of the same processes used to manufacture solid plastic products (i.e., extrusion and molding) are used to generate foamed plastic products. However, unlike solid plastic products manufacturing, the manufacture of foamed plastic products requires a specialized stage where air, chemical, or physical blowing agents are incorporated into the plastic mixture to produce a cellular structure unique to foamed plastics.

Foamed plastics are divided into three major types: blown, syntactic, and structural. Blown foam is an expanded matrix (resembles a sponge). Syntactic foam is the encapsulation of hollow micro spheres in a plastic matrix. Structural foam is a foamed core surrounded by a solid outer skin.

The following are some basic processes that are used in conjunction with standard molding and forming operations to produce blown and syntactic foam plastic:

- A chemical blowing agent that generates gas through thermal decomposition is incorporated into the polymer melt or pellet;
- Pressurized gas or liquid is injected into the melt and expands during pressure relief;
- A low-boiling-point liquid (i.e., hydrocarbons) is incorporated into the plastic compound and volatilized through the exothermic heat of reaction or the application of heat;
- Nonchemical gas-liberating agents, in the form of gas adsorbed on finely divided carbon, are added to the resin mix and released during heating;

- Air is dispersed by mechanical means within the polymer; or
- The external application of heat causes the expansion of small beads of thermoplastic resin containing a blowing agent.

Structural foam plastic is made by injection molding liquid resins that contain chemical blowing agents. Less mixture is injected into the mold than is needed to mold a solid plastic part. At first, the injection pressure is very high, causing the blowing agent to solidify against the mold without undergoing expansion. As the outer skin is formed, the pressure is reduced and the remaining resin expands to fill the remainder of the mold (EPA, 1995).

### ***Finishing Operations***

Many plastic products need finishing or machining after they have been processed to remove imperfections, repair defects, or decorate the plastic product. Finishing operations include filing, grinding, sanding, polishing, painting, bonding, coating, engraving, and a number of other operations. Some finishing operations, like bonding or grinding, can also be classified as major processes when they are a part of the operations employed to produce an intermediate product.

## **2.1.3 ADDITIVES**

Additives are incorporated in plastic materials prior to processing to impart specific chemical or physical properties to the plastic. Additives include lubricants, antioxidants, antistats, blowing (foaming) agents, colorants, plasticizers, heat stabilizers, flame retardants, and ultraviolet stabilizers. Three common additives (plasticizers, antioxidants, and stabilizers) are discussed below.

### ***Plasticizers***

Plasticizers are added to plastic materials to improve flexibility, workability, or extrudability. Most plasticizers are used in the manufacture of flexible polyvinyl chloride (PVC). Phthalates, adipates, and trimellitates are the most common plasticizers.

### ***Antioxidants***

Antioxidants are added to plastic materials to inhibit the oxidation of plastic exposed to air. Antioxidants minimize degradation during processing, storage, and service. Hindered phenols are the class of compounds predominantly used to stabilize most polymers.

## **Stabilizers**

Stabilizers are used to prevent plastic materials from degrading when subject to heat or ultraviolet radiation. For example, pure PVC degrades with the application of heat. Therefore, incorporating stabilizers into the PVC material can help maintain the physical and chemical properties of the PVC material throughout processing and the life of the PVC material.

Ultraviolet stabilizers protect plastics from degrading when exposed to sunlight. Hindered amine light stabilizers (HALS), benzotriazoles, benzophenones, and nickel compounds are typical light stabilizers (Midwest Research Institute, 1993).

## **2.2 EMISSION SOURCES**

Emissions from plastic products manufacturing come from a variety of sources and are highly dependent upon the chemical makeup of the raw materials (resins, additives) and types of production processes used. In addition, the diverse nature of these raw materials and manufacturing techniques results in a wide range of potential combinations of emission sources and pollutants.

The primary sources of emissions at plastic products manufacturing facilities are the pieces of equipment (e.g., extruder hopper, die head, sander) used to handle raw materials and produce the final product. These are typically the locations where chemical reactions occur, liquid solvents and solvent blends are exposed to the atmosphere, solid resin is heated and melted, and additives are introduced.

In addition to emissions generated directly from primary production processes associated with plastic products manufacturing, there may be additional emissions produced by secondary processes at these facilities. Emission sources from these secondary processes include storage tanks, equipment leaks, wastewater treatment, combustion sources, and cleaning and surface coating operations. Chapter 2 of this volume addresses emissions from combustion in boilers, Chapter 4 addresses emissions from equipment leaks, Chapter 5 addresses emissions from wastewater collection and treatment, and Chapter 7 addresses emissions from surface coating operations. In addition, Chapter 1 of this volume discusses general emission estimation approaches and includes useful references to other sources and tools for estimating emissions.

As explained earlier, there are multiple processes occurring at plastic products manufacturing facilities that give rise to a wide variety of pollutants. Emissions from plastic products manufacturing may be generally classified as follows:



- Volatile organic compound (VOC) and hazardous air pollutant (HAP) emissions resulting from the volatilization of free monomer or solvent in the primary polymer blend during processing;
- VOC and HAP emissions that result from secondary process materials, such as blowing agents, additives, and lubricants (mold release compounds);
- VOC, HAP, and particulate matter (PM) emissions that result from byproducts formed by chemical reactions or formed during heating of resins; and
- PM emissions generated during raw material handling and finishing operations.

The following discussion provides additional information on some of the specific pollutants emitted from plastic products manufacturing facilities and the specific processes giving rise to emissions.

### **2.2.1 FREE MONOMER/SOLVENT**

Emissions of free monomer (a single molecule of a chemical used in a polymer) may occur when a solid resin is heated during extrusion, molding, or any of the other processes discussed in Section 2.1. For example, one recent study (Contos et al., 1995) found a monomer (styrene) to be the principle component of the emissions produced during the extrusion of acrylonitrile-butadiene-styrene (ABS) resins.

Emissions of free monomer would also be expected from resins used in solvent form. Some resins may be handled using a solvent medium to store and transport the resin prior to processing. In this case, emissions would also come from the solvent used to suspend the resin prior to the polymerization step. Thermoset resins are often handled in monomer form prior to solidifying under heat or pressure, or reaction with a hardening agent to generate a solid polymer. For example, when curing of thermosets is accomplished during processing or when processing involves polymerization (such as when thermoset polyurethane elastomers are processed using reaction injection molding), substantial emissions of monomers are likely to be generated (Midwest Research Institute, 1993).

## 2.2.2 SECONDARY PROCESS MATERIALS

In addition to the bulk polymer and additives used to form the plastic product, additional materials may be used to assist in lubrication, or, in the case of blowing agents used to manufacture foams, to decrease the density of the final product.

### ***Lubrication***

Lubrication is used in molding and forming operations to prevent plastic material from sticking to mold surfaces. A mold release agent (lubricating or parting agent) is sprayed on a mold cavity surface in a thin waxy layer to facilitate the release or removal of the molded plastic form from the mold. Mold release agents contain carrier solvents (HAP-based and non-HAP based) that evaporate immediately when the mold release agent adheres to the mold cavity surface (EPA, 1996).

### ***Blowing Agents***

Emissions also occur from blowing agents used to manufacture certain foams. In expanded polystyrene (EPS) bead manufacturing, the blowing agent is typically contained in the raw polymer beads as they come from the supplier. This causes the beads to expand when exposed to heat. There are three general classes of emissions from this type of foam production: manufacturing emissions; prompt foam cell losses, which are losses that typically occur during storage and shipping; and banked emissions, which are losses that occur through slow diffusion of blowing agents out of the foam over the life of the product (EPA, 1990).

Another type of polystyrene foam is extruded polystyrene foam sheet (PSF). Pentane is the predominant hydrocarbon blowing agent used to manufacture PSF. After extrusion, sheets of intermediate product are wound into rolls and aged for 3 to 5 days. After aging, the sheets are thermoformed into consumer products and packaged for shipment. Typically 50 percent of the blowing agent is lost during the manufacturing and reclaim operations and the remainder as fugitives during warehousing, transportation, and after the product is sold (EPA, 1990).

In the manufacture of polyurethane foams, large quantities of auxiliary blowing agents are used to reduce foam density. The use of these blowing agents (predominantly methylene chloride or chlorofluorocarbons) does not involve any chemical reactions, but is merely a change of the physical state of the blowing agent. Volatilization of the auxiliary blowing agent from liquid to gas provides the volume needed to increase the number and size of foam cells. One recent study estimates that approximately 60 percent of methylene chloride is lost within the first 10 minutes of the process and the remaining 40 percent is lost slowly by diffusion over the next 24 hours (Kaufman and Overcash, 1993). The initial bulk of emissions are typically released through

process vents located at the foaming equipment, while the remaining 40 percent of emissions are released fugitively while the foam is being transported and stored.

### **2.2.3 CHEMICAL REACTIONS/BYPRODUCTS**

VOC and HAP emissions may be generated from chemical reactions occurring as a direct part of the process, as in the case of thermoset resins, or as an indirect result of the process environment. For example, pure PVC degrades with the application of heat to form hydrochloric acid (HCl) gas, which itself is a catalyst for further degradation.

Because many thermoplastic operations occur in heated environments, some amount of emissions occurs due to thermal degradation of additives as well as the actual polymeric material used to produce the final product.

### **2.2.4 PARTICULATE SOURCES**

Particulate emissions from plastic products manufacturing are composed of solid particulates and hydrocarbon-based aerosols (EPA, 1978). The solid particulates are generated during grinding, cutting, and sawing of raw materials as well as finished products; and from the pneumatic and manual conveying and subsequent handling of polymeric materials and additives.

The level of particulate emissions is dependent on several factors. For example, one publication noted an increase in the level of particulate emissions with an increase in process temperature (Barlow et al., 1996). This may be due to the increased level of oxidation (smoking) the raw polymer undergoes at higher temperatures. Thermoplastic resins may be handled in a variety of forms, from solvent suspended solutions to pellets, beads, flake, or granular form. In general, materials handled in finely divided solid form (resins or flakes) are more likely emitted from handling operations than materials handled in larger solid form (chips) or in aqueous solution.

## **2.3 PROCESS DESIGN AND OPERATING FACTORS INFLUENCING EMISSIONS**

### **2.3.1 PROCESS AND OPERATING FACTORS**

As mentioned above, emissions from plastic products manufacturing facilities occur where solid resins are heated and melted, liquid solvents and solvent blends are exposed to the atmosphere, additives are introduced, and where chemical reactions occur. Therefore, it is expected that emissions are influenced by chemical makeup of the process materials, the physical makeup of the plastic processing equipment, and the conditions under which processing occurs.

For thermoplastic resins, one of the most important factors is the temperature at which the resin is melted and shaped into the final product. Those processes which occur at or near the melting point of the solid resin result in lower emissions than processes occurring at temperatures well beyond the melting point of the resin. For example, published emission factors indicate that for low-density polyethylene resin, there is an increase of over 400 percent in VOC emissions with a change of temperature from 500 to 600°F (Barlow et al., 1996).

Another important factor is the time interval during which the raw product (solid resin, solvent solutions) is exposed to air. Closed processes, such as enclosed mixing tanks or injection molds, result in lower emissions due to less direct contact with air and less opportunity for materials to volatilize. Conversely, large open tanks or air cooled extrusion processes are likely to lead to higher emissions. In addition to volatilization of organics and PM emissions from wind, increased exposure to the atmosphere would lead to increased chemical reactions as most polymers are subject to attack from oxygen in the air (Midwest Research Institute, 1993).

Recent testing data appear to indicate that the total surface area of the plastic product exposed to air may also affect emissions. For example, the surface area to mass ratio is greater for blown sheet than for extruded rod, allowing more contact with air and greater opportunity for emissions (on a mass basis). However, further research is needed to validate these conclusions.

### **2.3.2 CONTROL TECHNIQUES**

Emissions from plastic products manufacturing may be reduced either through process modifications or by using add-on control devices. Process modifications include the use of alternative raw materials such as alternative blowing agents for foam or switching to non-HAP containing additives. Process modifications also refer to the use of modified equipment or operating practices such as covering storage piles. In addition, keeping the die temperature close to the resin melting temperature and reducing the residence time of the heated resin in air will help reduce emissions.

There are many types of add-on control devices that could potentially be employed at plastic products manufacturing facilities to control emissions of VOC, HAPs, and PM. These would typically be most appropriate for contained streams with pollutant concentrations high enough for add-on control devices to be cost effective. Unfortunately, there is little information available that indicates the types and extent of add-on control devices currently being used. It is expected that VOC and organic HAP emissions could be controlled by incineration, adsorption, absorption, or condensation. Incineration and carbon adsorption have been identified as technologies currently in use at polystyrene foam manufacturing facilities (EPA, 1990). PM emissions generated from finishing operations, including cutting and grinding, are typically controlled by cyclones or fabric filters.

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# 3

## OVERVIEW OF AVAILABLE METHODS

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### 3.1 EMISSION ESTIMATION METHODS

Several methods are available for estimating emissions from primary processes at plastic products manufacturing facilities. The best method to use depends upon available data, available resources, and the degree of accuracy required in the estimate. In general, site-specific data that are representative of normal operations at a particular site are preferred over data obtained from other similar sites, or industry-averaged data.

This section discusses the methods available for calculating emissions from plastic products manufacturing operations and identifies the preferred method of calculation on a pollutant basis. Although preferred methods are identified, this document is not regulatory in nature and does not mandate any emission estimation method. Industry personnel using this manual should contact the appropriate state or local air pollution control agency regarding use of suggested methods. A comparison of the methods is also presented.

#### 3.1.1 MATERIAL BALANCE

A material balance approach may be used to estimate emissions when the quantities of a material used, recycled, incorporated into a product, and disposed of are known. For example, in PSF sheet production, the amount of blowing agent entering the process is a known quantity. After manufacturing is completed, the blowing agent remaining in the product can be measured by gas chromatography or gravimetric methods. The difference between what was used and the residual left in the foam represents the total manufacturing emissions (Krutchen and Wu, 1988a, 1988b, 1988c).

For liquid applications, such as solvent use, usage figures would typically be in gallons. The difference (by mass) of the amount of a liquid used and the amount of the liquid recovered, disposed of, or converted to another form, is assumed to equal releases to the air.

### 3.1.2 SOURCE TESTS

Source tests provide a "snapshot" of emissions during the period of the test. Samples are collected using probes inserted into the stack, and pollutants are collected in or on various media and sent to a laboratory for analysis or analyzed on-site by continuous analysis. Pollutant concentrations are obtained by dividing the amount of pollutant collected during the test by the volume of the sample. Emission rates are then determined by multiplying the pollutant concentration by the volumetric stack flow rate.

EPA has published approved test methods for determining air emissions in Title 40 CFR Part 60, Appendix A. Methods that would be applicable to plastic products manufacturing would be Method 18 (speciated organics), Method 25 (total hydrocarbon [THC]), Method 5 (PM), Method 201 (PM-10), Method 202 (condensable PM) and Method 0030 (speciated organics). In order to obtain accurate results using source testing, state-of-the-art methods should be chosen which are specifically targeted for pollutants of interest.

### 3.1.3 EMISSION FACTORS

Emission factors are used to estimate emissions based on known relationships between process rates and emission rates. The use of emission factors to estimate emissions from plastic products manufacturing facilities is an appropriate approach. Development of an accurate emission factor would require detailed knowledge of the process conditions and chemical and resin usage rates during the time period for which emissions are known. Emission factors should be applied to similar-type processes utilizing similar or identical process recipes.

## 3.2 COMPARISON OF AVAILABLE EMISSION ESTIMATION METHODS

Table 11.3-1 identifies the preferred and alternative emission estimation approaches for the primary types of pollutants emitted at plastic products manufacturing facilities. The preferred method for estimating organic compound (VOC and HAP) emissions is dependent on how the material is used and the source of the emissions. For example, the preferred method for estimating emissions of methylene chloride used as a blowing agent is through the use of a material balance. Alternatively, the preferred method for estimating emissions of HAPs emitted during the heating of thermoplastics resins is the use of source testing since the extent of volatilization of the pollutant from the resin is unknown. In Table 11.3-1 these two cases are indicated as "Non-consumable VOC or HAP" and "Consumable VOC or HAP." "Consumable VOC or HAP" means chemical agents (such as monomers) used in the manufacturing process are chemically altered or bound and are consumed in the manufacturing process. For example, MDI (methylene di-para-phenylene isocyanate) is used in the manufacture of polyurethane. It reacts and becomes chemically bound in the final product. "Non-Consumable VOC or HAP" means chemical agents used in the manufacturing process that are not chemically altered or

bound and therefore are not consumed in the manufacturing process. For example, pentane is used as a blowing agent for polystyrene products to reduce density. Pentane is released throughout the manufacturing process. While some pentane remains in the product, overall it is chemically unchanged. It should be noted that for the material balance method to result in an accurate estimate, each fate of the chemical must be known when using this approach.

**TABLE 11.3-1**

**SUMMARY OF PREFERRED AND ALTERNATIVE EMISSION ESTIMATION METHODS FOR  
PLASTIC PRODUCTS MANUFACTURING OPERATIONS**

<b>Pollutant</b>	<b>Preferred Emission Estimation Approach</b>	<b>Alternative Emission Estimation Approaches</b>
Non-consumable VOC (Total and speciated) and non-consumable HAP	Material Balance	Source Testing Emission Factors
Consumable VOC (Total and speciated) and consumable HAP	Source Testing	Emission Factors Material Balance
Particulate Matter (Includes total PM, PM-10, PM-2.5)	Source Testing	Emission Factors

Emission factors may not be based solely on site-specific data and should only be used if one of the preferred methods is not a viable option due to lack of data or resources. It is possible to obtain high-quality emissions estimates using emission factors, but only if they were originally developed using one of the preferred methods mentioned above.

### **3.2.1 MATERIAL BALANCE**

A material balance approach is the preferred method for estimating emissions of VOCs, including specific HAPs (xylene, ethylbenzene, toluene, etc.) from solvent use and other solvent sources which are not consumed or expected to remain in the final product. These types of emittants are referred to as non-consumable VOC in Table 11.3-1. Examples of non-consumable VOCs including blowing agents and carrier solvents. This approach is suitable for these types of pollutants because they do not enter into chemical reactions. Also, their usage and waste rates may already be tracked for purchasing reasons as well as other non-air-related environmental reporting purposes.



For thermoplastic processing where blowing agents, solvents, or other liquids are not involved, a material balance technique is generally not the preferred method. For these processes, source testing or emission factors will generally give a more accurate estimate. Examples of these processes are discussed in Section 2 and include most thermoplastic processes where solvents are not added.

For other pollutants emitted at plastic products manufacturing facilities, a material balance may not be an appropriate primary emission estimate approach due to the uncertainty in the extent of chemical remaining in the product or generated as the result of chemical reactions. However, a material balance could be used as an alternative approach in cases where other methods are difficult or resource intensive and where a finite number of assumptions would result in a complete mass balance equation.

### **3.2.2 SOURCE TESTS**

The standard EPA test methods mentioned in Section 3.1.2 can be used to obtain emission estimates from plastic products manufacturing processes for specific classes of compounds. In general, stack tests result in an accurate assessment of emissions when performed at the point of emissions generation and when the emissions can be directly correlated to a process activity for use in developing a site specific emission factor.

However, many of the emissions generating processes found at plastic products manufacturing facilities are not specifically vented or hooded, resulting in emissions being released as fugitives (through building openings such as windows, doors, and ventilation ducts) rather than through discrete emission points (such as process vents or stacks).

The former scenario would not be conducive to the use of source testing for estimating emissions. Source testing is best applied to contained gas streams originating at a specific emission generating process such as process vents or sanding and finishing stations.

### **3.2.3 EMISSION FACTORS**

Emission factors may also be used to estimate emissions from plastic products manufacturing. However, because of the highly variable nature of the plastic products manufacturing process, emission factors should be determined using site-specific data whenever possible. There are three principal ways to derive emission factors for plastic products manufacturing operations: through the use of emissions test data; a material balance approach; or engineering judgement.

Once derived, these factors may be applied to estimate emissions based on production rates or other appropriate parameters such as usage rates of a particular chemical. This approach provides an alternative method of estimating emissions over a longer term or for a different

processing scenario based on short-term emission estimates (i.e., during the time of the test) obtained from individual process steps. Also, emission factors for one process or chemical may be appropriate to use for estimating emissions from similar processes occurring within a facility or at other similar facilities.

The Society of the Plastics Industry (SPI) recently began a testing program with the cooperation of several resin suppliers to characterize emissions and develop emission factors for a variety of resin types and manufacturing techniques. Initial results from these testing programs have been published in several recent journal articles (Barlow et al., 1996; Barlow et al., 1997; Contos et al., 1995). The types of resins addressed in these studies include polyethylene, ABS, polypropylene, PVC, polystyrene, polycarbonate, and Nylon.

Emission factors for plastic products manufacturing are also presented in *AP-42*; *Source Assessment: Plastics Processing, State of the Art* (EPA, 1978); and the Factor Information and Retrieval (FIRE) System database. The emission factors presented in *Source Assessment: Plastics Processing, State of the Art* were developed in the mid 1970's and appear to be several orders of magnitude higher than emission factors based on recent testing. The report acknowledges "...that the accuracy of the data in this table (Table 5-Emission Factors) is unknown." The reader should consult with their local air pollution agency to determine which emission factors are acceptable for a particular application.

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# 4

## PREFERRED METHODS FOR ESTIMATING EMISSIONS

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The preferred method for estimating non-consumable VOC emissions (including HAPs) from plastic products manufacturing processes is the use of a material balance. This approach can be used to estimate emissions from solvent use and coating application for pollutants not involved in chemical reactions. As mentioned in Section 3, material balance uses the raw material usage rate and material disposal rate (present in product or waste streams) to estimate emissions; therefore, a detailed knowledge of each fate of the chemical is needed.

The preferred method for estimating PM and consumable VOC (including HAPs) emissions is the use of source testing. This is also the preferred method for estimating emissions of pollutants generated as a result of chemical reactions, thermal degradation, or pollutants with uncertain fates or origins.

It should be noted that for many processes both consumable and non-consumable chemicals are used. As the preferred methods are chemical specific and not process specific, several estimation techniques may be preferred for an individual operation.

The equations and examples in this section present how material balance and source testing data may be used to estimate VOC, speciated organic, speciated inorganic, and particulate emissions. Table 11.4-1 lists the variables and symbols used in the following discussions.

TABLE 11.4-1

## LIST OF VARIABLES AND SYMBOLS

Variable	Symbol	Units
Material entering the process	$Q_{in}$	gal/hr
Material leaving the process as waste, recovered material, or in product	$Q_{out}$	gal/hr
Concentration of pollutant x at standard temperature, pressure	$C_x$	parts per million by volume dry (ppmvd) or lb/gal
Concentration of pollutant x in raw material entering a process	$X_{in}$	parts per million by volume dry (ppmvd), lb/gal or lb/lb
Concentration of pollutant x in material exiting a process	$X_{out}$	parts per million by volume dry (ppmvd), lb/gal or lb/lb
Percentage by weight of speciated pollutant x in material	$wt\%_x$	%
Density of material	$d$	lb/gal
Temperature correction for differences in temperature during test	$K_t$	dimensionless
Pressure correction for differences in pressure during test	$K_p$	dimensionless
Average concentration of pollutant x during test	$C_{a,x}$	ppmvd
Molecular weight of pollutant x	$MW_x$	lb/lb-mole
Stack gas volumetric flow rate	$V$	dry standard cubic feet per hour (dscf/hr)
Molar Volume	$M$	385.5 scf/lb-mole @ 68°F, 1 atm
Annual emissions of pollutant x	$E_{an,x}$	ton/yr
Hourly emissions of pollutant x	$E_{hr,x}$	lb/hr
Operating hours	$OH$	hr/yr

## 4.1 EMISSIONS CALCULATION USING MATERIAL BALANCE

Material balance is the preferred method for estimating emissions of VOCs and organic HAPs used in materials such as solvents, cleaners and blowing agents where the VOC or HAP is not incorporated into the final product. In order to use this approach, some information about the material is needed. Information such as material density, VOC content, and pollutant concentration can usually be found on the manufacturer's technical specification sheet or the material safety data sheet (MSDS).

If the pollutant concentration in a material is known, non-consumable VOC and HAP emissions from plastic products manufacturing may be estimated using a material balance approach by applying Equation 11.4-1:

$$E_{hr, x} = Q_{in} * X_{in} - Q_{out} * X_{out} \quad (11.4-1)$$

where:

- $E_{hr, x}$  = Hourly emissions of pollutant x (lb/hr)
- $Q_{in}$  = Material entering the process (gal/hr)
- $Q_{out}$  = Material leaving the process as waste, recovered material, or in product (gal/hr)
- $X_{in}$  = Concentration of pollutant x (lb/gal) in raw material entering a process
- $X_{out}$  = Concentration of pollutant x (lb/gal) in raw material exiting a process

The term  $Q_{out}$  may actually involve several different "fates" for an individual pollutant. This could include the amount recovered (or recycled), the amount leaving the process in the product, the amount leaving the process in the wastewater, the amount being converted to another compound, or the amount of material shipped off-site as hazardous waste. A thorough knowledge of the different fates for the pollutant of interest is necessary for an accurate emissions estimate. Example 11.4-1 illustrates the use of Equation 11.4-1.

Example 11.4-1

This example shows how non-consumable VOC emissions may be calculated using Equation 11.4-1.

In a given 1-hour period, a facility uses 2 gallons of a cleaning solvent containing 7.5 lb VOC/gal. At the end of the 1-hour period, 1.5 gallons of solvent remain. Based on hazardous waste profiles for this application you know the spent solvent contains 6.0 lb VOC/gal. Using the variables defined above, this information may be presented as:

$$\begin{aligned} Q_{in} &= 2.0 \text{ gal/hr} \\ Q_{out} &= 1.5 \text{ gal/hr} \\ X_{in} &= 7.5 \text{ lb VOC/gal} \\ X_{out} &= 6.0 \text{ lb VOC/gal} \end{aligned}$$

From Equation 11.4-1, VOC emissions are calculated as follows:

$$\begin{aligned} E_{hr, \text{VOC}} &= Q_{in} * X_{in} - Q_{out} * X_{out} \\ &= 2.0 \text{ (gal/hr)} * 7.5 \text{ (lb VOC/gal)} - 1.5 \text{ (gal/hr)} * 6.0 \text{ (lb VOC/gal)} \\ &= 6.0 \text{ (lb VOC/hr)} \end{aligned}$$

If the pollutant concentration in a material is unknown, but material density and the percentage, by mass, of a pollutant in material is known, a material balance approach may also be used. In this case, non-consumable VOC and HAP emissions may be estimated by using Equation 11.4-2:

$$E_{hr, x} = (Q_{in} - Q_{out}) * d * (\text{wt}\%_x)/100 \quad (11.4-2)$$

where:

$$\begin{aligned} E_{hr, x} &= \text{Hourly emissions of pollutant } x \text{ (lb/hr)} \\ Q_{in} &= \text{Material entering the process (gal/hr)} \\ Q_{out} &= \text{Material leaving the process as waste, recovered material, or in product (gal/hr)} \\ d &= \text{Density of material (lb/gal)} \\ \text{wt}\%_x &= \text{Percentage by weight of speciated pollutant } x \text{ in material (\%)} \end{aligned}$$

Example 11.4-2 illustrates the use of Equation 11.4-2.

#### Example 11.4-2

This example shows how toluene emissions may be estimated for a cleaning process using toluene-containing cleaner given the following data:

$$Q_{in} = 2 \text{ gal/hr}$$

$$Q_{out} = 1.5 \text{ gal/hr}$$

$$d = 7.5 \text{ lb/gal}$$

$$wt\%_x = 25\% \text{ toluene}$$

$$\begin{aligned} E_{hr, \text{ toluene}} &= (Q_{in} - Q_{out}) * d * (wt\%_{\text{toluene}})/100 \\ &= (2 \text{ gal/hr} - 1.5 \text{ gal/hr}) * 7.5 \text{ lb/gal} * 25/100 \\ &= 0.94 \text{ lb toluene/hr} \end{aligned}$$

## 4.2 EMISSIONS CALCULATION USING SOURCE TEST DATA

Stack sampling test methods can be used to estimate PM, consumable VOC, and inorganic HAP emission rates from plastic products manufacturing. Most sampling methods provide pollutant concentration data through grab sampling followed by laboratory analysis. Concentration data are used with exhaust flow rate measurements to determine an emission rate. Volumetric flow rates can be determined from flow rate meters or from pressure drops across a critical orifice (e.g., EPA Method 2). A detailed discussion of the applicability of stack sampling test methods for selected pollutants may be found in Chapter 1 of this volume.

Stack sampling test reports often provide chemical concentration data in parts per million by volume dry (ppmvd). For gaseous pollutants, the concentration of a pollutant ( $C_x$ ) at standard temperature and pressure can be determined using Equation 11.4-3:

$$C_x = K_t * K_p * C_{a,x} \quad (11.4-3)$$

where:

$$\begin{aligned} C_x &= \text{Concentration of pollutant } x \text{ at standard temperature, pressure (ppmvd)} \\ K_t &= \text{Temperature correction for differences in temperature during test (dimensionless)} \\ K_p &= \text{Pressure correction for differences in pressure during test (dimensionless)} \\ C_{a,x} &= \text{Average concentration of pollutant } x \text{ during test (ppmvd)} \end{aligned}$$



If the concentration is known, an hourly emission rate can be determined using Equation 11.4-4:

$$E_{hr,x} = (C_x * MW_x * V) / (M * 10^6) \quad (11.4-4)$$

where:

$E_{hr,x}$	=	Hourly emissions of pollutant x (lb/hr)
$C_x$	=	Concentration of pollutant x at standard temperature, pressure (ppmvd)
$MW_x$	=	Molecular weight of pollutant x (lb/lb-mole)
$V$	=	Stack gas volumetric flow rate (dscf/hr)
$M$	=	Molar volume; i.e., volume occupied by 1 mole of ideal gas at standard temperature and pressure (385.5 scf/lb-mole at 68°F and 1 atm)

Emissions in tons per year can be calculated by multiplying the hourly emission rate (lb/hr) from Equation 11.4-4 by the number of operating hours (as shown in Equation 11.4-5 below).

$$E_{an,x} = E_{hr,x} * OH * 1 \text{ ton}/2,000 \text{ lb} \quad (11.4-5)$$

where:

$E_{an,x}$	=	Annual emissions of pollutant x (ton/yr)
$E_{hr,x}$	=	Total hourly emissions of pollutant x (lb/hr)
$OH$	=	Operating hours (hr/yr)

Example 11.4-3 illustrates the use of Equations 11.4-3 through 11.4-5.

Concentration data obtained from source testing may come in a variety of units, including parts per million (ppm) or grams per dry standard cubic feet (g/dscf), and in a variety of conditions, such as wet, dry, or excess oxygen (O<sub>2</sub>). This may require conversion of concentration data to consistent units for compatibility with the equations given above.

Example 11.4-3

This example shows how annual hydrogen chloride (HCl) emissions can be calculated using the data obtained from a stack test. The concentration of HCl is calculated using Equation 11.4-3, hourly emissions are calculated using Equation 11.4-4, and annual emissions are calculated using Equation 11.4-5.

Given:

$$\begin{aligned}
 K_t &= 1.0 \\
 K_p &= 0.8 \\
 C_{a,HCl} &= 15.4 \text{ ppmvd (obtained from stack test data)} \\
 MW_{HCl} &= 36.46 \text{ lb/lb-mole of HCl} \\
 V &= 20,500 \text{ dscf/hr} \\
 OH &= 1,760 \text{ hr/yr} \\
 M &= 385.5 \text{ ft}^3/\text{lb-mole}
 \end{aligned}$$

The concentration of HCl ( $C_{HCl}$ ) is calculated from Equation 11.4-3:

$$\begin{aligned}
 C_{HCl} &= K_t * K_p * C_{a,HCl} \\
 &= 1.0 * 0.8 * 15.4 \text{ ppmvd} \\
 &= 12.32 \text{ ppmvd}
 \end{aligned}$$

Hourly emissions are calculated using Equation 11.4-4:

$$\begin{aligned}
 E_{hr,HCl} &= (C_{HCl} * MW_{HCl} * V) / (M * 10^6) \\
 &= 12.32 \text{ ppmvd} * 36.46 \text{ lb/lb-mole} * 20,500 \text{ dscf/hr} / (385.5 \text{ ft}^3 / \text{lb-mole} * 10^6) \\
 &= 0.02 \text{ lb/hr}
 \end{aligned}$$

Annual emissions are calculated using Equation 11.4-5:

$$\begin{aligned}
 E_{an,HCl} &= E_{HCl} * OH * 1 \text{ ton}/2,000 \text{ lb} \\
 &= 0.02 \text{ lb/hr} * 1,760 \text{ hr/yr} * 1 \text{ ton}/2,000 \text{ lb} \\
 &= 0.02 \text{ ton/yr}
 \end{aligned}$$

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# 5

## ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

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Source testing, material balance, and emission factors are all alternative methods for estimating organic compound emissions (including VOC and HAP) and inorganic compound emissions from primary processes at plastic products manufacturing facilities. Emission factors may be used as an alternative method for estimating emissions of PM.

The following equations and examples present how source test data, emission factors and material balance may be used to estimate PM, VOC (consumable and non-consumable), speciated organic, and speciated inorganic emissions. Table 11.5-1 lists the variables and symbols used in the following discussions.

### 5.1 EMISSIONS CALCULATION USING SOURCE TEST DATA

Various stack sampling test methods can be used to estimate non-consumable VOC and speciated organic emission rates from plastic products manufacturing (e.g., EPA Method 25). Volumetric flow rates can be determined from flow rate meters or from pressure drops across a critical orifice (e.g., EPA Method 2).

Stack sampling test reports often provide chemical concentration data in parts per million by volume dry (ppmvd). For gaseous pollutants, the concentration of a pollutant ( $C_x$ ) can be determined from Equation 11.5-1:

$$C_x = K_t * K_p * C_{a,x} \quad (11.5-1)$$

TABLE 11.5-1

## LIST OF VARIABLES AND SYMBOLS

Variable	Symbol	Units
Concentration of pollutant x at standard temperature, pressure	$C_x$	ppmvd or lb/gal
Temperature correction for differences in temperature during test	$K_t$	dimensionless
Pressure correction for differences in pressure during test	$K_p$	dimensionless
Average concentration of pollutant x during test	$C_{a,x}$	parts per million by volume dry (ppmvd) or lb/gal
Hourly emissions of pollutant x	$E_{hr,x}$	lb/hr
Molecular weight of pollutant x	$MW_x$	lb/lb-mole
Stack gas volumetric flow rate	$V$	dry standard cubic feet per hour (dscf/hr)
Molar volume	$M$	cubic feet (ft <sup>3</sup> )/lb-mole
Concentration of pollutant x in material entering a process	$X_{in}$	parts per million by volume dry (ppmvd), lb/gal, lb/lb
Concentration of pollutant x in material exiting a process	$X_{out}$	parts per million by volume dry (ppmvd), lb/gal, lb/lb
Annual emissions of pollutant x	$E_{an,x}$	ton/yr
Operating hours	OH	hr/yr
Emission factor for pollutant x	$EF_x$	lb/units
Activity factor	AF	units/hr
Material entering the process	$Q_{in}$	typically gal/hr or lb/hr
Material leaving the process as waste, recovered material, or in product	$Q_{out}$	typically gal/hr or lb/hr

where:

- $C_x$  = Concentration of pollutant x (ppmvd) at standard temperature, pressure
- $K_t$  = Temperature correction for differences in temperature during test (dimensionless)
- $K_p$  = Pressure correction for differences in pressure during test (dimensionless)
- $C_{a,x}$  = Average concentration of pollutant x (ppmvd) during test

If the concentration is known, an hourly emission rate can be determined using Equation 11.5-2:

$$E_{hr,x} = (C_x * MW_x * V) / (M * 10^6) \quad (11.5-2)$$

where:

- $E_x$  = Hourly emissions of pollutant x (lb/hr)
- $C_x$  = Concentration of pollutant x (ppmvd)
- $MW_x$  = Molecular weight of pollutant x (lb/lb-mole)
- $V$  = Stack gas volumetric flow rate (dscf/hr)
- $M$  = Molar volume; i.e., volume occupied by 1 mole of ideal gas at standard temperature and pressure (385.5 ft<sup>3</sup>/lb-mole at 68°F and 1 atm)

Emissions in tons per year can be calculated by multiplying the average hourly emission rate (lb/hr) from Equation 11.5-2 by the number of operating hours (as shown in Equation 11.5-3 below) or by multiplying an average emission factor (lb/gal) by the total annual amount of material used (gal).

$$E_{an,x} = E_{hr,x} * OH * 1 \text{ ton}/2,000 \text{ lb} \quad (11.5-3)$$

where:

- $E_{an,x}$  = Annual emissions of pollutant x (ton/yr)
- $E_{hr,x}$  = Hourly emissions of pollutant x (lb/hr)
- $OH$  = Operating hours (hr/yr)

Example 11.5-1 illustrates the use of Equations 11.5-1 through 11.5-3.

Concentration data obtained from source testing may come in a variety of units, including parts per million (ppm) or grams per dry standard cubic feet (g/dscf), and in a variety of conditions, such as wet, dry, or excess O<sub>2</sub>. This may require conversion of concentration data to consistent units for compatibility with the equations given above.

### Example 11.5-1

This example shows how annual methyl ethyl ketone (a non-consumable VOC) emissions can be calculated using data obtained from a stack test. The concentration of methyl ethyl ketone (MEK) is calculated using Equation 11.5-1, hourly emissions are calculated using Equation 11.5-2, and annual emissions are calculated using Equation 11.5-3.

Given:

$$\begin{aligned} K_t &= 1.0 \\ K_p &= 0.8 \\ C_{a, \text{MEK}} &= 9 \text{ ppmvd (obtained from stack test data)} \\ MW_{\text{MEK}} &= 72.11 \text{ lb/lb-mole of MEK} \\ V &= 30,200 \text{ dscf/hr} \\ OH &= 1,760 \text{ hr/yr} \\ M &= 385.5 \text{ ft}^3/\text{lb-mole} \end{aligned}$$

The concentration of MEK ( $C_{\text{MEK}}$ ) is calculated from Equation 11.5-1:

$$\begin{aligned} C_{\text{MEK}} &= K_t * K_p * C_{a, \text{MEK}} \\ &= 1.0 * 0.8 * 9 \text{ ppmvd} \\ &= 7.2 \text{ ppmvd} \end{aligned}$$

Hourly emissions are calculated using Equation 11.5-2:

$$\begin{aligned} E_{\text{hr, MEK}} &= (C_{\text{MEK}} * MW_{\text{MEK}} * V) / (M * 10^6) \\ &= 7.2 \text{ ppmvd} * 72.11 \text{ lb/lb-mole} * 30,200 \text{ dscf/hr} / (385.5 \text{ ft}^3/\text{lb-mole} * 10^6) \\ &= 0.04 \text{ lb/hr} \end{aligned}$$

Annual emissions are calculated using Equation 11.5-3:

$$\begin{aligned} E_{\text{an, MEK}} &= E_{\text{hr, MEK}} * OH * 1 \text{ ton}/2,000 \text{ lb} \\ &= 0.04 \text{ lb/hr} * 1,760 \text{ hr/yr} * 1 \text{ ton}/2,000 \text{ lb} \end{aligned}$$

## 5.2 EMISSIONS CALCULATION USING EMISSION FACTORS

Emission factors may be used to estimate PM, VOC (consumable and non-consumable), organic HAP, and inorganic HAP emissions from plastic products manufacturing operations using Equation 11.5-4:

$$E_{hr,x} = EF_x * AF \quad (11.5-4)$$

where:

$$\begin{aligned} E_{hr,x} &= \text{Hourly emissions of pollutant } x \text{ (lb/hr)} \\ EF_x &= \text{Emission factor for pollutant } x \text{ (lb/units)} \\ AF &= \text{Activity factor (units/hr)} \end{aligned}$$

Example 11.5-2 illustrates the use of Equation 11.5-4. It should be noted that at this time, there is not a comprehensive listing of emission factors for all plastic products manufacturing processes, and emission factors will need to be developed for each pollutant and process or operation of interest.

### Example 11.5-2

This example shows how PM emissions can be calculated for a high-density polyethylene (HDPE) blow molding process using an emission factor<sup>a</sup> and Equation 11.5-4 given the following data:

$$\begin{aligned} EF_{PM} &= 19.6 \text{ lb PM/million lb HDPE (at } 380^\circ\text{F)} \\ AF &= 2,000 \text{ lb HDPE/hr} \end{aligned}$$

$$\begin{aligned} E_{hr, PM} &= EF_{PM} * AF \\ &= (19.6 \text{ lb PM}/1 * 10^6 \text{ lbs HDPE}) * (2,000 \text{ lb HDPE/hr}) \\ &= 3.92 * 10^{-2} \text{ lb PM/hr} \end{aligned}$$

<sup>a</sup> The emission factor used in this example comes from the SPI study mentioned previously (Barlow et al., 1996).



### 5.3 EMISSIONS CALCULATION USING MATERIAL BALANCE

Consumable VOC emissions from plastic products manufacturing may be estimated using a material balance approach by applying Equation 11.5-5:

$$E_{hr,x} = Q_{in} * X_{in} - Q_{out} * X_{out} \quad (11.5-5)$$

where:

$E_{hr,x}$	=	Hourly emissions of pollutant x (lb/hr)
$Q_{in}$	=	Material entering the process (gal/hr or lb/hr)
$Q_{out}$	=	Material leaving the process as waste, recovered material, or in product (gal/hr or lb/hr)
$X_{in}$	=	Concentration of pollutant x (lb/gal) in raw material entering a process
$X_{out}$	=	Concentration of pollutant x (lb/gal) in raw material exiting a process

The term  $Q_{out}$  may actually involve several different “fates” for an individual pollutant. This could include the amount recovered (or recycled), the amount leaving the process in the product, the amount leaving the process in the wastewater, the amount being converted to another compound or the amount of material shipped off-site as hazardous waste. A thorough knowledge of the different fates for the pollutant of interest is necessary for an accurate emissions estimate. Fates of pollutants should include pollutants created through chemical degradation or re-polymerization. Example 11.5-3 illustrates the use of Equation 11.5-5.

Example 11.5-3

This example shows how to calculate emissions evolving from blowing agents used in foam production. Most blowing agents contain VOCs that immediately volatilize during foam processing; however, depending on the blowing agent used, some of the blowing agent remains in the product after processing.

Over a 30 day period a polystyrene packaging plant manufactures consumer products using pentane as a blowing agent. Using a mass balance approach, calculate the emissions for the facility for the last month (30 days). Assume the blowing agent leaves the facility only as product or as emissions.

Given:

$$\begin{aligned}Q_{in} &= 66,500 \text{ lbs of pure pentane} \\X_{in} &= 1 \text{ lb pentane/lb pentane} \\Q_{out} &= 1,000,000 \text{ lbs of polystyrene product} \\X_{out} &= 3.6\% \text{ pentane, measured by GC or gravimetric methods}\end{aligned}$$

Solution:

$$E_x = Q_{in} * X_{in} - Q_{out} * X_{out}$$

Note that  $Q_{in}$  is known and equals 66,500 lbs of blowing agent, so:

$$\begin{aligned}E_{\text{pentane}} &= Q_{in} - Q_{out} * X_{out} \\E_{\text{pentane}} &= 66,500 \text{ lbs} - 1,000,000 \text{ lbs product} * 3.6 \text{ (lb pentane/100 lbs product)} \\E_{\text{pentane}} &= 30,500 \text{ lbs of pentane emitted in 30 days}\end{aligned}$$

or

$$E_{\text{pentane}} = 30,500 / (30 \text{ days} * 24 \text{ hr/day}) = 42.36 \text{ lbs/hr}$$

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# 6

## QUALITY ASSURANCE/QUALITY CONTROL

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Quality assurance (QA) and quality control (QC) are essential elements in producing high quality emission estimates and should be included in all methods used to estimate emissions. QA/QC of emissions estimates are accomplished through a set of procedures that ensure the quality and reliability of data collection and processing. These procedures include the use of appropriate emission estimation methods, reasonable assumptions, data reliability checks, and accuracy/logic checks of calculations. Volume VI of this EIIP document series, *Quality Assurance Procedures*, describes methods and tools for performing these QA/QC procedures.

In addition, Chapter 1 of this EIIP Point Sources Volume, *Introduction to Point Source Emission Inventory Development*, provides QA/QC guidance for preparing point source emission estimates. The following sections discuss QA/QC considerations that are specific to the emission estimation methods presented in this chapter for estimating emissions from plastic products manufacturing.

### 6.1 QA/QC FOR USING MATERIAL BALANCE

The material balance method for estimating emissions may use various approaches, so the QA/QC considerations will vary and may be specific to an approach. Generally, the fates of all materials of interest are identified, and then the quantity of material allocated to each fate determined. Identifying these fates, such as material contained in a product or material leaving the process in the wastewater, is usually straightforward. However, estimating the amount of material allocated to each fate is sometimes complicated and is the prime QA/QC consideration in using the material balance approach. Amounts obtained by direct measurement are more accurate and produce emission estimates of higher quality than those obtained by engineering or theoretical calculations. QA/QC of an emissions estimate developed from a material balance approach should include a thorough check of all assumptions and calculations.

### 6.2 QA/QC FOR USING EMISSION FACTORS

When using emission factors to estimate emissions from plastic products manufacturing, the applicability and representativeness of the emission factor are the first criteria to consider. To assess applicability, the reviewer needs to examine how closely the process of interest matches

the process for which the emission factor is available. Similarly, the reviewer should look at how well the range of conditions on which the available emission factor is based compares to the conditions of interest. For example, an emission factor that is based on a strand extruder process may be appropriate for a conservative estimate of emissions from heavy sheet and profile extrusion (as well as closed mold operations such as injection molding) and thermoforming, but may not be the best emission factor for a film process.

### 6.3 QA/QC FOR USING SOURCE TEST DATA

In reviewing stack sampling data, the first consideration is whether the method measures the pollutant of interest or can only be used as a surrogate. For example, if particulate matter concentration in a hood exhaust is measured, PM-10 emissions could be estimated only after assuming all, or a given percentage, of the particulate is present as PM-10. Next, the reviewer should determine whether the sampling conditions represent the operating conditions of interest for the emission estimate. For example, if the data are to be used to estimate emissions during typical operations, then sampling should have been done during typical operating conditions. Parameters that should be evaluated in QA/QC of stack sampling data and the acceptance criteria for stack sampling are presented in Chapter 1 of this volume and in the individual test methods.

### 6.4 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

One measure of emission inventory data quality is the DARS score. Chapter 4 of Volume VI, *Quality Assurance Procedures*, and the QA/QC section in Chapter 1 of this volume provide a complete discussion of DARS. DARS assumes activity data and factor data are used to generate an inventory and provides criteria that are used to assign a numerical score to each data set. The activity score is multiplied by the factor score to obtain a composite score for the emissions estimate. The highest (best) possible value for an individual or composite score is 1.0. The composite score for the emissions estimate can be used to evaluate the quality and accuracy of the estimate.

DARS was used to evaluate the methods for estimating emissions that are presented in this document to provide an idea of the relative quality of each method. This was accomplished by assuming an inventory was developed using each method and using DARS to score each inventory. Because the inventories are hypothetical, it was necessary to make some additional assumptions. The first three assumptions were that emissions are for a 1-year period, from one process or from one facility, and for normal operating conditions. Also, all material usage data used were assumed to be reasonably accurate. Some scores are expressed as a range, with the lower value representing an estimate developed from low- to medium-quality data and the upper value representing an estimate based on relatively high-quality data. Tables 11.6-1 through

11.6-3 present the DARS scores for the different emission estimation methods presented in this chapter. It should be noted that the DARS scoring is currently applied manually, but the system will eventually be publicly available as an electronic tool.

Comparing the scores for the different methods, the preferred methods (material balance and source testing) received higher scores and the alternative method (emission factors) received the lowest. The material balance method for estimating emissions received the highest DARS score (0.98), as shown in Table 11.6-1. Note that the score is based on the assumption that the factor data were measured continuously during the year (the inventory period) and that the pollutant is a non-consumable VOC. Also, note that if factor data and activity data are measured continuously over the year, a perfect score (1.0) is possible for an emissions estimate when using material balance. Table 11.6-1 assumes the pollutant being estimated is a non-consumable VOC.

The source testing approach received the next highest overall score (0.78-0.93), as shown in Table 11.6-2. As indicated by the scores, the major parameters affecting the quality of stack sampling data are the number of tests (range of process rates; number of tests performed over the year) and the frequency of measurement of activity data (intermittent or continuous). A high DARS score for an emissions estimate based on stack sampling data is possible if the factor data are the result of numerous tests performed during typical operations and the emission activity data are the result of continuous measurements over the inventory period.

In using DARS to score the emission factor approach, the example provided shows how the representativeness (or quality) of an emission factor may vary and how emission factor quality affects emission estimates. The example shown in Table 11.6-3 assumes the emission factor was developed from a process that is similar, if not identical, to the process for which the emissions estimate was made. Because the emission factor represents a process similar to the inventory process, a high score is assigned. Assuming the activity data were measured continuously, a composite score of 0.83 to 0.90 results. The lower value reflects the score assigned to an estimate based on a lower-quality emission factor and the upper value reflects an estimate based on a higher-quality emission factor. As shown by the scores in Table 11.6-3, the quality of an emissions estimate developed from emission factors is directly affected by the quality of the emission factors and can vary greatly. The scores also indicate that a source-specific emission factor may produce an emissions estimate of higher quality than an estimate developed from a factor developed for a similar process.

The examples provided in the tables are given as an illustration of the relative quality of each estimation method. If DARS was applied to actual inventories developed using the preferred and alternative methods and data of reasonably good quality were used for each method, the scores could be different; however, the relative ranking of the methods would be expected to remain the same.

TABLE 11.6-1

**DARS SCORES: MATERIAL BALANCE DATA<sup>a</sup>**

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/Method	0.9	1.0	0.9	Factor is based on accurate data	Direct, continuous measurement of activity
Source Specificity	1.0	1.0	1.0	Factor developed specifically for the intended source	Activity data represent the emission process exactly
Spatial Congruity	1.0	1.0	1.0	Factor developed for and specific to the given spatial scale	Activity data developed for and specific to the inventory area (one process)
Temporal Congruity	1.0	1.0	1.0	Factor developed for and applicable to the same temporal scale	Activity data specific to 1 year
Composite Score	0.98	1.0	0.98		

<sup>a</sup> The “activity” is the amount of material (pollutant) used in a year and is directly measurable. The “factor” is the fraction of material used that is emitted to the atmosphere. The fraction is based on engineering calculations and is assumed to remain constant over the year. Example assumes pollutant being scored is a non-consumable VOC.

TABLE 11.6-2

## DARS SCORES: SOURCE TEST DATA

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/Method	0.7 - 0.9	0.9 - 1.0	0.63 - 0.9	Lower score reflects a small number of tests at typical process rates; upper score represents numerous tests over a range of process loads	Lower score reflects direct, intermittent measurement of activity; upper score reflects direct, continuous measurement of activity
Source Specificity	1.0	1.0	1.0	Factor developed specifically for the intended source	Activity data represent the emission process exactly
Spatial Congruity	1.0	1.0	1.0	Factor developed for and specific to the given spatial scale (one process)	Activity data developed for and specific to the inventory area (one process)
Temporal Congruity	0.7 - 0.9	0.7 - 0.9	0.49 - 0.81	Lower score reflects factor developed for a shorter time period with moderate to low temporal variability; upper score reflects factor derived from an average of numerous tests during the year	Lower score reflects activity data representative of short period of time with low to moderate temporal variability; upper score reflects activity data measured numerous times during the year
Composite Score	0.85 - 0.95	0.90 - 0.98	0.78 - 0.93		



TABLE 11.6-3

**DARS SCORES: SOURCE-SPECIFIC EMISSION FACTOR DATA<sup>a</sup>**

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/Method	1.0	0.9 - 1.0	0.9 - 1.0	Continuous or near-continuous measurement of pollutant	Lower scores reflect direct, intermittent measurement of activity; upper scores reflect direct, continuous measurement of activity
Source Specificity	0.8	1.0	0.8	Factor developed for a similar category; low variability	Activity data represent the emission process exactly
Spatial Congruity	0.9	1.0	0.9	Factor developed from a process of similar size; low variability	Activity data developed for and specific to the inventory area (one process)
Temporal Congruity	1.0	0.7 - 0.9	0.7 - 0.9	Factor developed for and applicable to a period of 1 year	Lower score reflects activity data representative of short period of time with low to moderate temporal variability; upper score reflects activity data measured numerous times during the year
Composite Score	0.93	0.90 - 0.98	0.83 - 0.90		

<sup>a</sup> Assumes emission factor was developed from an identical or similar facility and is of high quality.

# 7

## DATA CODING PROCEDURES

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This section describes the methods and codes available for characterizing emission sources at plastic products manufacturing facilities. Consistent categorization and coding will result in greater uniformity among inventories. In addition, the procedures described here will assist the reader who is preparing data for input to the Aerometric Information Retrieval System (AIRS) or a similar database management system. The use of the Source Classification Codes (SCCs) provided in Table 11.7-1 is recommended for describing various plastic products manufacturing operations. Refer to the Clearinghouse for Inventories and Emission Factors (CHIEF) web site ([www.epa.gov/ttn/chief](http://www.epa.gov/ttn/chief)) for these codes and any additional codes that may be added to describe plastic products manufacturing operations.

### 7.1 SOURCE CLASSIFICATION CODES

SCCs for various processes occurring at plastic products manufacturing facilities are presented in Table 11.7-1.

### 7.2 AIRS CONTROL DEVICE CODES

Control device codes that may be applicable to plastic products manufacturing operations are presented in Table 11.7-2. These should be used to enter the type of applicable emission control device into the AIRS Facility Subsystem (AFS). The "099" control code may be used for miscellaneous control devices that do not have a unique identification code.

TABLE 11.7-1

**SOURCE CLASSIFICATION CODES FOR PLASTIC PRODUCTS  
MANUFACTURING PROCESSES**

<b>Source Description</b>	<b>Process Description</b>	<b>SCC</b>	<b>Units</b>
Plastic Production	Extruder	30101809	Tons Product
		30101814	Tons Product
		30101863	Tons Product
	Conveying	30101810	Tons Product
	Storage	30101811	Tons Product
	Pellet Silo	30101815	Tons Product
	Transferring/Handling/Loading/Packing	30101816	Tons Product
	Extruding/Pelletizing/Conveying/Storage	30101821	Tons Product
	Resin Storage Tank	30101840	1000 Gallons Thinned-Resins Stored
	Pellet Silo/Storage	30101864	Tons Product
	Transferring/Conveying	30101865	Tons Product
	Packing/Shipping	30101866	Tons Product
	Blowing Agent: Freon (Polyether Resins)	30101871	Tons Product
	Blowing Agent: Freon (Polyurethane)	30101881	Tons Agent Used
	Blowing Agent: Methylene Chloride (Polyurethane)	30101882	Tons Agent Used
	Transferring/Conveying/Storage (Polyurethane)	30101883	Tons Product
	Packing/shipping (Polyurethane)	30101884	Tons Product
	Raw Material Storage	30101893	Tons Raw Material
	Solvent Storage	30101894	Tons Solvent
	Plastic Production - Others Not Specified	30101899	Tons Product
Rubber & Misc. Plastics Products - Fiberglass Resin Products	Plastic Machining: Drilling/Sanding/Sawing, etc.	30800701	Tons Processed
	Mould Release	30800702	Tons Product
	Solvent Consumption	30800703	Tons Solvent
	Adhesive Consumption	30800704	Tons Adhesive
	Wax Burnout Oven	30890001	Tons Was Burned

**TABLE 11.7-2****AIRS CONTROL DEVICE CODES FOR PLASTIC PRODUCTS MANUFACTURING**

<b>Control Device</b>	<b>Code</b>
Centrifugal Collector - High Efficiency	007
Centrifugal Collector - Medium Efficiency	008
Centrifugal Collector - Low Efficiency	009
Fabric Filter - High Temperature	016
Fabric Filter - Medium Temperature	017
Fabric Filter - Low Temperature	018
Activated Carbon Adsorption	048
Single Cyclone	075
Miscellaneous Control Device	099

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# **APPENDIX A**

## **EXAMPLE DATA COLLECTION FORMS AND INSTRUCTIONS - PLASTIC PRODUCTS MANUFACTURING**

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**EXAMPLE DATA COLLECTION FORMS INSTRUCTIONS -  
PLASTIC PRODUCTS MANUFACTURING FACILITIES**

1. These forms may be used as worksheets to aid the plant engineer in collecting the information necessary to calculate emissions from plastic products manufacturing facilities. The information requested on the forms relates to the methods (described in Sections 3, 4, and 5) for quantifying emissions. These forms may also be used by the regulatory agency to assist in area wide inventory preparation.
2. The completed forms should be maintained in a reference file by the plant engineer with other supporting documentation.
3. If the information requested is unknown, write "unknown" in the blank. If the information requested does not apply to a particular unit or process, write "NA" in the blank.
4. If you want to modify the form to better serve your needs, an electronic copy of the form may be obtained through the EIIP on the Clearinghouse for Inventories and Emission Factors (CHIEF) web site.
5. Collect all Material Safety Data Sheets (MSDSs) for all materials containing potential air contaminants that are used at the facility.
6. The plant engineer should maintain all material usage information and MSDSs in a reference file.

**EXAMPLE DATA COLLECTION FORM****FORM A: GENERAL INFORMATION**

Facility/Plant: \_\_\_\_\_

SIC Code: \_\_\_\_\_

SCC: \_\_\_\_\_

SCC Description: \_\_\_\_\_

Location

County: \_\_\_\_\_

City: \_\_\_\_\_

State: \_\_\_\_\_

Parent Company Name and Address: \_\_\_\_\_

Plant Geographical Coordinates

Latitude: \_\_\_\_\_

Longitude: \_\_\_\_\_

UTM Zone: \_\_\_\_\_

UTM Easting: \_\_\_\_\_

UTM Northing: \_\_\_\_\_

Date of Initial Operation: \_\_\_\_\_

Source ID Number: \_\_\_\_\_

Type of Plant: \_\_\_\_\_

Permit Number: \_\_\_\_\_

Permitted Hours of Operation (Per Year): \_\_\_\_\_

Actual Hours of Operation (Per Year): \_\_\_\_\_

Hours/Day: \_\_\_\_\_

Days/Week: \_\_\_\_\_

Weeks/Year: \_\_\_\_\_

Contact Name: \_\_\_\_\_

Title: \_\_\_\_\_

Telephone Number: \_\_\_\_\_

## EXAMPLE DATA COLLECTION FORM

**FORM B: SOURCE INFORMATION** (complete a separate form for each process unit)

Unit ID:

Permit No.:

Location:

Unit Description:

Source ID Number:

Manufacturer:

Date Installed:

Date Modified:

Operating Schedule:

Hours/Day:

Days/Week:

Weeks/Year:

Raw Material Used:

Material Name <sup>a</sup>	Constituents	Mass %	Annual Usage <sup>b</sup>	Reclaim <sup>b</sup>

<sup>a</sup> For resins, specify resin type<sup>b</sup> Document annual usage and reclaim quantities with appropriate units (i.e., tons, gallons).

**EXAMPLE DATA COLLECTION FORM****FORM C: CONTROL DEVICE INFORMATION** (complete a form for each control device)

Unit ID: \_\_\_\_\_

Permit No.: \_\_\_\_\_

Location: \_\_\_\_\_

Pollutant Controlled: \_\_\_\_\_

Control Efficiency (Indicate source of information): \_\_\_\_\_

Type of Control Device: \_\_\_\_\_

☐ Baghouse☐ Thermal Incinerator☐ Other (indicate type) \_\_\_\_\_

Manufacturer: \_\_\_\_\_

Date Installed: \_\_\_\_\_

Date Modified: \_\_\_\_\_

Operating Schedule: \_\_\_\_\_

Hours/Day: \_\_\_\_\_

Days/Week: \_\_\_\_\_

Weeks/Year: \_\_\_\_\_

Source(s) Linked to this Control Device: \_\_\_\_\_

**EXAMPLE DATA COLLECTION FORM****FORM D: STACK INFORMATION** (if applicable)

Stack ID:

Unit ID:

Stack (Release) Height (ft):

Stack Diameter (inch):

Stack Gas Temperature (°F):

Stack Gas Velocity (ft/sec):

Stack Gas Flow Rate (dscf/hr):

Source(s) Linked to this Stack:



### EXAMPLE DATA COLLECTION FORM

**FORM E: MATERIAL DATA FORMS** (to be completed for each material used)

Manufacturer Name:

Material Description or Brand Name and Number:

Typical Units (Check one):

☐ Gallons    ☐ Pounds    ☐ Cubic Feet    ☐ Other

Density: \_\_\_\_\_ lb/gal                      or                      \_\_\_\_\_ lb/ft<sup>3</sup>

Volatile Organic Compound (VOC) Content: \_\_\_\_\_ lb/gal or  
 \_\_\_\_\_ wt % VOC in the material

Solids Content: wt % solids in the material

True Vapor Pressure \_\_\_\_\_ psia  
@ 70°F:

Boiling Point: \_\_\_\_\_ °F

### Antoine's Coefficients:

A \_\_\_\_\_ B \_\_\_\_\_  
C Ref

---

Molecular Weight: lb/lb-mole

Fuels: Heat Content \_\_\_\_\_ Btu usage/unit \_\_\_\_\_

## EXAMPLE DATA COLLECTION FORM

**FORM F: MATERIAL DATA FORMS** (to be completed for each raw material used) (cont.)

Component Name	CAS# <sup>a</sup>	Wt % in Material	ppmv in Material

<sup>a</sup> Provide Chemical Abstract Service number if applicable.

[illegible]

## FORM H: FACILITY-WIDE RESIN USAGE

Calendar Year \_\_\_\_\_

[illegible]

## FORM I: FACILITY-WIDE SOLVENT USAGE

Calendar Year \_\_\_\_\_

[illegible]

## EXAMPLE DATA COLLECTION FORM

SCC Name: \_\_\_\_\_

SCC: \_\_\_\_\_

**FORM J: ANNUAL FACILITY-WIDE EMISSION ESTIMATES<sup>d</sup>** (this form must be completed for each SCC)

[illegible]

<sup>a</sup> Pollutants include VOCs, PM/PM-10, and HAPs (list individually).

<sup>b</sup> Use the following codes to indicate which emission estimation method is used for each pollutant:

Emission Factor = EF

Material Balance = MB

Other Method (indicate) = 0

Stack Test = ST

Emission Model = EM

<sup>c</sup> Where applicable, enter the emission factor and provide full citation of the reference or source of information from where the emission factor came. Indicate edition, version, table and page numbers if *AP-42* is used.

<sup>d</sup> Emissions must be calculated for all process activities (i.e., process unit operations, process vessel cleaning, spills, material handling, solvent reclamation, etc.)

Please copy the blank form and attach additional sheets, as necessary.

## FORM K: ANNUAL FACILITY-WIDE EMISSION SUMMARY

[illegible]

# HOW TO INCORPORATE THE EFFECTS OF AIR POLLUTION CONTROL DEVICE EFFICIENCIES AND MALFUNCTIONS INTO EMISSION INVENTORY ESTIMATES

July 2000



Prepared by:  
Eastern Research Group, Inc.

Prepared for:  
Point Sources Committee  
Emission Inventory Improvement Program



## **DISCLAIMER**

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

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# 1

## INTRODUCTION

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There are two approaches used by owners and operators of industry to reduce pollution:

- Preventing pollution from forming by alternating manufacturing or production practices, substitution of raw materials, or improved process control methods; and
- Achieving emissions reductions with control equipment which capture or destroy pollutants which would otherwise be released.

Sometimes, both approaches are employed.

Emission inventory preparers often have to estimate emission reductions or emission control efficiencies of specific types of air pollution control devices (APCDs). Also, they sometimes must estimate the effect on emission levels caused by APCD malfunctions. Depending on the known operating characteristics of the facility and purposes of the inventory, state and local inventory preparers may need to apply an adjustment to the control device efficiency values to correct the underestimation of emissions if the control efficiency used is based on design specifications or is based on controls specified by a regulation. Applying an adjustment has the effect of reducing the assumed control device efficiency and increasing the estimated emissions. This is a reasonable assumption since control equipment may sometimes fail or be off line for maintenance, etc. This adjustment has been incorrectly called Rule Effectiveness (RE) and a default value of 80 percent has been frequently used. Much confusion has existed over the Environmental Protection Agency's (EPA) RE policy and its application. EPA has drafted a paper that clarifies the confusion and addresses the applicability of RE to emission inventories and the draft paper is included in Appendix A. Additionally, the Emission Inventory Improvement Program (EIIP) Point Sources Committee has published a technical paper, titled *Emission Inventories and Proper Use of Rule Effectiveness*, addressing the application of RE to emission inventories. The technical paper is also included in Appendix B and may be accessed through EPA's CHIEF web site at: <http://www.epa.gov/ttn/chief>. Guidance contained in Chapter 12 allows the inventory preparer to avoid the necessity of using the 80 percent adjustment factor.

This document provides background information and can be used as a primer to gain a basic understanding of different air pollution control devices, how they work, the pollutants they control, and how to adjust emission estimates to account for APCD malfunction.

This document focuses only on the following basic types of APCDs used in industry today:

- Mechanical collectors;
- Scrubbers;
- Fabric filters;
- Electrostatic precipitators;
- Incinerators;
- Condensers;
- Catalytic reactors;
- Absorbers (where pollutants are collected as the molecules pass through the surface of the absorbent to become distributed throughout the phase); and
- Adsorbers (where pollutants are collected by concentration on the surface of a liquid or solid).

Various terms may be used to describe a specific air pollution control device. Appendix C presents a cross-reference for terms used to identify air pollution control devices.

EPA uses “criteria pollutants” as indicators of air quality. These pollutants are:

- Ozone ( $O_3$ );
- Nitrogen oxides ( $NO_x$ );
- Sulfur dioxide ( $SO_2$ );
- Particulate matter with aerodynamic diameter less than or equal to 10 microns ( $PM_{10}$ );
- Particulate matter with aerodynamic diameter less than or equal to 2.5 microns ( $PM_{2.5}$ );
- Carbon monoxide (CO); and
- Lead (Pb).

While industrial ozone emissions are not usually regulated, EPA also regulates emissions of volatile organic compounds (VOC) under criteria pollutant programs. VOC are ozone precursors—they react with  $\text{NO}_x$  in the atmosphere in the presence of sunlight to form ozone.

This document identifies the APCDs used for criteria pollutants and presents ranges of typical control efficiencies. Section 2 describes the criteria pollutants. Sections 3 and 4 of this document discuss the different types of APCDs and the pollutants they are intended to control. Appendix G presents data sources for information presented in Section 5. Appendix D provides details on how the control efficiency data were compiled and presented in Section 3 of this document and contains a summary of additional data acquired but not evaluated for this document. Section 5 presents the information necessary (including example calculations) to assist an inventory preparer in determining the impact of APCD malfunction on emissions from point sources. Example calculations and example scenarios are presented in Appendices E and F.

For detailed descriptions and additional information on APCDs, refer to the references listed in Section 6 of this document. Appendix G presents data sources for information presented in Section 5.

## 1.1 WHAT IS CONTROL EFFICIENCY?

Control efficiency (CE) is a measure of emission reduction efficiency. It is a percentage value representing the amount of emissions that are controlled by a control device, process change, or reformulation.

## 1.2 HOW DO I DETERMINE CONTROL EFFICIENCY?

Control efficiency is calculated as:

$$\frac{\text{Uncontrolled Emission Rate} - \text{Controlled Emission Rate}}{\text{Uncontrolled Emission Rate}} * 100 \quad (12.1-1)$$

If the emission rates (or concentration) are not known and the control efficiency cannot be calculated, another method for determining efficiency is to refer to Section 3 of this document that presents summary tables (Tables 12.3-1 through 12.3-7) for the control efficiencies of APCDs used to reduce nitrogen oxides, sulfur dioxide, volatile organic compounds, particulate matter, and carbon monoxide. These values are averages and may not be accurate for individual



situations. Consult permit applications for APCD design efficiencies of particular equipment if needed. Refer to Section 5 for determining control efficiency during APCD malfunction.

For fabric filters, which are used to reduce PM emissions, if the actual (measured) concentration of PM in the inlet stream to the fabric filter and the expected concentration of PM in the outlet stream are known, Equation 12.1-1 may be used to back calculate the control efficiency. Generally, fabric filters are designed to reduce overall PM emissions to below an expected concentration when the inlet concentrations are within a specified range. For example, the design specifications for a fabric filter may state that the expected outlet emissions are 0.01 grains of PM per dry standard cubic foot of stack gas (gr/dscf) when the inlet emissions are between 5 and 20 gr/dscf. Thus, the outlet emission rate remains relatively “constant” even though the inlet concentration varies and, as the inlet emissions decrease, the overall control efficiency is decreased. Therefore controlled emissions are calculated using the dust loading in the flue gas and the exhaust flow rate. There is no need to estimate the control efficiency. Example 12.1-1 shows how PM emissions are calculated using stack gas outlet concentrations and flow rate.

#### Example 12.1-1

This example shows how to estimate PM emissions from a fabric filter when exit gas flow rate and dust concentration is known.

$E_{PM} = Q \times C$  where:

$Q$  = exit gas flow rate (dscf/min)

$C$  = PM concentration (gr/dscf)

$$\begin{aligned} E_{PM} &= Q \times C \\ &= 50,000 \text{ (dscf/min)} \times 0.01 \text{ (gr/dscf)} \\ &= 500 \text{ (gr/min)} \end{aligned}$$

To convert to (lb/hr):

$$\begin{aligned} E(\text{lb/hr}) &= E \text{ (gr/min)} \times (1 \text{ lb}/7,000 \text{ gr}) \times (60 \text{ min/hr}) \\ &= 500 \text{ (gr/min)} \times (1 \text{ lb}/7,000 \text{ gr}) \times (60 \text{ min/hr}) \\ &= 4.29 \text{ (lb/min)} \end{aligned}$$

Note that in this example inlet concentration and control efficiency data are not needed.

### **1.3 CAN I ASSUME APCDs ARE ALWAYS OPERATED AT THE MAXIMUM LEVEL OF EFFICIENCY?**

No. Some facilities do not always operate devices at their maximum level of efficiency. Although APCDs should be designed to accommodate reasonable process variation and some deterioration, some types of control devices vary in efficiency based on process equipment operating rates, fuel quality, and age. Usually an emission limit must be met and the primary goal of the facility is to meet that limit. It may or may not be necessary to operate the control device at its maximum level of efficiency in order to meet that limit. Also, in most cases, operation below maximum efficiency can reduce operating costs.

Moreover, as detailed in Section 1.4, there are many factors that may reduce the level of efficiency of a control device.

### **1.4 HOW DO I ESTIMATE ACTUAL CONTROL EFFICIENCY?**

You can use the control efficiencies presented in Tables 12.3-1 through 12.3-7 and information about the operating conditions of the device to estimate actual control efficiency. These are typical values. Facility operators, engineers, and maintenance personnel are most qualified to provide more specific information. You can also use the references in each table for more information. Permit applications may also provide information.

Questions that should be asked or information that should be obtained, are described below:

- How old is the control device? Some devices are affected by age and their control efficiencies deteriorate over time if not properly maintained. In the case of an ESP, for example, the collection efficiency declines due to corrosion, warpage, and the accumulation of non-removeable dust on surfaces.
- Is the control device properly maintained? Most devices require routine maintenance and some devices may require intensive maintenance. For example, the bags (filters) in a fabric filter should be cleaned when they are blinded by a permanently entrained cake of particulate matter. Bags can also develop rips if not replaced frequently enough. The fields in an electrostatic precipitator must be maintained to operate at a specific voltage. If a device is not properly maintained, the control efficiency will be reduced.
- Is the device operated under conditions necessary for maximum efficiency and are these conditions monitored? A fabric filter may be designed to operate at a

specific pressure drop in order to attain maximum efficiency and the pressure should be monitored. A thermal incinerator must operate at a particular temperature and residence time, and these parameters should also be monitored. Wet scrubbers must have the scrubbing liquor available at all times in proper amounts. When a device is not operated properly, the control efficiency will be reduced.

- What is the throughput to the control device relative to its design capacity? If a device is operated above its design capacity, the control efficiency may be reduced. For example, if too much gas is forced through a wet scrubber, channeling of gas can result and the control efficiency is reduced.

**Note:** The inventory preparer should use the information obtained from facility personnel to determine the adjustment to the control efficiency value provided in Tables 12.3-1 through 12.3-7 to estimate an actual control efficiency.

## 1.5 WHEN MULTIPLE CONTROL DEVICES ARE USED, ARE THEIR EFFICIENCIES ADDITIVE?

No. In general, when estimating the overall control efficiency for a combination of control devices in series, inventory preparers should not assume the overall efficiency is additive or cumulative. This is because control efficiency for a particular device is often dependent on the inlet concentration. The overall control efficiency of a series of APCDs is typically higher than the efficiencies of the individual control devices, but smaller than the sum of the individual control efficiencies. However, in some cases the control efficiencies of multiple devices in series may be assumed to be additive. In this case, the overall control efficiency of a series of "n" devices is:

$$CE \text{ (overall)} = 1 - [ (1 - CE_1/100) * (1 - CE_2/100) * \dots * (1 - CE_n/100) ] \quad (12.1-2)$$

When the last device in a series of control devices is a fabric filter, you should assume that the control efficiency of the APCDs is equal to the control efficiency of the fabric filter, and the other devices help to reduce the load on the fabric filter. For example, suppose a wood boiler is equipped with a multicyclone designed to operate at a control efficiency of 60 percent and a fabric filter designed to operate at 99 percent, then the overall control efficiency is likely to be around 99 percent, and for all practical purposes, can be assumed to be 99 percent.

# 2

## DESCRIPTION OF CRITERIA POLLUTANTS

---

### 2.1 OZONE (O<sub>3</sub>)

Ozone, a colorless gas, is the major component of smog. Except for very low levels of emissions from a limited number of processes, ozone is not emitted directly into the air but is formed in the atmosphere in the presence of sunlight through complex chemical reactions between precursor emissions of VOC and NO<sub>x</sub> in the presence of sunlight. These reactions are accelerated by sunlight and increased temperatures and, therefore, peak ozone levels typically occur during the warmer times of the year.

### 2.2 NITROGEN OXIDES (NO<sub>x</sub>)

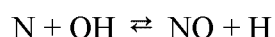
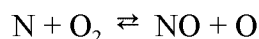
Nitrogen oxides include numerous compounds comprised of nitrogen and oxygen. Nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>) are the most significant nitrogenous compounds, in terms of quantity released to the atmosphere. Generally, sources of NO<sub>x</sub> emissions may be categorized either as stationary or mobile, and as combustion processes or noncombustion processes. Nitric oxide is the primary nitrogen compound formed in high temperature combustion processes when nitrogen present in the fuel and/or combustion air combines with oxygen. On a national basis, total emissions of NO<sub>x</sub> from noncombustion stationary sources (such as chemical processes) are small relative to those from stationary combustion sources (such as utility boilers).

#### 2.2.1 HOW ARE NITROGEN OXIDES FORMED IN STATIONARY COMBUSTION SOURCES?

The formation of NO<sub>x</sub> from a specific combustion device is determined by the interaction of chemical and physical processes occurring within the device. The three principal types of NO<sub>x</sub> formations are:

- **Thermal NO<sub>x</sub>:** Formed through high temperature oxidation of the nitrogen found in the high-temperature post-flame region of the combustion system. During

combustion, oxygen radicals (O) are formed and attack atmospheric nitrogen molecules to start the reactions that comprise the thermal NO<sub>x</sub> formation mechanism:



Four factors influence thermal NO<sub>x</sub> formation:

- Temperature;
- Oxygen concentration;
- Nitrogen concentration; and
- Residence time.

Of these, temperature is the most important. Significant levels of NO<sub>x</sub> are usually formed above 2200°F under oxidizing conditions, with exponential increases as the temperature increases. Maximum thermal NO<sub>x</sub> production occurs at a slightly lean fuel-to-air ratio due to the excess availability of oxygen for reaction within the hot flame zone. Thermal NO<sub>x</sub> is typically controlled by reducing the peak and average flame temperatures. If the temperature or the concentration of oxygen or nitrogen can be reduced quickly after combustion, thermal NO<sub>x</sub> formation can be suppressed or “quenched.”

- **Fuel NO<sub>x</sub>:** Formed by the oxidation of fuel-bound nitrogen to NO<sub>x</sub> during combustion. Nitrogen found in fuels such as coal and residual oils is typically bound to the fuel as part of the organic compounds in the fuel. The rate of fuel NO<sub>x</sub> formation is strongly affected by the mixing rate of the fuel and air, and by the oxygen concentration. Although fuel NO<sub>x</sub> levels increase with increasing fuel nitrogen content, the increase is not proportional. In general, the control strategy for reducing fuel NO<sub>x</sub> formation involves increasing the fuel-to-air ratio. The fuel-bound nitrogen is released in a reducing atmosphere as molecular nitrogen (N<sub>2</sub>) rather than being oxidized to NO<sub>x</sub>. As with thermal NO<sub>x</sub>, controlling excess oxygen is an important part of controlling fuel NO<sub>x</sub> formation.

- **Prompt NO<sub>x</sub>:** Formed in the combustion system through the reaction of hydrocarbon fragments and atmospheric nitrogen. The name reflects the fact that prompt NO<sub>x</sub> is formed very early in the combustion process. The formation of prompt NO<sub>x</sub> is weakly dependent on temperature and is significant only in very fuel-rich flames. It is not possible to quench prompt NO<sub>x</sub> formation, as it is for thermal NO<sub>x</sub> formation.

The traditional parameters leading to complete fuel combustion (high temperatures, long residence time, and high turbulence or mixing) all tend to **increase** the rate of NO<sub>x</sub> formation.

### 2.2.2 HOW ARE NITROGEN OXIDES FORMED IN STATIONARY NONCOMBUSTION SOURCES?

Stationary noncombustion sources include various chemical processes, such as nitric acid and explosives manufacturing. In these processes, the formation of NO<sub>x</sub> generally results from nitrogen compounds used or produced in chemical reactions.

### 2.2.3 WHAT CHARACTERISTICS OF NITROGEN OXIDES DETERMINE THE TYPE OF AIR POLLUTION CONTROL DEVICE USED FOR EMISSIONS CONTROL?

Characteristics of nitrogen oxides that impact the effectiveness of specific air pollution control devices include:

- NO<sub>x</sub> can be chemically reduced by reburning using natural gas. NO<sub>x</sub> can also be reduced by injecting ammonia or urea at the proper temperature with or without a catalyst.
- The quantity of NO<sub>x</sub> formed during combustion depends on: the quantity of nitrogen and oxygen available; temperature; level of mixing; and the time for reaction. Management of these parameters can form the basis of control strategies involving process control and burner design (low NO<sub>x</sub> burners and flue gas recirculation).

## 2.3 SULFUR DIOXIDE (SO<sub>2</sub>)

### 2.3.1 HOW IS SULFUR DIOXIDE FORMED?

Sulfur oxides, primarily SO<sub>2</sub> and sulfur trioxide (SO<sub>3</sub>), are formed whenever any material that contains sulfur is burned. From 95 to 100 percent of the total sulfur oxides emissions are in the form of SO<sub>2</sub>, which is formed during combustion via the following reaction:



### 2.3.2 WHAT CHARACTERISTICS OF SULFUR DIOXIDE DETERMINE THE TYPE OF AIR POLLUTION CONTROL DEVICE USED FOR EMISSIONS CONTROL?

Characteristics of SO<sub>2</sub> that impact the effectiveness of specific air pollution control devices include:

- Sulfur can sometimes be removed from fuel prior to combustion. This may be a cost effective way to reduce SO<sub>2</sub> formation.
- SO<sub>2</sub> is chemically reactive. Therefore, control techniques that reduce pollutant levels via chemical reaction (such as wet acid gas scrubbers and spray dryer absorbers) are appropriate. Also, it can be removed by fluidized limestone bed combustion.
- Formation of SO<sub>2</sub> occurs early in the primary flame and will occur even in fuel-rich flames. As a result, combustion control techniques are not applicable to reduce SO<sub>2</sub> emissions.
- Formation of SO<sub>3</sub> is found to occur only in fuel-rich mixtures and can be influenced by control of combustion conditions.

## **2.4 VOLATILE ORGANIC COMPOUNDS (VOC)**

### **2.4.1 HOW ARE VOLATILE ORGANIC COMPOUNDS FORMED?**

The class of air pollutants referred to as volatile organic compounds includes hundreds of individual compounds, each with its own chemical and physical properties. VOC are emitted from combustion processes, industrial operations, solvent evaporation, and a wide variety of other sources.

### **2.4.2 WHAT CHARACTERISTICS OF VOLATILE ORGANIC COMPOUNDS DETERMINE THE TYPE OF AIR POLLUTION CONTROL DEVICE USED FOR EMISSIONS CONTROL?**

Characteristics of VOC that impact the effectiveness of specific air pollution control devices include:

- Most VOC are adsorbable and may be collected by concentration on the surface of a liquid or solid.
- VOC are combustible and may be oxidized by thermal or catalytic incineration.

## **2.5 PARTICULATE MATTER (PM)**

### **2.5.1 HOW IS PARTICULATE MATTER FORMED?**

Particulate matter can be formed as the result of three processes:

- Materials handling or processing (e.g., crushing or grinding ores, loading bulk materials, sanding of wood, abrasive cleaning [sandblasting]);
- Combustion can emit particles of noncombustible ash or incompletely burned materials; and
- Gas conversion reactions or condensation in the atmosphere.



### **2.5.2 WHAT CHARACTERISTICS OF PARTICULATE MATTER DETERMINE THE TYPE OF AIR POLLUTION CONTROL DEVICE USED FOR EMISSIONS CONTROL?**

Characteristics of PM that impact the effectiveness of specific air pollution control devices include:

- Particle size and size distribution;
- Particle shape;
- Particle density;
- Stickiness;
- Corrosivity;
- Condensation temperature;
- Reactivity; and
- Toxicity.

You must also consider these characteristics of the flue gas stream:

- Gas flow rate;
- Particulate loading;
- Pressure;
- Temperature;
- Viscosity;
- Humidity;
- Chemical composition; and
- Flammability.

## 2.6 CARBON MONOXIDE (CO)

### 2.6.1 HOW IS CARBON MONOXIDE FORMED?

During the combustion of any carbonaceous fuel, CO can be formed as the result of two mechanisms:

- **Incomplete combustion.** The burning of carbonaceous fuels is a complex chemical process. Carbon monoxide formed as the first step in the combustion process is then converted to carbon dioxide (CO<sub>2</sub>) by combustion with oxygen at temperatures greater than 1160°F. When less than the stoichiometric amount of oxygen is present, CO is the final product of the reaction.
- **High-temperature dissociation of CO<sub>2</sub>.** The bond energy for CO<sub>2</sub> is moderately low. At high temperatures CO<sub>2</sub> easily dissociates to form CO and oxygen (O<sub>2</sub>).

At elevated temperatures, an increase in oxygen concentration tends to decrease CO levels not only by allowing for complete combustion, but because reaction rates increase with temperature, increasing the chance for collision between CO and O<sub>2</sub> molecules.

### 2.6.2 WHAT CHARACTERISTICS OF CARBON MONOXIDE DETERMINE THE TYPE OF AIR POLLUTION CONTROL DEVICE USED FOR EMISSIONS CONTROL?

Characteristics of carbon monoxide that impact the effectiveness of specific air pollution control devices include:

- The quantity of CO formed during combustion depends on: quantity of oxygen available; temperature; level of mixing; and the time for reaction. Management of these parameters can form the basis of control strategies involving process control and burner design.
- CO is combustible and can be oxidized to CO<sub>2</sub>.

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# 3

## CONTROL TECHNIQUES FOR CRITERIA POLLUTANTS

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A variety of practices and equipment are applied either individually or in combination, to reduce the emissions of criteria pollutants. In general, these techniques can be classified into:

- **Process modifications.** These are changes made to the chemical, physical, or thermal process. Process modifications include:
  - Substitution of raw materials. For example, a facility could change the solvent used in a chemical process to reduce VOC emissions.
  - Substitution of fuels. For example, an electrical utility could switch to coal with a lower sulfur content, or use a pre-processed or alternative fuel.
  - Modification of the combustion unit or changing the conditions within the combustion unit. For example, the temperature profile in a boiler can be controlled to limit the formation of nitrogen oxides by the application of combustion unit modifications such as low NO<sub>x</sub> burners.
- **Post-process modifications.** Also referred to as “end-of-pipe” or “tailpipe” modifications, these techniques are applied downstream of the process, after the flue gas has passed through the combustion or reaction unit. For example, ammonia can be injected into the post-combustion flue gas stream to reduce NO<sub>x</sub> emissions.

### 3.1 HOW ARE APPROPRIATE AIR POLLUTION CONTROL DEVICES SELECTED?

Selection of the appropriate air pollution control device may be based on the following criteria:

- The physical and chemical characteristics of the pollutant. For example, particulate (solid) matter pollutants are controlled by different techniques and equipment than gaseous pollutants. Also, the particle shape and size, as well as

chemical reactivity, abrasiveness, and toxicity of PM pollutants must be considered.

- Gas stream characteristics such as volumetric flow rate, temperature, humidity, density, viscosity, toxicity, or combustibility may limit the applicability of a specific APCD in some facilities.
- Control efficiency of the device. Federal, state, or local regulations may dictate specific emission limits for pollutants based on control efficiency.
- Requirements for handling and disposal of collected waste. For example, wet scrubber installations have to consider treatment of wastewater and dry scrubbers produce quantities of dry fine particulate that must be disposed of.
- Siting characteristics such as available space; ambient conditions; availability of utilities such as power and water; availability of ancillary system facilities such as waste treatment and disposal.
- Economic considerations:
  - Capital costs including equipment costs, installation costs, and engineering fees;
  - Operating costs including fuel, treatment chemicals, utilities, and maintenance; and
  - Expected equipment lifetime.

An air pollution control device or process change selected to reduce emissions of one pollutant can result in increased emissions of another pollutant. For example, increasing the air-to-fuel ratio (i.e., increasing the amount of oxygen available during combustion) is an effective mechanism to decrease CO emissions, but it dramatically increases NO<sub>x</sub> emissions. Care must be taken to ensure that the entire emission control system provides adequate control of all emissions. Selection of APCDs is normally made on flue gas stream-specific characteristics, pollutant characteristics, and desired control efficiency.

## **3.2 CONTROL OF NITROGEN OXIDES EMISSIONS**

### **3.2.1 WHAT PROCESS AIR POLLUTION CONTROL DEVICES ARE TYPICALLY USED TO CONTROL NITROGEN OXIDES EMISSIONS?**

Process controls typically used to control NO<sub>x</sub> emissions include fuel switching and fuel denitrification.

#### ***Fuel Switching***

Conversion to a fuel with a lower nitrogen content or one that burns at a lower temperature may result in a reduction of NO<sub>x</sub> emissions. Combustion of natural gas or distillate oils tends to result in lower NO<sub>x</sub> emissions than is the case for coal or heavy fuel oils. While fuel switching may be an attractive alternative from the standpoint of NO<sub>x</sub> emission reductions, technical constraints and the availability and costs of alternative fuels are major considerations in determining the viability of fuel switching. Moreover, fuel switching may result in greater emissions of other criteria pollutants.

#### ***Fuel Denitrification***

Fuel denitrification of coal or heavy oils could, in principle, be used to control fuel NO<sub>x</sub> formation. Denitrification currently occurs as a side benefit of fuel pretreatment to remove other pollutants, such as pretreatment of oil by desulfurization and chemical cleaning, or solvent refining of coal for ash and sulfur removal. The low denitrification efficiency and high costs of these processes do not make them attractive on the basis of NO<sub>x</sub> control alone, but they may prove cost effective on the basis of total environmental impact.

### **3.2.2 WHAT COMBUSTION AIR POLLUTION CONTROL DEVICES ARE TYPICALLY USED TO CONTROL NITROGEN OXIDES EMISSIONS?**

NO<sub>x</sub> reduction mechanisms applied during the combustion process include controlling the rate of the fuel-air mixing, reducing oxygen availability in the initial (primary) combustion zone, and reducing peak flame temperatures. These include:

- Low NO<sub>x</sub> burners (refer to Section 4.3);
- Natural gas burner/reburn (refer to Section 4.4);
- Water/stream injection (refer to Section 4.5);

- Staged combustion (refer to Section 4.6);
- Flue gas recirculation (refer to Section 4.7);
- Low excess air (refer to Section 4.8); and
- Staged overfire air (refer to Section 4.9).

### **3.2.3 WHAT POST-PROCESS AIR POLLUTION CONTROL DEVICES ARE TYPICALLY USED TO CONTROL NITROGEN OXIDES EMISSIONS?**

Post-process controls are techniques applied downstream of the combustion unit. In post-process control,  $\text{NO}_x$  is reduced to nitrogen and water through a series of reactions with a chemical agent injected into the flue gas. These emission control techniques include:

- Selective catalytic reduction (refer to Section 4.1); and
- Selective noncatalytic reduction (refer to Section 4.2).
- Nonselective catalytic reduction (refer to Section 4.10).

Table 12.3-1 presents control efficiencies for the various APCDs used to reduce nitrogen oxide emissions. The table presents average, maximum, and minimum control efficiencies reported in the references by each unique combination of emission source and control device. Refer to Appendix D for a complete description of how the data were compiled and presented. Appendix D also contains tables that present control efficiencies reported in the references for control devices not evaluated in this document.

## **3.3 CONTROL OF SULFUR DIOXIDE EMISSIONS**

### **3.3.1 WHAT PROCESS AIR POLLUTION CONTROL DEVICES ARE TYPICALLY USED TO CONTROL SULFUR DIOXIDE EMISSIONS?**

Process controls typically used to control  $\text{SO}_2$  emissions include fuel switching, coal washing, coal gasification and liquefaction, desulfurization of oil and natural gas, and fluidized bed combustion.

### ***Fuel Switching***

Approximately two-thirds of the sulfur dioxide emitted in the United States are from coal-fired power plants. Many coal-fired facilities attempt to reduce these emissions by switching to coal with a lower sulfur content, such as subbituminous coal which generally contains less sulfur than bituminous coal.

### ***Coal Washing***

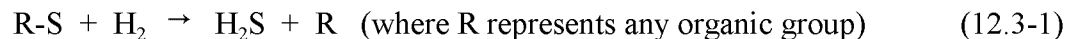
Much of the sulfur in coal is in pyrite ( $\text{FeS}_2$ ) or in mineral sulfate form, much of which can be removed by washing or other physical cleaning processes. However, disposal of the solid or liquid wastes formed during these processes can be difficult and/or expensive.

### ***Coal Gasification and Liquefaction***

Organic sulfur, which is part of the molecular structure of the coal, cannot be removed by washing or other physical cleaning processes. Chemical desulfurization of organic sulfur from coal is extremely expensive. Coal gasification and liquefaction can remove much of the organic sulfur, but results in a substantial loss of total available heating value.

### ***Desulfurization of Oil and Natural Gas***

The sulfur in crude oils and natural gas can be removed easily and economically and the elemental sulfur recovered as a by-product can be sold as a raw material. The steps in the desulfurization of oil or natural gas are:



### ***Fluidized Bed Combustion***

Also, combustion of crushed coal in a bed of a sorbent material (fluidized-bed combustion) can reduce  $\text{SO}_2$  emissions. Sulfur dioxide in the coal reacts with limestone or dolomite in the bed to form gypsum.



### **3.3.2 WHAT POST-PROCESS AIR POLLUTION CONTROL DEVICES ARE TYPICALLY USED TO CONTROL SULFUR DIOXIDE EMISSIONS?**

Dry and wet scrubbing are the most common technologies to desulfurize flue gas. Slurries of sorbent and water react with SO<sub>2</sub> in the flue gas. Refer to Sections 4.11 through 4.13.

Table 12.3-2 presents control efficiencies for the various APCDs used to reduce SO<sub>2</sub> emissions. This table presents average, maximum, and minimum control efficiencies reported in the references by each unique combination of emission source and control device. Refer to Appendix D for a complete description of how the data are compiled and presented. For those wanting additional information, Appendix D also presents control efficiencies reported in the references for control devices not evaluated in this document.

## **3.4 CONTROL OF VOLATILE ORGANIC COMPOUNDS**

### **3.4.1 WHAT PROCESS AIR POLLUTION CONTROL DEVICES ARE TYPICALLY USED TO CONTROL VOLATILE ORGANIC COMPOUNDS EMISSIONS?**

Typical strategies are:

- Change of coating formulation, such as conversion to water-based paint;
- Change from a VOC-based coating to a non-liquid coating such as powder coat; and
- Change to coating methods that increase transfer efficiency and reduce total coatings used per application.

### **3.4.2 WHAT POST-PROCESS AIR POLLUTION CONTROL DEVICES ARE TYPICALLY USED TO CONTROL VOLATILE ORGANIC COMPOUNDS EMISSIONS?**

Typical post-process control devices of VOC are:

- Carbon adsorber (refer to Section 4.14);
- Incinerator (refer to Sections 4.15 through 4.17);
- Floating-roof storage tank (refer to Section 4.18);
- Vapor capture device during tank filling; and

- Fluid capture, recycle, and reuse.

Table 12.3-3 presents control efficiencies for the various APCDs used to reduce VOC emissions. This table presents average, maximum, and minimum control efficiencies reported in the references by each unique combination of emission source and control device. Refer to Appendix D for a complete description of how the data are compiled and presented. Appendix D also contains tables that present control efficiencies reported in the references for control devices not evaluated.

**Note:** Many VOC emission sources are processes that are not enclosed or contained and the VOC are emitted into the ambient work area. Before the emissions can be routed to a control device, they must first be captured. There are many types of capture systems (a laboratory hood is a good example) and they seldom capture 100% of the emissions. Although the capture efficiency of a system does not always affect the control efficiency of a downstream control device, it does affect the estimate of overall emissions reduction and, thus, the emissions estimate. Therefore, inventory preparers should be aware that, for some processes, not all of the VOCs generated are captured and controlled. Where a capture system is used, they should talk to facility personnel to get an idea of the efficiency of the system. The questions provided in Section 1.4 about control devices can be used as a guide for obtaining information about capture systems.

## 3.5 CONTROL OF PARTICULATE MATTER

### 3.5.1 WHAT PROCESS AIR POLLUTION CONTROL DEVICES ARE TYPICALLY USED TO CONTROL PARTICULATE MATTER EMISSIONS?

Process controls typically used to control particulate matter emissions include fuel switching, coal cleaning, and good combustion practices.

#### ***Fuel Switching***

Fuel type has a great impact on particulate matter emissions. PM emissions can be reduced by fuel substitution. Coal and fuel oil contain a variety of noncombustible minerals and mineral oxides that are collectively referred to as ash. In terms of fuel composition, ash content of fuel is the major factor in determining PM emissions: the higher the ash content, the higher the amount of PM emitted from combustion. Fuel substitution can have a significant impact on PM emissions. Reductions in emissions of PM<sub>10</sub> and PM<sub>2.5</sub> resulting from fuel substitution are shown in Tables 12.3-4 and 12.3-5.

In many cases, switching fuels will impact more than one type of pollutant. For example, substituting natural gas for coal to reduce PM emissions can also effectively reduce sulfur dioxide and nitrogen oxides emissions. However, switching to low sulfur coal to reduce sulfur dioxide emissions can increase PM emissions.

### ***Coal Cleaning***

Physical cleaning of coal can be used to reduce mineral matter. This decreases PM emissions and increases the energy content of the coal, but may not always be cost effective.

### ***Good Combustion Practices***

Incomplete combustion can result in increased particulate emissions due to unburned carbon material released as particulate matter. Particulate emissions can be controlled by following “good combustion practices” that include design and operational elements such as:

- Control of the amount and distribution of excess air in the combustion zone;
- Adequate turbulence in the combustion zone to ensure good mixing;
- High temperature zone to ensure complete burning; and
- Sufficient residence time (1 - 2 seconds) at the high temperature.

These good combustion practices also limit CO and dioxin/furan emissions, but can increase the formation of NO<sub>x</sub>.

## **3.5.2 WHAT POST-PROCESS AIR POLLUTION CONTROL DEVICES ARE TYPICALLY USED TO CONTROL PARTICULATE MATTER EMISSIONS?**

Four classes of control equipment are used to remove PM from gas streams:

- Mechanical collectors such as cyclones (refer to Section 4.19);
- Electrostatic precipitators (refer to Section 4.20);
- Fabric filters, also referred to as baghouses (refer to Section 4.21); and
- Wet PM scrubbers (refer to Section 4.22).

Table 12.3-6 presents CE for the various APCDs used to reduce PM emissions. This table presents average, maximum, and minimum CE reported in the references by each unique combination of emission source and control device.

## **3.6 CONTROL OF CARBON MONOXIDE**

Process controls typically used to control CO emissions include fuel switching, good combustion practices; and CO catalyst.

### **3.6.1 WHAT PROCESS AIR POLLUTION CONTROL DEVICES ARE TYPICALLY USED TO CONTROL CARBON MONOXIDE EMISSIONS?**

#### ***Fuel Switching***

Fuel substitution can be used as a technique to reduce CO emissions because CO emissions from coal-fired combustion are usually higher than those from the combustion of oil or natural gas. Note, however that fuel substitution may result in higher emissions of other pollutants.

#### ***Good Combustion Practices***

CO emissions can be controlled by following “good combustion practices” because CO emissions from well-operated boilers are usually quite low. Good combustion practices include:

- Control of the amount and distribution of excess air in the combustion zone;
- Adequate turbulence in the combustion zone to ensure good mixing;
- High temperature zone to ensure complete burning; and
- Sufficient residence time (1 - 2 seconds) at the high temperature.

#### ***CO Catalysts***

CO oxidation catalysts are typically used on gas turbines to control CO emissions, especially turbines that use steam injection which can increase CO and unburned hydrocarbons in the exhaust. CO catalysts are also being used to reduce gaseous organic compounds, including organic HAPs emissions.

### 3.6.2 WHAT POST-PROCESS COMBUSTION AIR POLLUTION CONTROL DEVICES ARE TYPICALLY USED TO CONTROL CARBON MONOXIDE EMISSIONS?

Post-process techniques to reduce CO emissions are based on treatment of the exhaust gas to oxidize CO to CO<sub>2</sub>. Air pollution control devices used are:

- Thermal oxidizers (refer to Section 4.15);
- Catalytic oxidizers (refer to Section 4.16); and
- Flares (refer to Section 4.17).

The most critical operating parameter, in terms of limiting CO emissions, is the air-to-fuel ratio. There must be sufficient levels of oxygen available to ensure complete combustion of CO to CO<sub>2</sub>.

Some catalysts that reduce emissions of CO may decrease SO<sub>2</sub> emissions and increase in NO<sub>x</sub> emissions.

Table 12.3-7 presents control efficiencies for the various APCDs used to reduce CO emissions. This table presents average, maximum, and minimum control efficiencies reported in the references by each unique combination of emission source and control device.

TABLE 12.3-1

CONTROL EFFICIENCIES (%) FOR NO<sub>x</sub> BY SOURCE CATEGORY AND CONTROL DEVICE TYPE

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference
					Minimum Value	Maximum Value	
Chemical Manufacturing	Acrylonitrile-Incinerator Stacks	Selective Non-catalytic Reduction	80	a			
Fuel Combustion-Coal	Boiler	Flue Gas Recirculation			5	45	b
Fuel Combustion-Coal	Boiler	Low Excess Air			5	30	
Fuel Combustion-Coal	Boiler	Low NO <sub>x</sub> Burners			35	55	f
Fuel Combustion-Coal	Boiler	Natural Gas Burners/Reburn			50	70	c
Fuel Combustion-Coal	Boiler	Overfire Air			5	30	b
Fuel Combustion-Coal	Boiler	Selective Catalytic Reduction			63	94	d
Fuel Combustion-Coal	Boiler	Selective Non-catalytic Reduction	90	b			
Fuel Combustion-Distillate Oil	Boiler	Flue Gas Recirculation			45*	55*	f
Fuel Combustion-Distillate Oil	Boiler	Low Excess Air			2	19	
Fuel Combustion-Distillate Oil	Boiler	Overfire Air			20	45	f
Fuel Combustion-Distillate Oil	Boiler	Selective Catalytic Reduction				90	b
Fuel Combustion-Coal		Low-NO <sub>x</sub> Burner with Selective Non-catalytic Reduction			50	80	f

\* Average of widely varying values.

TABLE 12.3-1

CONTROL EFFICIENCIES (%) FOR NO<sub>x</sub> BY SOURCE CATEGORY AND CONTROL DEVICE TYPE (CONTINUED)

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference
					Minimum Value	Maximum Value	
Fuel Combustion-Coal		Low -NO <sub>x</sub> Burner with Overfire Air and Selective Catalytic Reduction			85	95	f
Fuel Combustion Coal	Boiler	Low -NO <sub>x</sub> Burner with Overfire Air			40	60	f
Fuel Combustion-Municipal Waste	Boiler	Selective Catalytic Reduction	69	b		80	a
Fuel Combustion-Municipal Waste	Incinerator	Selective Non-catalytic Reduction			30	65	a
Fuel Combustion-Natural Gas	Boiler	Flue Gas Recirculation			49	68	b
Fuel Combustion-Natural Gas	Boiler	Low Excess Air			0	31	b
Fuel Combustion-Natural Gas	Boiler	Low NO <sub>x</sub> Burners			40	85	e
Fuel Combustion-Natural Gas	Boiler	Overfire Air	60	b	13	73	b
Fuel Combustion-Natural Gas	Boiler	Selective Catalytic Reduction			80	90	e
Fuel Combustion-Natural Gas	Boiler	Selective Non-catalytic Reduction			35	80	b
Fuel Combustion-Natural Gas	Gas Turbines	Selective Catalytic Reduction			60	96	g
Fuel Combustion-Natural Gas	Gas Turbines	Water or Steam Injection			60	94	g
Fuel Combustion-Natural Gas	Reciprocating Engines	Selective Non-catalytic Reduction			80	90	e
Fuel Combustion- Natural Gas	Gas Turbines	Staged Combustion			50	80	g
Fuel Combustion-Natural Gas	Boiler	Low-NO <sub>x</sub> Burner with Overfire Air			40	50	f

TABLE 12.3-1

CONTROL EFFICIENCIES (%) FOR NO<sub>x</sub> BY SOURCE CATEGORY AND CONTROL DEVICE TYPE (CONTINUED)

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference
					Minimum Value	Maximum Value	
Fuel Combustion-Residual Oil	Boiler	Flue Gas Recirculation	21	b	2	31	b
Fuel Combustion-Residual Oil	Boiler	Low Excess Air			5	31	b
Fuel Combustion-Residual Oil	Boiler	Overfire Air			24	47	b
Fuel Combustion-Residual Oil	Boiler	Selective Catalytic Reduction			70	80	b
Fuel Combustion-Residual Oil	Boiler	Selective Non-catalytic Reduction			35	70	b
Fuel Combustion-Utility Oil or Natural Gas	Boiler	Flue Gas Recirculation			40	65	b
Fuel Combustion-Wood	Boiler	Selective Non-catalytic Reduction			50	70	a
Mineral Products Industry	Glass Flue	Selective Non-catalytic Reduction			50	75	a
Petroleum Industry	Process Heaters	Selective Catalytic Reduction	90	b			
Petroleum Industry	Process Heaters	Selective Non-catalytic Reduction			35	70	b



TABLE 12.3-1

**CONTROL EFFICIENCIES (%) FOR NO<sub>x</sub> BY SOURCE CATEGORY AND CONTROL DEVICE TYPE (CONTINUED)**

- <sup>a</sup> Air & Waste Management Association. 1992. *Air Pollution Engineering Manual*. Anthony J. Buonicore and Wayne T. Davis, editors, Van Nostrand Reinhold, New York, New York.
- <sup>b</sup> EPA. 1992b. *Summary of NO<sub>x</sub> Control Techniques and their Availability and Extent of Application*. U.S. Environmental Protection Agency, EPA 450/3-9200094.
- <sup>c</sup> Pratapas, J. and J. Bluestein. 1994. Natural Gas Reburn: Cost Effective NO<sub>x</sub> Control. *Power Engineering*, May 1994.
- <sup>d</sup> EPA. 1997. *Performance of Selective Catalytic Reduction on Coal-Fired Steam Generating Units*. U.S. Environmental Protection Agency, Acid Rain Division.
- <sup>e</sup> EPA. 1995. *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, Fifth Edition, AP-42. Supplements A, B, C, D, and E*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.
- <sup>f</sup> EPA, 1994a. Alternative Control Techniques Document - NO<sub>x</sub> Emissions from Utility Boilers. U.S. Environmental Protection Agency, EPA-453/R-94-023. [http://www.epa.gov/ttn/catc/dir1/nox\\_act.txt](http://www.epa.gov/ttn/catc/dir1/nox_act.txt)
- <sup>g</sup> EPA, 1994b. Alternative Control Techniques Document - NO<sub>x</sub> Emissions from Stationary Gas Turbines. U.S. Environmental Protection Agency, EPA-453/R-93-007. [http://www.epa.gov/ttn/catc/dir1/nox\\_act.txt](http://www.epa.gov/ttn/catc/dir1/nox_act.txt)

TABLE 12.3-2

CONTROL EFFICIENCIES (%) FOR SO<sub>2</sub> BY SOURCE CATEGORY AND CONTROL DEVICE TYPE

Process	Operation	Control Device Type	Average CE (%) <sup>a</sup>	Reference	CE Range (%) <sup>a</sup>		Reference
					Minimum Value	Maximum Value	
Chemical Manufacturing	Boiler	Wet Acid Gas Scrubber			90	99	b
Chemical Manufacturing	Sulfuric Acid Industry	Scrubber, General			60	99	b
Fuel Combustion-Coal	Boiler	Wet Acid Gas Scrubber			80	99	c
Fuel Combustion-Coal	Boiler	Spray Dryer Absorber <sup>d</sup>			70	90	c
Fuel Combustion-Lignite	Boiler	Wet Acid Gas Scrubber			90		c
Fuel Combustion-Lignite-Municipal Waste	Incinerator	Spray Dryer Absorber	50	c		95	c

<sup>a</sup> Reported control efficiencies are for sulfur oxides (SO<sub>x</sub>).

<sup>b</sup> EPA. 1981. *Control Techniques for Sulfur Oxide Emissions from Stationary Sources. Second Edition.* U.S. Environmental Protection Agency, EPA 452/3-81-004.

<sup>c</sup> Air & Waste Management Association. 1992. *Air Pollution Engineering Manual.* Anthony J. Buonicore and Wayne T. Davis, editors, Van Nostrand Reinhold, New York, New York.

<sup>d</sup> Calcium hydroxide slurry, vaporizes in spray vessel.

TABLE 12.3-3

## CONTROL EFFICIENCIES (%) FOR VOC BY SOURCE CATEGORY AND CONTROL DEVICE TYPE

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference
					Minimum Value	Maximum Value	
Automobile Manufacturing	Bake Oven Exhaust	Thermal Incinerator			90		a
Can Coating	Exterior Coating	Catalytic Incinerator	90	a			
Can Coating	Exterior Coating	Thermal Incinerator	90	a			
Can Coating	Interior Coating	Carbon Adsorber	90	a			
Can Coating	Interior Coating	Catalytic Incinerator	90	a			
Can Coating	Interior Coating	Thermal Incinerator	90	a			
Chemical Manufacturing	Absorber Vent	Catalytic Incinerator			95	97	a
Chemical Manufacturing	Absorber Vent	Thermal Incinerator	99.9	a			
Chemical Manufacturing	Acrylonitrile-Absorber Vent	Catalytic Incinerator			95	97	a
Chemical Manufacturing	Acrylonitrile-Absorber Vent	Thermal Incinerator	99.9	a			
Chemical Manufacturing	Reactor Vents	Carbon Adsorber	97	a			
Chemical Manufacturing	Residue Tower Bottoms	Thermal Incinerator	99.9	a			
Chemical Manufacturing	SOCMI Reactor	Carbon Adsorber				95	a
Chemical Manufacturing	Waste Gas Column	Flares			98	99	a

**TABLE 12.3-3****CONTROL EFFICIENCIES (%) FOR VOC BY SOURCE CATEGORY AND CONTROL DEVICE TYPE (CONTINUED)**

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference
					Minimum Value	Maximum Value	
Degreasing- In-line Cleaner	General	Carbon Adsorber				65	a
Degreasing- Open Top Vapor Cleaner	General	Carbon Adsorber				39	a
Dry Cleaning	Petroleum Solvent	Carbon Adsorber			95		a
Fabric Coating	General	Carbon Adsorber	95	b			
Fabric Coating	General	Thermal Incinerator	95	b			
Food Industry	Spiral Ovens	Catalytic Incinerator	90	a			
Food Industry	Whiskey Manufacturing/ Warehousing	Carbon Adsorber	85	b			
General	Can Production	Thermal Incinerator				90	b
General	General	Carbon Adsorber			95	99	c
General	General	Catalytic Incinerator			95	99	c
General	General	Flares	98	c			
General	General	Thermal Incinerator				99	c

**TABLE 12.3-3****CONTROL EFFICIENCIES (%) FOR VOC BY SOURCE CATEGORY AND CONTROL DEVICE TYPE (CONTINUED)**

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference
					Minimum Value	Maximum Value	
General	General	Thermal Incinerator			98		d
General	Natural Gas Processing	Flares			96	99	b
General	Natural Gas Processing	Floating Roof Tank			60	99	b
Graphic Arts	Drying Ovens	Catalytic Incinerator			90	98	a
Graphic Arts	Drying Ovens	Thermal Incinerator	99	a			
Graphic Arts	Flexography	Catalytic Incinerator			90	98	a
Graphic Arts	Flexography	Thermal Incinerator			95	98	a
Graphic Arts	Gravure Printing	Carbon Adsorber			95		a
Graphic Arts	Gravure Printing	Thermal Incinerator	99	a	95	99.8	a
Graphic Arts	Heatset Web Offset	Catalytic Incinerator			90	98	a
Graphic Arts	Heatset Web Offset	Thermal Incinerator			95	99.8	a
Graphic Arts	Printing Presses	Carbon Adsorber			75	95	b
Graphic Arts	Printing Presses	Thermal Incinerator	95	b			
Groundwater Treatment	Air Strippers	Carbon Adsorber			75	95	a

**TABLE 12.3-3****CONTROL EFFICIENCIES (%) FOR VOC BY SOURCE CATEGORY AND CONTROL DEVICE TYPE (CONTINUED)**

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference
					Minimum Value	Maximum Value	
Groundwater Treatment	Air Strippers	Thermal Incinerator			90	98	a
Liquid Storage Tanks	Storage Tanks	Thermal Incinerator			96	99	c
Lithography	Printing Presses	Catalytic Incinerator	90	b			
Lithography	Printing Presses	Thermal Incinerator	90	b			
Magnetic Tape Manufacturing	Drying Ovens	Carbon Adsorber	95	a			
Magnetic Tape Manufacturing	Drying Ovens	Catalytic Incinerator	98	a			
Magnetic Tape Manufacturing	Drying Ovens	Thermal Incinerator	98	a			
Metallurgical Industry	Open Arc Furnaces	Flares	98	c			
Metallurgical Industry	Smelters	Spray Dyer Absorber	90	a			
Mineral Manufacturing	Kilns	Spray Dryer Absorber			95	99	c
Mineral Products Industry	Kilns	Thermal Incinerator	95	c			
Municipal Solid Waste	Landfill	Flares	98	a			

TABLE 12.3-3

## CONTROL EFFICIENCIES (%) FOR VOC BY SOURCE CATEGORY AND CONTROL DEVICE TYPE (CONTINUED)

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference
					Minimum Value	Maximum Value	
Pharmaceutical Industry	Vent Streams	Thermal Incinerator	98	a			
Plywood Manufacturing	General	Thermal Incinerator			90		b
Printing Lines	Flexography	Thermal Incinerator	60	a			
Printing Lines	Letterpress	Thermal Incinerator	95	a			
Printing Lines	Lithography	Thermal Incinerator	95	a			
Printing Lines	Rotogravure Operations	Carbon Adsorber	75	a			
Printing Lines	Rotogravure Operations	Thermal Incinerator	65	a			
Rubber Manufacturing	Blow Down Tanks	Scrubber, General	90	a			
Surface Coating	Bake Oven	Catalytic Incinerator	96	a			
Surface Coating	Bake Oven	Thermal Incinerator	96	a			
Surface Coating	Coating Line	Carbon Adsorber	80	a			
Surface Coating	Curing Oven Exhaust	Thermal Incinerator	90	b			
Surface Coating	Drying Ovens	Carbon Adsorber	95	b			

**TABLE 12.3-3****CONTROL EFFICIENCIES (%) FOR VOC BY SOURCE CATEGORY AND CONTROL DEVICE TYPE (CONTINUED)**

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference
					Minimum Value	Maximum Value	
Petroleum Industry	Fixed Roof Tank	Carbon Adsorber	98	b			
Petroleum Industry	Fixed Roof Tank	Vent Recovery System	85	a			
Petroleum Industry	Floating Roof Tank	Vent Recovery System			95	99	a
Petroleum Industry	General	Catalytic Incinerator			95		a
Petroleum Industry	General	Thermal Incinerator			98	99	a
Petroleum Industry	Petroleum Tank Cleaning	Flares	90	b			
Petroleum Industry	Petroleum Tank Cleaning	Thermal Incinerator	98	b			
Petroleum Industry	Petroleum Tank Transfer	Flares			63	81	b
Petroleum Industry	Petroleum Tank Transfer	Thermal Incinerator			68	88	b
Petroleum Industry	Vent Streams	Flares	98	a			
Pharmaceutical Industry	Vent Streams	Carbon Adsorber			95	99	a



TABLE 12.3-3

## CONTROL EFFICIENCIES (%) FOR VOC BY SOURCE CATEGORY AND CONTROL DEVICE TYPE (CONTINUED)

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference
					Minimum Value	Maximum Value	
Surface Coating	Drying Ovens	Thermal Incinerator	95	b			
Surface Coating	Entire Process	Carbon Adsorber	90	a			
Surface Coating	Flatwood Paneling Processes	Thermal Incinerator				94	b
Surface Coating	General	Carbon Adsorber			90		a
Surface Coating	General	Thermal Incinerator	90	a			
Surface Coating	Magnet Wire Production	Thermal Incinerator	90	a	90		b
Surface Coating	Metal Coating	Carbon Adsorber	90	a			
Surface Coating	Metal Coil Coating	Catalytic Incinerator	95	a	90		a
Surface Coating	Metal Coil Coating	Thermal Incinerator			80	90	b
Surface Coating	Metal Coil Coating	Thermal Incinerator	95	a	90		a
Surface Coating	Paper film	Thermal Incinerator	95	a			
Surface Coating	Paper film/foil	Carbon Adsorber	95	b			

TABLE 12.3-3

## CONTROL EFFICIENCIES (%) FOR VOC BY SOURCE CATEGORY AND CONTROL DEVICE TYPE (CONTINUED)

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference
					Minimum Value	Maximum Value	
Surface Coating	Paper film/foil	Thermal Incinerator	98	b			
Surface Coating	Polymeric Coating	Carbon Adsorber	95	a			
Surface Coating	Polymeric Coating	Catalytic Incinerator	98	a			
Surface Coating	Polymeric Coating	Thermal Incinerator	98	a			
Surface Coating	Spray Booth	Carbon Adsorber	90	a			
Waste Solvent Reclamation	Solvent Recovery	Carbon Adsorber				95	a
Waste Solvent Reclamation	Solvent Recovery	Floating Roof Tank				98	a
Waste Treatment and Land Disposal	General	Flares	98	a			
Wastewater Industry	Treatment System	Carbon Adsorber			90	99	a
Wastewater Industry	Water Filtration	Carbon Adsorber			90	99	e

<sup>a</sup> Air & Waste Management Association. 1992. *Air Pollution Engineering Manual*. Anthony J. Buonicore and Wayne T. Davis, editors, Van Nostrand Reinhold, New York, New York.

<sup>b</sup> EPA. 1992a. *Control Techniques for Volatile Organic Compound Emissions from Stationary Sources*. U.S. Environmental Protection Agency, EPA 453/R-92-018.

<sup>c</sup> EPA. 1991. *Control Technologies for HAPs*. U.S. Environmental Protection Agency.

<sup>d</sup> EPA. 1998. *Stationary Source Control Techniques Document for Fine Particulate Matter*. U.S. Environmental Protection Agency, EPA, 452/R-97-001

<sup>e</sup> EPA. 1995. *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, Fifth Edition, AP-42. Supplements A, B, C, D, and E*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

TABLE 12.3-4

POTENTIAL PM<sub>10</sub> EMISSION REDUCTIONS WITH FUEL SWITCHING (%)<sup>a</sup>

Original Fuel	Replacement Fuel						
	Industrial				Utility		
	Subbituminous	Residual Oil <sup>b</sup>	Natural Gas	Distillate Oil <sup>c</sup>	Subbituminous	Residual Oil <sup>b</sup>	Natural Gas
Bituminous Coal	21.4%	62.9%	98.2%	99.0%	21.4%	69.5%	99.3%
Subbituminous Coal	--	52.8%	97.7%	98.8%	--	61.2%	99.2%
Residual Oil <sup>b</sup>	--	--	95.1%	97.4%	--	--	97.9%

<sup>a</sup> Source: EPA. 1998. *Stationary Source Control Techniques Document for Fine Particulate Matter*. U.S. Environmental Protection Agency. EPA 452/R-97-001

<sup>b</sup> Residual Oil includes No. 4, 5, and 6 fuel oil.

<sup>c</sup> Distillate Oil is No. 2 fuel oil.

TABLE 12.3-5

POTENTIAL PM<sub>2.5</sub> EMISSION REDUCTIONS WITH FUEL SWITCHING (%)<sup>a</sup>

Original Fuel	Replacement Fuel						
	Industrial				Utility		
	Subbituminous	Residual Oil <sup>b</sup>	Natural Gas	Distillate Oil <sup>c</sup>	Subbituminous	Residual Oil <sup>b</sup>	Natural Gas
Bituminous Coal	21.4%	7.4%	93.1%	99.0%	21.4%	14.8%	97.5%
Subbituminous Coal	--	--	91.2%	98.8%	--	--	96.8%
Residual Oil <sup>b</sup>	--	--	92.5%	99.0%	--	--	97.0%

<sup>a</sup> Source: EPA. 1998. *Stationary Source Control Techniques Document for Fine Particulate Matter*. U.S. Environmental Protection Agency. EPA 452/R-97-001.

<sup>b</sup> Residual Oil includes No. 4, 5, and 6 fuel oil.

<sup>c</sup> Distillate Oil is No. 2 fuel oil.

TABLE 12.3-6

**CONTROL EFFICIENCIES (%) FOR PM BY SOURCE CATEGORY AND CONTROL DEVICE TYPE**

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference
					Minimum Value	Maximum Value	
Fuel Combustion- Bagasse	Boiler	Mechanical Collector			20	60	a
Fuel Combustion- Bagasse	Boiler	Wet PM Scrubber			90		b
Fuel Combustion- Coal	Boiler	Electrostatic Precipitator	99	b	90	99.9	a
Fuel Combustion- Coal	Boiler	Fabric Filter	99	b	99		a
Fuel Combustion- Coal	Boiler	Mechanical Collector	65	b	90	95	b
Fuel Combustion- Coal	Boiler	Wet PM Scrubber			50	99	b
Fuel Combustion- Coal (anthracite)	Boiler	Electrostatic Precipitator	98.4	c			
Fuel Combustion- Coal (anthracite)	Boiler	Fabric Filter			98.4	99.4	c
Fuel Combustion- Coal (bituminous)	Boiler	Electrostatic Precipitator			96	99.4	c
Fuel Combustion- Coal (bituminous)	Boiler	Fabric Filter			98.3	99.9	c
Fuel Combustion- Lignite	Boiler	Electrostatic Precipitator			95	99.5	a
Fuel Combustion- Lignite	Boiler	Mechanical Collector			60	80	a

TABLE 12.3-6

## CONTROL EFFICIENCIES (%) FOR PM BY SOURCE CATEGORY AND CONTROL DEVICE TYPE (CONTINUED)

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference
					Minimum Value	Maximum Value	
Fuel Combustion- Wood	Boiler	Electrostatic Precipitator			93	99.8	a, b
Fuel Combustion- Wood	Boiler	Fabric Filter	98	b	95.9	99.9	a
Fuel Combustion- Wood	Boiler	Mechanical Collector			65	95	b
Fuel Combustion- Wood	Boiler	Wet PM Scrubber	90	b	95	99	a
Sewage Sludge Incineration	Boiler	Wet PM Scrubber			60	99	a
Charcoal Industry	Briquetting Operation	Fabric Filter	99	b			
Charcoal Industry	Briquetting Operation	Mechanical Collector	65	b			b
Chemical Manufacturing	Charcoal Production	Fabric Filter	99	a			
Chemical Manufacturing	Charcoal Production	Mechanical Collector	65	a			a
Chemical Manufacturing	Condenser Unit	Mechanical Collector			90	98	b

TABLE 12.3-6

## CONTROL EFFICIENCIES (%) FOR PM BY SOURCE CATEGORY AND CONTROL DEVICE TYPE (CONTINUED)

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference
					Minimum Value	Maximum Value	
Chemical Manufacturing	Condenser Unit	Scrubbers, General				99	b
Chemical Manufacturing	Condenser Unit	Thermal Incinerator with Wet PM Scrubber	96	b			
Iron and Steel Production	Delsulfurization	Fabric Filter	96.7	c			
Coal Industry	Drying Ovens	Wet PM Scrubber			98	99.9	b
Ferroalloy Industry	Ferroalloy Electric Arc Furnace	Fabric Filter			96.3	98.7	c
Zinc Smelting	Furnace	Fabric Filter	96.3	b			b
Chemical Manufacturing	General	Thermal Incinerator			79	96	c
Fuel Combustion- Wood	General	Wet PM Scrubber			92.1	93.3	c
Fuel Combustion- Wood Bark	General	Wet PM Scrubber			83.8	85.1	c
General	General	Electrostatic Precipitator			95	99.9	d
General	General	Fabric Filter			99		d
General	General	Mechanical Collector			80	95	c
General	General	Wet PM Scrubber	99	c			
Petroleum Industry	General	Electrostatic Precipitator				85	a

TABLE 12.3-6

## CONTROL EFFICIENCIES (%) FOR PM BY SOURCE CATEGORY AND CONTROL DEVICE TYPE (CONTINUED)

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference
					Minimum Value	Maximum Value	
Iron and Steel Production	Gray Iron Cupolas	Fabric Filter			93.4	93.9	c
Metallurgical Industry	Iron Foundry	Fabric Filter			98	99	a
Metallurgical Industry	Lead Smelters	Electrostatic Precipitator			95	99	a
Metallurgical Industry	Lead Smelters	Fabric Filter			95	99	a
Metallurgical Industry	Lead Smelters	Mechanical Collector			80	90	a
Copper Smelting	Multiple Hearth Roaster	Electrostatic Precipitator	99	c			
Iron and Steel Production	Open Hearth Furnace	Electrostatic Precipitator	99.2	c			
Coke Production	Preheater	Wet PM Scrubber			89	92.9	b
Petroleum Industry	Process Heaters	Mechanical Collector				85	b
Petroleum Industry	Process Heaters	Electrostatic Precipitator				85	b
Soap Industry	Production Line	Mechanical Collector			90		a
Wood Products	Recover Furnace	Electrostatic Precipitator			90	99	a
Wood Products	Recover Furnace	Wet PM Scrubber with Electrostatic Precipitator			85	99	b
Copper Smelting	Reverberatory Smelter	Electrostatic Precipitator	97.2	c			

TABLE 12.3-6

## CONTROL EFFICIENCIES (%) FOR PM BY SOURCE CATEGORY AND CONTROL DEVICE TYPE (CONTINUED)

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference
					Minimum Value	Maximum Value	
Metallurgical Industry	Roasters	Cold Electrostatic Precipitator	95	a			
Metallurgical Industry	Roasters	Hot Electrostatic Precipitator			20	80	a
Medical Waste Incineration	Rotary Kiln	Fabric Filter				99.9	a
Iron and Steel Production	Sinter Furnace	Electrostatic Precipitator			90	94	c
Copper Smelting	Smelters	Fabric Filter	99	b			
Food Industry	Smokehouses	Wet PM Scrubber	69	b			
Mineral Products Industry	Thermal Dryer	Wet PM Scrubber			98	99.9	b
Phosphate Industry	Thermal Dryer	Electrostatic Precipitator			90	99	b
Phosphate Industry	Thermal Dryer	Wet PM Scrubber			96	99.9	b
Phosphate Industry	Thermal Dryer	Wet PM Scrubber			80	99	b
Polystyrene Production	Thermal Dryer	Mechanical Collector with Fabric Filter				99	b
Soap Industry	Thermal Dryer	Mechanical Collector with Fabric Filter				99	b
Agriculture Industry	Transfer Systems	Fabric Filter			99		a
Petroleum Industry	Vent Streams	Mechanical Collector			90		a



TABLE 12.3-6

**CONTROL EFFICIENCIES (%) FOR PM BY SOURCE CATEGORY AND CONTROL DEVICE TYPE (CONTINUED)**

- <sup>a</sup> Air & Waste Management Association. 1992. *Air Pollution Engineering Manual*. Anthony J. Buonicore and Wayne T. Davis, editors, Van Nostrand Reinhold, New York, New York.
- <sup>b</sup> EPA. 1995. *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, Fifth Edition, AP-42. Supplements A, B, C, D, and E*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.
- <sup>c</sup> EPA. 1991. *Control Technologies for HAPs*. U.S. Environmental Protection Agency.
- <sup>d</sup> EPA. 1998. *Stationary Source Control Techniques Document for Fine Particulate Matter*. U.S. Environmental Protection Agency, EPA 452/R-97-001

TABLE 12.3-7

## CONTROL EFFICIENCIES (%) FOR CO BY SOURCE CATEGORY AND CONTROL DEVICE TYPE

Process	Operation	Control Device Type	Average CE (%)	Reference	CE Range (%)		Reference	Comments
					Minimum Value	Maximum Value		
Chemical Manufacturing	Catalytic Process for Acrylonitrile	Thermal Incinerator			95		a	
Chemical Manufacturing	Catalytic Process for Acrylonitrile	Catalytic Incinerator			95		a	
Chemical Manufacturing	Catalytic Process for Phthalic Anhydride	Thermal Incinerator				99	a	
Chemical Manufacturing	Condenser Unit	Thermal Incinerator	96	a				
Fuel Combustion- Natural Gas	Incinerator	Thermal Incinerator				90		
General	General	Catalytic Incinerator	90	b				
General	General	Thermal Incinerator			90			
Metallurgical Industry	Open Arc Furnaces	Flare	98	a				
Metallurgical Industry	Furnaces	Flare	98	c				

<sup>a</sup> EPA. 1995. *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, Fifth Edition, AP-42. Supplements A, B, C, D, and E.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

<sup>b</sup> EPA. 1979. *Control Techniques for Carbon Monoxide Emissions.* U.S. Environmental Protection Agency, EPA 452/3-79-006.

<sup>c</sup> Air and Waste Management Association. 1992. *Air Pollution Engineering Manual.* Anthony J. Buonicore and Wayne T. Davis, editors, Van Nostrand Reinhold, New York, New York.

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# 4

## DESCRIPTIONS OF AIR POLLUTION CONTROL DEVICES

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### 4.1 SELECTIVE CATALYTIC REDUCTION (SCR)

#### 4.1.1 WHAT POLLUTANTS ARE CONTROLLED USING SELECTIVE CATALYTIC REDUCTION?

$\text{NO}_x$  is controlled using SCR. SCR is the most developed and widely applied post-process  $\text{NO}_x$  control technique used today.

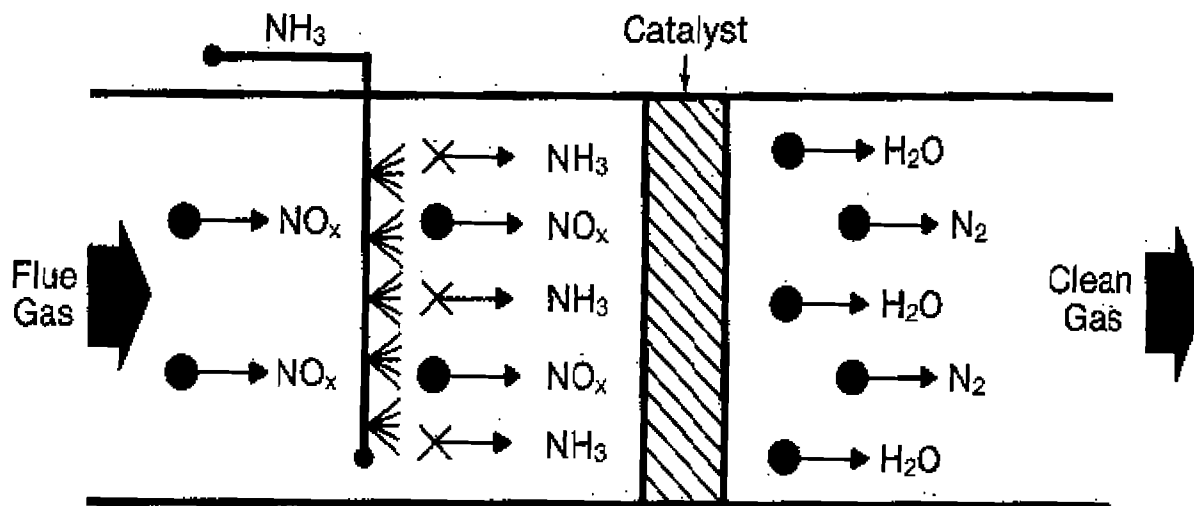
#### 4.1.2 HOW DOES SELECTIVE CATALYTIC REDUCTION WORK?

A reducing agent, usually diluted with water, steam, or air, is injected through a grid system into the flue gas stream upstream of a catalyst bed enclosed in a reactor. On the catalyst surface, the reagent reacts with the  $\text{NO}_x$  to form molecular nitrogen and water. The rate of reaction of the reagent and  $\text{NO}_x$  is increased by the presence of excess oxygen. The reduction reaction is illustrated in Figure 12.4-1.

**Note:** SCR is “selective” in that the reagent reacts primarily with  $\text{NO}_x$ , not with  $\text{O}_2$  or other major components of the flue gas.

The performance of an SCR system is influenced by five factors:

- Flue gas temperature;
- Reagent-to- $\text{NO}_x$  ratio;
- $\text{NO}_x$  concentration at the SCR inlet;
- Space velocity (measure of the volumetric feed capacity of a continuous-flow reactor per unit residence time); and
- Condition of the catalyst.

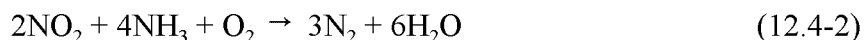
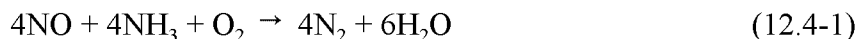


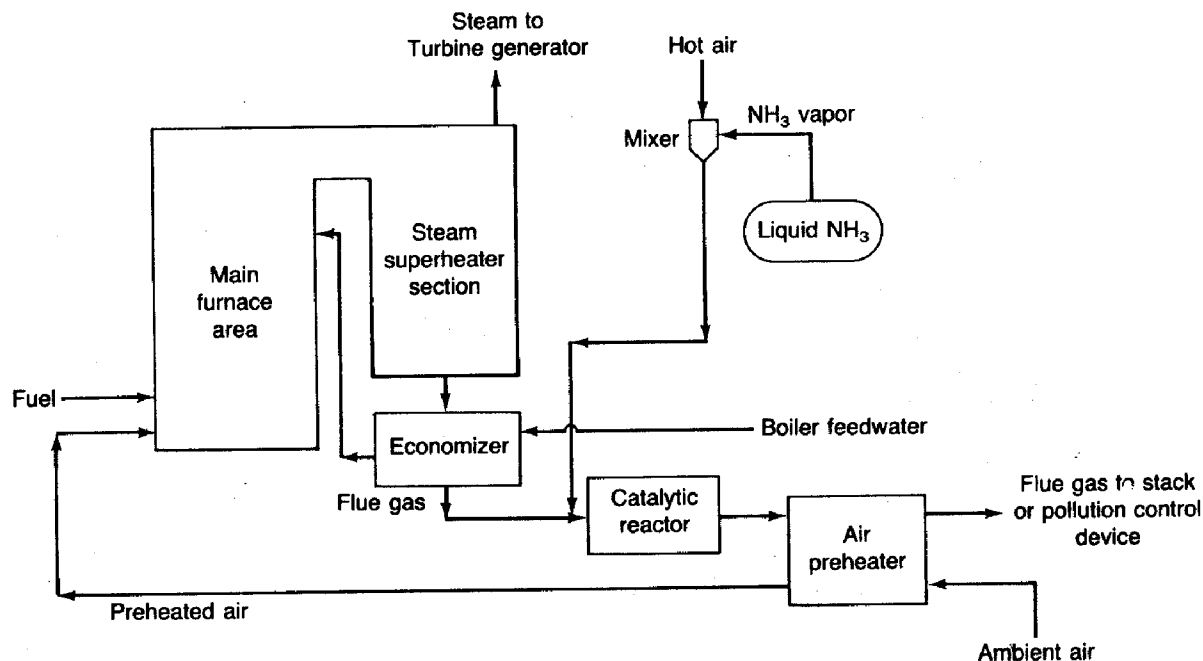
**FIGURE 12.4-1. REMOVAL OF  $\text{NO}_x$  BY SCR**  
**(BABCOCK & WILCOX, 1992)**

The primary variable affecting  $\text{NO}_x$  reduction is temperature. Below the optimal temperature range, which depends on the type of catalyst used, the activity of the catalyst is greatly reduced, allowing unreacted reagent to slip through. On the other hand, extreme temperatures can damage the catalyst. Figure 12.4-2 illustrates a typical SCR system.

#### 4.1.3 WHAT REDUCING AGENT IS USED IN SELECTIVE CATALYTIC REDUCTION?

With an appropriate catalyst, ammonia ( $\text{NH}_3$ ) or an ammonia derivative (i.e., urea), could be used as the reducing gas; however, the most commonly used material is  $\text{NH}_3$ . The reduction reactions for the SCR process are:





**FIGURE 12.4-2. SCHEMATIC FLOW DIAGRAM FOR THE SELECTIVE CATALYTIC REDUCTION METHOD OF NO<sub>x</sub> CONTROL (AWMA, 1992)**

#### 4.1.4 WHAT CATALYSTS ARE USED IN SELECTIVE CATALYTIC REDUCTION?

Catalyst formulation is the key to SCR system performance. The catalyst must reduce NO<sub>x</sub> emissions without producing other pollutants or compounds that could damage the equipment downstream. The formulations of the catalytically active phases are proprietary, but generally fall into 3 categories of composition:

- Base metal catalysts which typically contain titanium and vanadium oxides and may also contain molybdenum, tungsten, and other elements. Base metal catalysts are used at temperatures between 450 and 800°F.
- Zeolite catalysts (crystalline aluminosilicate compounds) are used at high temperature operations, between 675 and 1100°F.

- Precious metal catalysts which contain metals such as platinum and palladium. These are used in clean, low temperature (between 350 and 550°F) operations.

Additional compounds may be present to give thermal or structural stability or to increase surface area. Catalyst beds may be constructed in a honeycomb, plate, or bed configuration.

#### **4.1.5 WHAT ISSUES ARE OF CONCERN WHEN USING SELECTIVE CATALYTIC REDUCTION?**

Catalyst deactivation and residual ammonia (ammonia slip) in the flue gas are two key considerations in SCR systems. Catalyst activity decreases with operating time due to fouling.

“Ammonia slip” is the unreacted ammonia that remains in the flue gas stream downstream of the SCR. Ammonia slip occurs when there is not enough  $\text{NO}_x$  in the flue gas to react with the injected ammonia. Ammonia slip is an indication that the ammonia injection rate should be reduced. As flue gas temperatures decrease, this excess ammonia can react with sulfur compounds from the fuel (especially  $\text{SO}_3$ ) to form ammonium salts such as ammonium sulfate and ammonium bisulfate. Ammonium sulfate is a fine particulate and contributes to plume opacity. An increase in plume opacity can cause a facility to be out of compliance with state and/or federal opacity limits. Ammonium bisulfate is highly acidic and sticky and can result in fouling and corrosion when deposited downstream. Ammonia uptake by flyash can make disposal or reuse of the ash more of a challenge.

Ammonia slip is controlled by careful injection of the ammonia or urea into regions of the combustion unit with appropriate conditions (temperature, residence time, concentration) for the reduction reaction to occur. Distribution of the ammonia that matches flue gas strata is the important factor in control of ammonia slip. The amount of ammonia slip is usually monitored and used to determine the ammonia injection rate. Many units operate with an ammonia slip of less than 1 parts per million (ppm). Units are usually guaranteed to operate at less than 5 ppm.

#### **4.1.6 WHAT WASTES RESULT FROM USING SELECTIVE CATALYTIC REDUCTION?**

Other than the spent catalyst, SCR produces no waste. Spent catalyst is typically reactivated for use as a reducing agent or the components are recycled for other uses. When disposal is necessary, spent catalyst can be disposed of in approved landfills because EPA has determined that spent catalyst is not a hazardous waste (ICAC, 1997).

## 4.2 SELECTIVE NONCATALYTIC REDUCTION (SNCR)

### 4.2.1 WHAT POLLUTANTS ARE CONTROLLED USING SELECTIVE NONCATALYTIC REDUCTION?

$\text{NO}_x$  is controlled using SNCR. This air pollution control technique is sometimes referred to as ammonia injection, even though most systems currently use urea injection.

### 4.2.2 HOW DOES SELECTIVE NONCATALYTIC REDUCTION WORK?

A reducing agent is injected into the  $\text{NO}_x$ -laden flue gas stream in a specific temperature zone in the upper combustion unit. The SNCR process requires proper mixing of the gas and the reagent, and the mixture must have adequate residence time for the reduction reactions to occur. High temperatures (between 1400 to 2000°F) are required to provide activation energy sufficient to eliminate the need for the use of catalysts. The  $\text{NO}_x$  is reduced to molecular nitrogen and water.

**Note:** SNCR is “selective” in that the reagent reacts primarily with  $\text{NO}_x$ , not with  $\text{O}_2$  or other major components of the flue gas. Also, SNCR differs from SCR in that no catalyst is used in the former.

Five factors influence the performance of urea- or ammonia-based SNCR systems:

- Flue gas temperature;
- Reagent-to- $\text{NO}_x$  ratio;
- $\text{NO}_x$  concentration in the flue gas entering the combustion unit;
- Residence time; and
- Mixing.



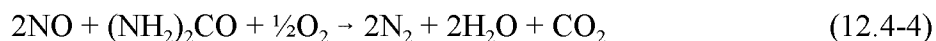
### 4.2.3 WHAT REDUCING AGENTS ARE USED IN SELECTIVE NONCATALYTIC REDUCTION?

Ammonia or urea, with urea used most often. Ammonia is usually injected into the gas stream in the gaseous state; urea is injected in the aqueous state and therefore requires a longer residence time to volatilize.

The chemical reaction for the ammonia-based process is:



The chemical reaction for the urea-based process is:



### 4.2.4 WHAT ISSUES ARE OF CONCERN WHEN USING SELECTIVE NONCATALYTIC REDUCTION?

Excess urea degrades to nitrogen, carbon dioxide, and unreacted ammonia. Also, as with SCR, “ammonia slip” can occur with SNCR. To minimize ammonia slip, the SNCR must be designed to ensure good distribution and mixing of injected ammonia or urea within the proper temperature zone. Many units operate with an ammonia slip of less than 1 ppm. Units are usually guaranteed to operate at less than 5 ppm.

### 4.2.5 WHAT WASTES RESULT FROM USING SELECTIVE NONCATALYTIC REDUCTION?

No solid or liquid wastes are generated in the SNCR process, other than ammonia slip.

## 4.3 LOW NO<sub>x</sub> BURNERS (LNB)

### 4.3.1 WHAT POLLUTANTS ARE CONTROLLED USING LOW NO<sub>x</sub> BURNERS?

Low NO<sub>x</sub> burners are used to inhibit the formation of NO<sub>x</sub>.

### 4.3.2 HOW DO LOW NO<sub>x</sub> BURNERS WORK?

Low-NO<sub>x</sub> burners inhibit NO<sub>x</sub> formation by controlling the mixing of fuel and air. Different burner manufacturers use different hardware to control the fuel-air mixing, but all designs essentially automate two methods of NO<sub>x</sub> reduction: low excess air, described in Section 4.8, and staged overfire air, described in Section 4.9.

Low NO<sub>x</sub> burners reduce:

- The oxygen level in the primary combustion zone to limit fuel NO<sub>x</sub> formation;
- The flame temperature to limit thermal NO<sub>x</sub> formation; and/or
- The residence time at peak temperature to limit thermal NO<sub>x</sub> formation.

The most common design approach is to control NO<sub>x</sub> formation by carrying out the combustion in stages:

- Staged air burners, or delayed combustion LNBs, are two-stage combustion burners which are fired fuel-rich in the first stage. They are designed to reduce flame turbulence, delay fuel/air mixing, and establish fuel-rich zones for initial combustion. The reduced availability of oxygen in the primary combustion zone inhibits fuel NO<sub>x</sub> formation. Radiation of heat from the primary combustion zone results in reduced temperature. The longer, less intense flames resulting from the staged combustion lower flame temperatures and reduce thermal NO<sub>x</sub> formation.
- Staged fuel burners also use two-stage combustion, but mix a portion of the fuel and all of the air in the primary combustion zone. The high level of excess air greatly lowers the peak flame temperature achieved in the primary combustion zone, reducing thermal NO<sub>x</sub> formation. The secondary fuel is injected at high pressure into the combustion zone through a series of nozzles which are positioned around the perimeter of the burner. Because of its high velocity, the fuel gas entrains furnace gases and promotes rapid mixing with first stage combustion products. The entrained gases stimulate flue gas recirculation. Heat is transferred from the first stage combustion products prior to the second stage combustion and, as a result, second stage combustion is achieved with lower concentrations of oxygen and lower temperatures than would normally be encountered.

### 4.3.3 WHAT ISSUES ARE OF CONCERN WHEN USING LOW NO<sub>x</sub> BURNERS?

LNBs are applicable to tangential and wall-fired boilers of various sizes but are not applicable to other boiler types such as cyclone furnaces or stokers. For example, in cyclone furnaces, combustion occurs outside of the main furnace. As a result, low NO<sub>x</sub> burner modification of the furnace is not suitable for this combustion system design.

More specifically, staged air burners lengthen the flame configuration. As a result, staged air burners are applicable only to installations large enough to avoid impingement on the furnace walls. Staged fuel burners are designed only for gas firing.

### 4.3.4 WHAT WASTES RESULT FROM USING LOW NO<sub>x</sub> BURNERS?

In some cases, LNBs with coal combustion increase the levels of carbon-in-ash. This can result in the ash requiring treatment as a waste, rather than being a marketable product.

## 4.4 NATURAL GAS BURNER/REBURN

### 4.4.1 WHAT POLLUTANTS ARE CONTROLLED USING NATURAL GAS BURNER/REBURN?

NO<sub>x</sub> is controlled using natural gas burner/reburn. Also, as a secondary benefit, since it replaces 10 to 20 percent of the heat input from the primary fuel, sulfur dioxide emissions may be reduced, depending on the sulfur content of the primary fuel. When coal is the primary fuel, carbon dioxide, particulate and air toxics emissions are reduced.

### 4.4.2 HOW DOES NATURAL GAS BURNER/REBURN WORK?

In a reburn configured boiler, reburn fuel (natural gas, oil, or pulverized coal) is injected into the upper furnace region to convert the NO<sub>x</sub> formed in the primary fuel's combustion zone to molecular nitrogen and water. Figure 12.4-3 is a schematic diagram of a typical reburn system. There are several natural gas burner/reburn boiler configurations. In general, the overall process occurs within three zones of the boiler:

- **Combustion zone.** The amount of fuel (coal, oil, or gas) input to the burners in the primary combustion zone is reduced by 10 to 20 percent. To minimize NO<sub>x</sub> formation and to provide appropriate conditions for reburning, the burners or

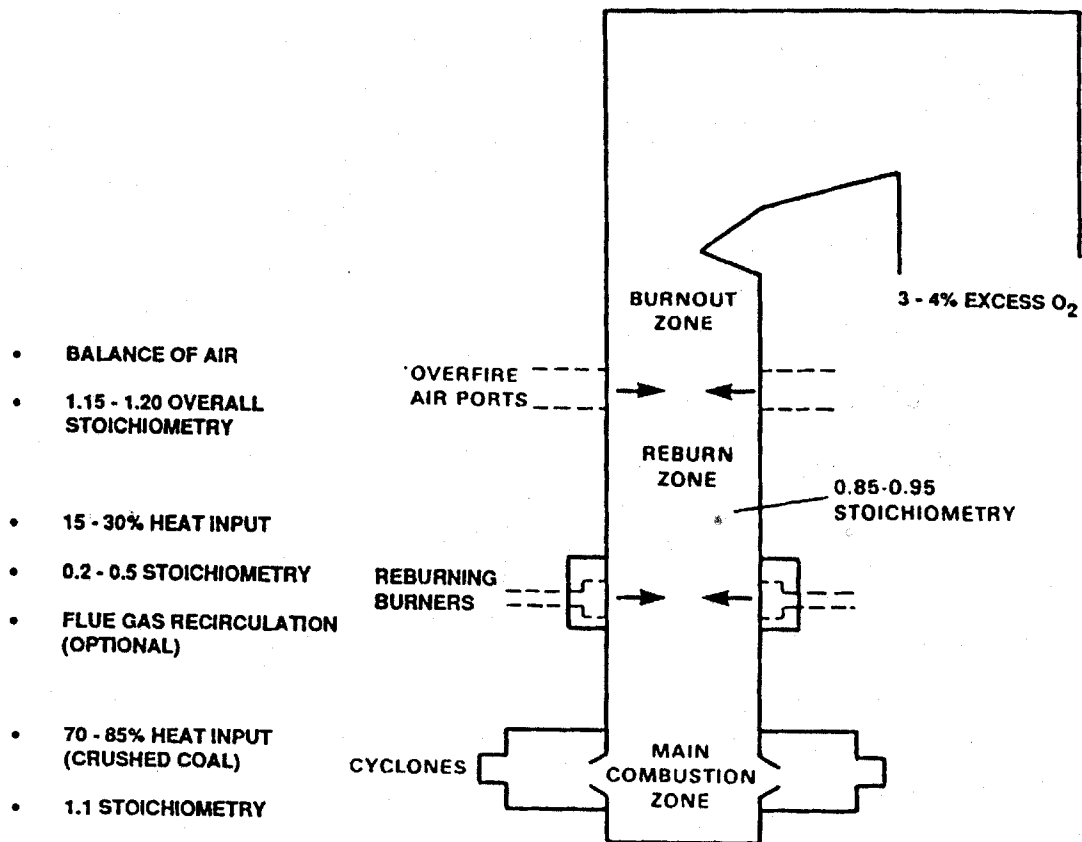


FIGURE 12.4-3. SCHEMATIC DIAGRAM OF A TYPICAL REBURN SYSTEM (AWMA, 1992)

cyclones may be operated at the lowest excess air consistent with normal commercial operation.

- **Gas reburning zone.** Reburn fuel (between 10 and 20 percent of boiler heat input) is injected above the primary combustion zone. This creates a fuel-rich region where hydrocarbon radicals react with  $\text{NO}_x$  to form molecular nitrogen. Recirculated flue gases may be mixed in with the reburn fuel before it is injected to promote better mixing within the boiler.
- **Burnout zone.** A separate overfire air system redirects air from the primary combustion zone to a location above the gas reburning reaction zone to ensure the complete combustion of any unreacted fuel and combustible gases. Separate overfire air systems also generally require new boiler penetrations and retrofitted ducting.

Operational parameters that affect the performance of reburn include:

- Reburn zone stoichiometry;
- Residence time in the reburn zone;
- Reburn fuel carrier gas; and
- Temperature and  $\text{O}_2$  level in the burnout zone.

Decreasing the reburn zone stoichiometry can reduce  $\text{NO}_x$  emissions. However, decreasing the stoichiometry requires adding a larger portion of fuel to the reburn zone, which can adversely affect upper furnace conditions by increasing the furnace exit gas temperature.

#### 4.4.3 WHAT ISSUES ARE OF CONCERN WHEN USING NATURAL GAS BURNER/REBURN?

There must be sufficient space in the furnace above the primary burners to allow installation of the necessary equipment.

#### 4.4.4 WHAT WASTES RESULT FROM USING NATURAL GAS BURNER/REBURN?

None.

## **4.5 WATER/STEAM INJECTION**

### **4.5.1 WHAT POLLUTANTS ARE CONTROLLED USING WATER/STEAM INJECTION?**

NO<sub>x</sub> from gas turbines are controlled using water/stream injection.

### **4.5.2 HOW DOES WATER /STEAM INJECTION WORK?**

Water or steam is injected into the gas turbine, reducing the temperatures in the NO<sub>x</sub>-forming regions. The water or steam can be injected into the fuel, the combustion air, or directly into the combustion chamber.

### **4.5.3 WHAT ISSUES ARE OF CONCERN WHEN USING WATER /STEAM INJECTION?**

Both hydrocarbon and carbon monoxide emissions are increased by large rates of water injection.

Water injection can increase the rate of equipment corrosion. Although water injection usually results in a 2 to 3 percent decrease in efficiency, it may result in an increase in power output. With combustion turbines for example, the power increase results because fuel flow is increased to maintain turbine inlet temperature at manufacturers' specifications.

### **4.5.4 WHAT WASTES RESULT FROM USING WATER/STREAM INJECTION?**

None.

## **4.6 STAGED COMBUSTION**

### **4.6.1 WHAT POLLUTANTS ARE CONTROLLED USING STAGED COMBUSTION?**

NO<sub>x</sub> from gas turbines are controlled using staged combustion.

### **4.6.2 HOW DOES STAGED COMBUSTION WORK?**

Most gas turbines were originally designed to operate with a stoichiometric mixture (an air-to-fuel ratio of 1.0). Several types of staging methods are used in order to reduce NO<sub>x</sub> emissions from gas turbines. These include:

- Lean combustion;

- Lean premixed combustion; and
- Two-stage rich/lean combustion.

### ***Lean Combustion***

Lean combustion involves increasing the air-to-fuel ratio so that the peak and average temperature within the combustor will be less than that of the stoichiometric mixture. In lean combustion, the additional excess air cools the flame, which reduces the peak flame temperature and reduces the rate of thermal  $\text{NO}_x$  formation.

### ***Lean Premixed Combustion***

In a conventional combustor, air and fuel mixing and combustion take place simultaneously in the combustion zone. As a result, wide variations in air-to-fuel ratios exist, and the combustion of localized fuel-rich pockets produces significant levels of  $\text{NO}_x$  emissions. Lean premixed combustors, also known as two-stage lean/lean combustors, involve premixing of fuel and air at very lean air-to-fuel ratios prior to introduction into the combustion zone. Premixing results in a homogeneous mixture, which minimizes localized fuel-rich zones, resulting in greatly reduced  $\text{NO}_x$  formation rates.

### ***Two-Stage Rich/Low Combustion***

Two-stage rich/lean combustors, also known as rich/quench/lean (RQL) combustors, burn fuel-rich in the primary zone and fuel-lean in the secondary zone. Incomplete combustion from the fuel-rich mixture in the primary zone produces lower temperatures (as compared to a stoichiometric mixture) and higher CO and hydrogen ( $\text{H}_2$ ). The CO and  $\text{H}_2$  replace some of the  $\text{O}_2$  available for  $\text{NO}_x$  generation and also act as reducing agents for any  $\text{NO}_x$  formed in the primary zone. Thus, fuel nitrogen is released with minimal conversion to  $\text{NO}_x$ . The lower peak flame temperatures due to partial combustion also reduce the formation of thermal  $\text{NO}_x$ . Before entering the secondary zone, the combustion products of the primary zone pass through a low-residence-time quench zone where the combustion products are diluted by large amounts of air or water. This rapid dilution extinguishes the flames, cools the combustion products, and at the same time produces a lean mixture. The combustion of the lean mixture is then completed in the secondary zone under fuel lean conditions. This step minimally contributes to the formation of fuel  $\text{NO}_x$  because most of the fuel nitrogen will have been converted to  $\text{N}_2$  prior to the lean combustion phase. Thermal  $\text{NO}_x$  is minimized during lean combustion due to the low flame temperature.

### 4.6.3 WHAT ISSUES ARE OF CONCERN WHEN USING STAGED COMBUSTION?

#### ***Lean Combustion***

The performance of lean combustion is directly affected by the primary zone equivalence air-to-fuel ratio. The closer the ratio is to 1.0, the greater the NO<sub>x</sub> emissions. However, if the ratio is reduced too far, CO emissions increase. This emissions tradeoff effectively limits the amount of NO<sub>x</sub> reduction that can be achieved by lean combustion alone.

#### ***Lean Premixed Combustion***

The primary factor affecting the performance of lean premixed combustors is the air-to-fuel ratio. To achieve low NO<sub>x</sub> emissions levels, the air-to-fuel ratio must be maintained in a narrow range near the lean flammability limit of the mixture. Lean premixed combustors are designed to maintain this air-to-fuel ratio at the rated load. At reduced load conditions, the fuel input requirement decreases. To avoid combustion instability and excessive CO emissions that would occur as the air-to-fuel ratio reaches the lean flammability limit, all manufacturers' lean premixed combustors switch to diffusion-type combustion mode at reduced load conditions, which results in higher NO<sub>x</sub> emissions.

Another factor that affects the performance of lean premixed combustors is the type of fuel used. Natural gas produces lower NO<sub>x</sub> levels than do oil fuels, because natural gas has a lower flame temperature, and the ability to premix with air prior to delivery into the second combustion stage. When using liquid fuels, currently available lean premixed combustors require water injection to achieve appreciable NO<sub>x</sub> reductions.

#### ***Two-Stage Rich/Lean Combustion***

NO<sub>x</sub> emissions from two-stage rich/lean combustors are affected primarily by the air-to-fuel ratio in the primary combustion zone, and by the quench air flow rate. If the air-to-fuel ratio is not selected carefully in the fuel-rich zone, both thermal and fuel NO<sub>x</sub> formation can be increased. Further NO<sub>x</sub> emissions can increase with reduced quench air flow rates, which in turn, increases the air-to-fuel ratio in the lean combustion stage.

### 4.6.4 WHAT WASTE RESULTS FROM USING STAGED COMBUSTION?

None.



## **4.7 FLUE GAS RECIRCULATION (FGR)**

### **4.7.1 WHAT POLLUTANTS ARE CONTROLLED USING FLUE GAS RECIRCULATION?**

Flue gas recirculation (FGR) is applied to reduce  $\text{NO}_x$  formation.

### **4.7.2 HOW DOES FLUE GAS RECIRCULATION WORK?**

A portion of flue gas is recycled back to the primary combustion zone. This system reduces  $\text{NO}_x$  formation by two mechanisms:

- Heating in the primary combustion zone of the inert combustion products contained in the recycled flue gas lowers the peak flame temperature, thereby reducing thermal  $\text{NO}_x$  formation.
- To a lesser extent, FGR reduces thermal  $\text{NO}_x$  formation by lowering the oxygen concentration in the primary flame zone.

The recycled flue gas may be pre-mixed with the combustion air or injected directly into the flame zone. Direct injection allows more precise control of the amount and location of FGR.

**Note:** In order for FGR to reduce  $\text{NO}_x$  formation, recycled flue gas must enter the flame zone.

### **4.7.3 WHAT ISSUES ARE OF CONCERN WHEN USING FLUE GAS RECIRCULATION?**

The use of FGR has several limitations. The decrease in flame temperature alters the distribution of heat and can lower fuel efficiency. Because FGR reduces only thermal  $\text{NO}_x$ , the technique is applied primarily to natural gas or distillate oil combustion.

Flue gas recirculation requires modifications to the ductwork of the combustion unit. Additional power is required to operate recirculation fans, making the operating cost of flue gas recirculation higher than some other combustion techniques.

### **4.7.4 WHAT WASTES RESULT FROM USING FLUE GAS RECIRCULATION?**

None.

## **4.8 LOW EXCESS AIR (LEA)**

### **4.8.1 WHAT POLLUTANTS ARE CONTROLLED USING LOW EXCESS AIR?**

Low excess air is applied to reduce  $\text{NO}_x$  formation.

Excess air is the amount of air (oxygen) above the level stoichiometrically required for 100 percent combustion of the fuel. Because mixing of air and fuel is not complete at all times in all regions of the combustor, some excess air is required to ensure complete combustion of the fuel and to prevent CO and smoke formation or excess carbon-in-ash.

### **4.8.2 HOW DOES LOW EXCESS AIR WORK?**

Low excess air works by reducing levels of excess air to the combustor, usually by adjustments to air registers and/or fuel injection positions, or through control of overfire air dampers. The lower oxygen concentration in the burner zone reduces conversion of the fuel nitrogen to  $\text{NO}_x$ . Also, under excess air conditions in the flame zone, a greater portion of fuel-bound nitrogen is converted to  $\text{N}_2$  therefore reducing the formation of fuel  $\text{NO}_x$ .

### **4.8.3 WHAT ISSUES ARE OF CONCERN WHEN USING LOW EXCESS AIR?**

Issues that can be associated with low excess air systems include:

- Too little excess air can result in increased emissions of carbon monoxide or unburned carbon smoke; and
- Too little excess air can reduce flame stability.

### **4.8.4 WHAT WASTES RESULT FROM USING LOW EXCESS AIR?**

None.

## **4.9 STAGED OVERFIRE AIR**

### **4.9.1 WHAT POLLUTANTS ARE CONTROLLED USING STAGED OVERFIRE AIR?**

Staged overfire air is applied to reduce  $\text{NO}_x$  formation.

### 4.9.2 HOW DOES STAGED OVERFIRE AIR WORK?

Staged overfire air works by:

- Partially delaying and extending the combustion process. This results in less intense combustion and cooler flame temperatures, thereby suppressing thermal  $\text{NO}_x$  formation.
- Lowering the concentration of air in the burner combustion zone where volatile fuel nitrogen is evolved, thereby suppressing fuel  $\text{NO}_x$  formation.

Staged combustion, or off-stoichiometric combustion, combusts the fuel in two or more steps. A percentage of the total combustion air is diverted from the burners and injected through ports above the top burner level. The total amount of combustion air fed to the furnace remains unchanged. Initially, fuel is combusted in a primary, fuel-rich, combustion zone. Combustion is completed at lower temperatures in a secondary, fuel-lean, combustion zone. The sub-stoichiometric oxygen introduced with the primary combustion air into the high temperature, fuel-rich zone reduces fuel and thermal  $\text{NO}_x$  formation. Combustion in the secondary zone is conducted at a lower temperature, reducing thermal  $\text{NO}_x$  formation.

Staged overfire air combustion involves firing the burners more fuel-rich than normal while admitting the remaining combustion air through overfire air ports or an idle top row of burners.

### 4.9.3 WHAT ISSUES ARE OF CONCERN WHEN USING STAGED OVERFIRE AIR?

Staged overfire air systems provide less available oxygen in the primary combustion zone. This can result in:

- Increased emissions of CO, organic compounds, and visible emissions;
- Reduced flame stability, and changed furnace heat release rates and flue gas exit temperatures;
- Increased upper furnace ash deposits, referred to as “slagging”; and
- Increased corrosion due to a reducing atmosphere in the lower furnace.

### 4.9.4 WHAT WASTES RESULT FROM USING STAGED OVERFIRE AIR?

None.

## 4.10 NONSELECTIVE CATALYTIC REDUCTION (NSCR)

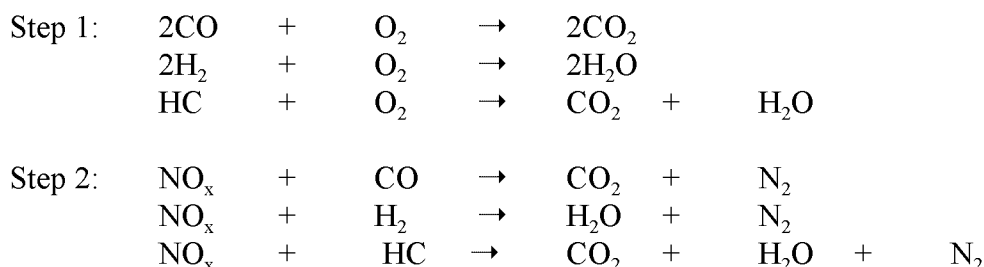
### 4.10.1 WHAT POLLUTANTS ARE CONTROLLED USING NONSELECTIVE CATALYTIC REDUCTION?

Primarily NO<sub>x</sub>, but NSCR reduces CO and hydrocarbons (HC) as well.

### 4.10.2 HOW DOES NONSELECTIVE CATALYTIC REDUCTION WORK?

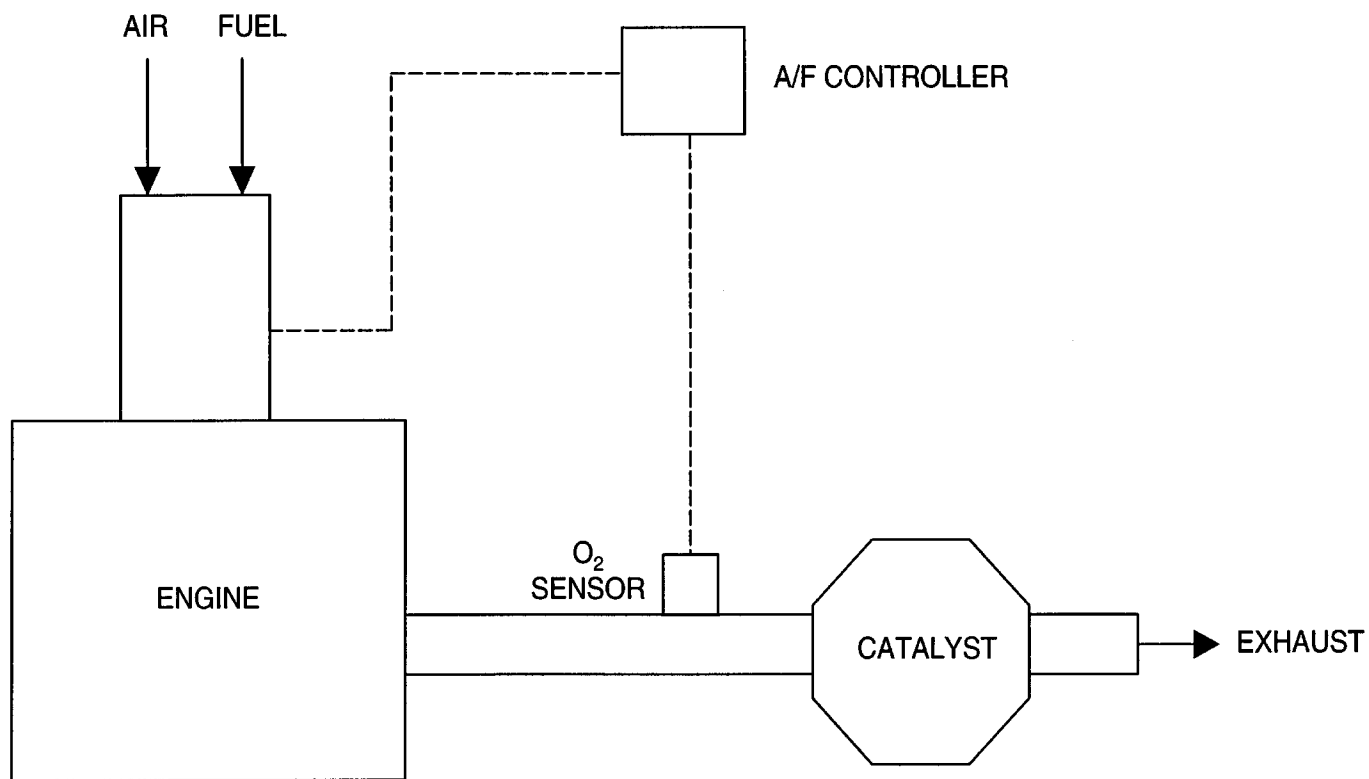
NSCR technique is essentially the same as the catalytic reduction systems that are used in automobiles applications. NSCR is achieved by placing a catalyst in the exhaust stream of the engine.

NSCR technique is also referred to as three-way catalyst because it simultaneously reduces NO<sub>x</sub>, CO, and HC to water, CO<sub>2</sub>, and N<sub>2</sub>. This conversion occurs in two discrete and sequential steps:



In the first step, excess oxygen is removed from the exhaust gas. Because CO and HC react more readily with O<sub>2</sub>, the O<sub>2</sub> content of the exhaust is kept below approximately 0.5 percent. This will ensure adequate NO<sub>x</sub> reduction in the second step. Therefore, NSCR is applicable only to carbureted rich-burn engines.

Typically, natural gas is used as the NO<sub>x</sub> reducing agent in NSCR. Natural gas is injected into the exhaust stream ahead of the catalyst reactor and acts as a reducing agent for NO<sub>x</sub>. Figure 12.4-4 is a schematic diagram of a typical NSCR system.



**FIGURE 12.4-4. SCHEMATIC OF A NONSELECTIVE CATALYTIC REDUCTION SYSTEM DESIGN WITH A SINGLE CATALYTIC REACTOR**

### 4.10.3 WHAT ISSUES ARE OF CONCERN WHEN USING NONSELECTIVE CATALYTIC REDUCTION?

The main issue of concern with NSCR is its limited applicability resulting from the narrow range of exhaust  $O_2$  level required for consistent  $NO_x$  reduction. NSCR can be installed on new engines or retrofit to existing units. However, because of the air-to-fuel ratio necessary for the operation of NSCR, this control technique can be used on carbureted rich-burn engines, but not to fuel-injected units.

Other issues of concern when using NSCR include:

- Control of air-to-fuel ratio: In order to reduce  $NO_x$  emissions while minimizing CO emissions from the catalyst, the exhaust  $O_2$  concentration must be maintained at approximately 0.5 percent by volume. This  $O_2$  level is accomplished by maintaining the air-to-fuel ratio in a narrow band.
- Exhaust temperature: The operating temperature range for various NSCR catalysts is from 375° to 825° C (700° to 1500° F). For  $NO_x$  reductions of 90 percent or greater, the temperature range narrows to approximately 425° to 650° C (800° to 1200° F). Although this temperature range is based on a compilation of available catalyst formulations, individual catalysts will have narrower operating temperature range, and maximum reduction efficiencies may not be achievable over the entire spectrum of exhaust temperatures for an engine operating in a variable load application. Moreover, abnormal operating conditions, such as backfiring, can result in excessive temperatures that damage the highly porous catalyst surface, permanently reducing the emission reduction capability of the catalyst.
- Masking or poisoning of the catalyst: Masking occurs when materials deposit on the catalyst surface and cover the active areas. Poisoning occurs when materials deposit on the catalyst surface and chemically react with active areas. Masking and poisoning reduce the catalyst's reduction capacity. Masking agents include sulfur, calcium, fine silica particles, and hydrocarbons. Poisoning agents include phosphorus, lead, and chlorides. Examples of masking and poisoning containing fuels include landfill and digester gas fuels.

### 4.10.4 WHAT WASTES RESULT FROM USING NONSELECTIVE CATALYTIC REDUCTION?

None.

## **4.11 WET ACID GAS SCRUBBERS**

### **4.11.1 WHAT POLLUTANTS ARE CONTROLLED USING WET ACID GAS SCRUBBERS ?**

Wet acid gas scrubbers are used to control SO<sub>2</sub> emissions.

### **4.11.2 HOW DO WET ACID GAS SCRUBBERS WORK?**

In most large systems, a sorbent material is milled and mixed into a slurry and pumped to an absorber reaction tank. Flue gas is fed to the reactor and the SO<sub>2</sub> in the gas is absorbed, neutralized, and partially oxidized as the result of coming in contact with the sorbent material. Wet acid gas scrubbers occur downstream of the particulate control devices to avoid erosion of the desulfurization equipment and possible interference of particulate matter with the scrubbing process. The slurry falls to a perforated plate tray where additional SO<sub>2</sub> is absorbed into the froth created by the interaction of the flue gas and the slurry on the tray. The slurry then drains back into the reaction tank. A fraction of the slurry is continuously diverted to the disposal (dewatering) system. Refer to Figure 12.4-5.

### **4.11.3 WHAT SORBENT MATERIAL IS USED IN WET ACID GAS SCRUBBERS?**

Lime or limestone is used as the sorbent material. Both processes are nonregenerable; the reagent is consumed by the process and must be continually replaced. Lime scrubbing and limestone scrubbing are very similar in equipment and process flow, except that lime is a much more reactive reagent than limestone. The major advantage of limestone scrubbing is that the absorbent material is abundant and inexpensive. The disadvantages include scaling (hard plugging), equipment plugging (soft plugging), and corrosion. The advantages of lime scrubbing include better utilization of the reagent and more flexibility in operations. The major disadvantage is the high cost of lime relative to limestone.

### **4.11.4 WHAT ISSUES ARE OF CONCERN WHEN USING WET ACID GAS SCRUBBERS?**

Several parameters must be controlled in a wet scrubber to ensure continuous operation. The pH of the slurry is one of these. Early scrubbers suffered from severe scale and plugging problems. Scaling (hard plugging) resulted from precipitation of limestone in piping and on other surfaces if the pH was too high. A low pH indicates a high concentration of calcium sulfite in the slurry and can cause plugging (soft plugging) in pipes and other passages. The final reaction product, calcium sulfate, can also produce hard plugging if it precipitates due to changes in pH.

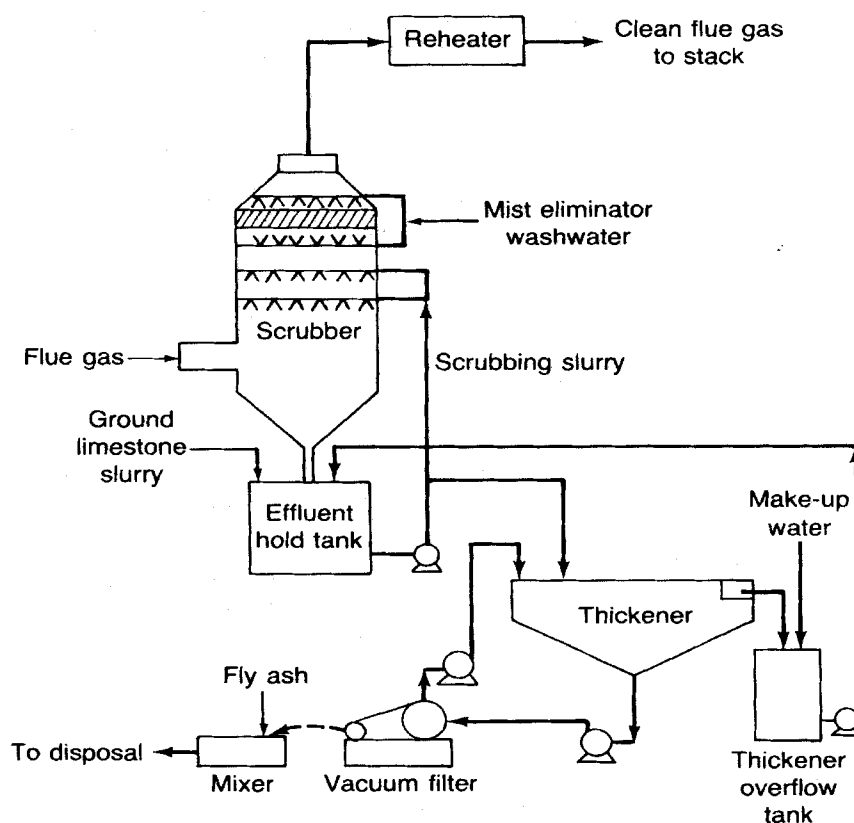


FIGURE 12.4-5. SCHEMATIC PROCESS FLOW DIAGRAM FOR A LIMESTONE-BASED SO<sub>2</sub> WET SCRUBBING SYSTEM (COOPER AND ALLEY, 1994)

Fresh lime or limestone slurry is introduced into the system to control pH in the scrubber slurry. Since the volume of slurry in the scrubber vessel must remain relatively constant, a bleed stream of slurry must also be withdrawn from the scrubber.

Stainless steel, commonly 317L or similar quality, in wet acid gas scrubbers must be protected from corrosion due to high concentrations of chloride salts in the slurry which is normally limited to a fixed value. These salts are controlled by replacement of liquid of the slurry. The combination of slurry necessary to control pH and concentration of limestone in the fresh slurry are both varied to satisfy both of these limitations.



These operational factors affect SO<sub>2</sub> removal. Other operational parameters, such as the recirculation rate of the slurry and the spray atomization characteristics in the scrubber will also affect acid gas removal performance.

#### **4.11.5 WHAT WASTES RESULT FROM USING WET ACID GAS SCRUBBERS ?**

Wet acid gas scrubbers generate large quantities of spent slurry. This waste can be disposed of by:

- Ponding the spent slurry without dewatering. This is the simplest method, but requires a large ponding area and the management of the site is expensive.
- A combination of dewatering, secondary dewatering, and landfilling. This is the most common disposal strategy in the United States.
- Sulfite sludge can be mixed with flyash and lime to yield a material suitable for landfilling.
- Gypsum can be concentrated to a cake and sold for use in wallboard or fertilizer manufacture.

### **4.12 SPRAY DRYER ABSORBERS (SDA)**

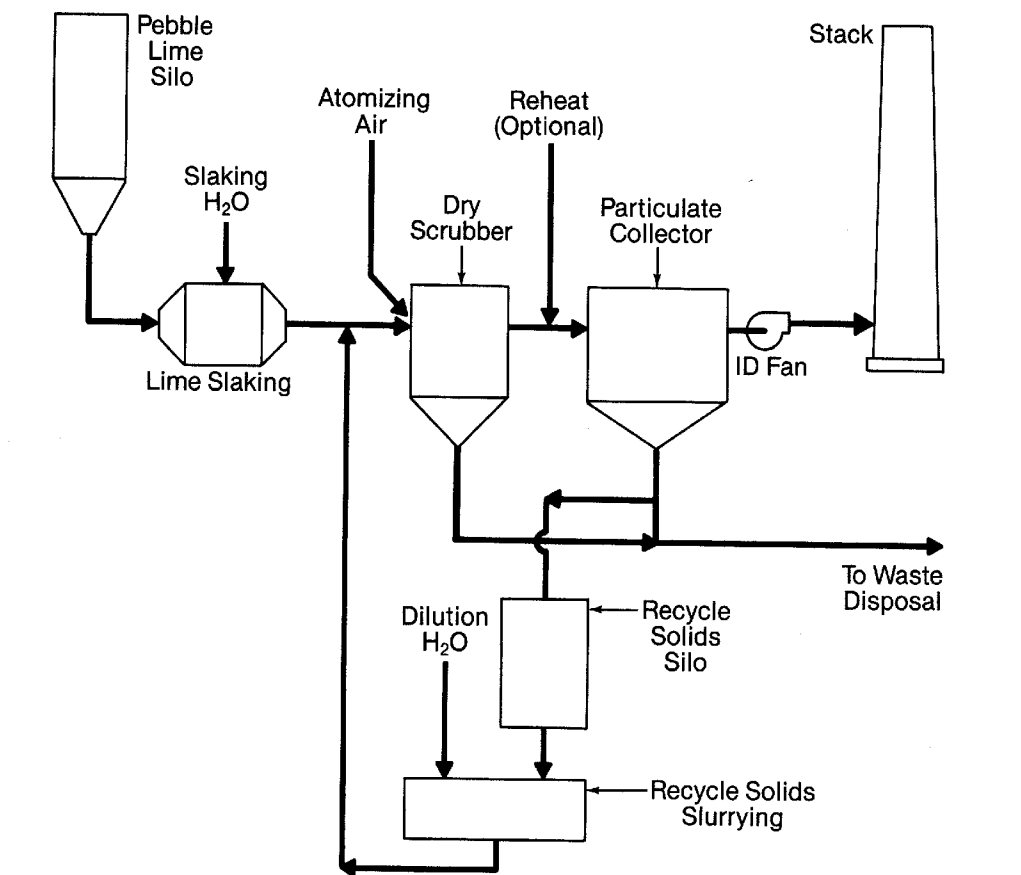
#### **4.12.1 WHAT POLLUTANTS ARE CONTROLLED USING SPRAY DRYER ABSORBERS?**

Spray dryer absorbers (SDA) are used primarily to control SO<sub>2</sub>. SDA have been applied to utility boilers, smaller industrial applications, and for combined hydrogen chloride (HCl) and SO<sub>2</sub> control at waste-to-energy units.

Spray dryer absorbers are also referred to as spray dryers, spray absorbers, dry scrubbers, and semi-wet scrubbers.

#### **4.12.2 HOW DO SPRAY DRYER ABSORBERS WORK?**

Unlike a wet scrubber, an SDA is positioned before the particulate matter collector. In an SDA, a highly atomized or aqueous lime slurry is sprayed into an absorption tower so that the slurry droplets dry as they contact the hot flue gas. Sulfur dioxide is absorbed by the slurry, forming CaSO<sub>3</sub>/CaSO<sub>4</sub>. The liquid-to-gas ratio is such that the water evaporates before the droplets reach the bottom of the tower. The dry solids are carried out with the gas and collected in a fabric filter with the fly ash. Refer to Figure 12.4-6.



**FIGURE 12.4-6. SPRAY DRYER ABSORBER SYSTEM SCHEMATIC (BABCOCK & WILCOX, 1992)**

#### 4.12.3 WHAT SORBENT MATERIAL IS USED IN SPRAY DRYER ABSORBERS?

Slaked lime is usually used as the sorbent.

#### 4.12.4 WHAT ISSUES ARE OF CONCERN WHEN USING SPRAY DRYER ABSORBERS?

The reagent slurry feed into the spray dryer generally is a mix of two feed systems and these systems require close monitoring and maintenance to ensure proper operation of the SDA. The first feed system is the rich lime slurry. The slurry is usually produced by slaking quick lime ( $\text{CaO}$ ) at the plant site to produce hydrated lime ( $\text{Ca(OH)}_2$ ) in a water based slurry. High quality

water is necessary for the slaking operation. The second feed is “dilution” water, which can contain plant wastewater, river water, and landfill leachate.

Both of these feeds are used to control operation of the SDA. Acid gas removal is achieved by regulating the rich lime slurry feed rate. The longer the slurry droplets take to dry, while maintaining a liquid surface, the greater the chemical reactivity of the lime and resulting removal of acid gases. This is accomplished by regulating the dilution water feed rate to control the SDA outlet gas to a fixed temperature as low as possible while maintaining the temperature high enough to ensure the drying of solids to protect ductwork and downstream particulate control devices.

Controls for both feeds are linked because the slurry contains water and will also affect the outlet gas temperature. Most systems measure the acid gas concentration and temperature in the outlet gas of the SDA, and the feed rates are regulated based on these measurements.

Control problems may occur if the system can not feed enough rich lime slurry into the unit. This can result from improper design of the dual feed control system or if the rich lime slurry is not sufficiently reactive to produce proper acid gas control alone.

Another concern is the response time of the feed system to varying acid gas concentrations in the flue gas stream. Some facilities mix both feeds in a tank prior to SDA injection. Acid gas concentrations will vary with time. This will occur quickly for some processes and will be more pronounced in smaller units. Therefore, the mix tank must be designed to change its lime concentration quickly enough to respond to changes in acid gas concentration.

#### **4.12.5 WHAT WASTES RESULT FROM USING SPRAY DRYER ABSORBERS?**

Spray dryer absorbers generate dry particulate matter that is collected in downstream air pollution control devices.

### **4.13 DRY INJECTION**

#### **4.13.1 WHAT POLLUTANTS ARE CONTROLLED USING DRY INJECTION?**

Acid gas pollutants including  $\text{SO}_2$  and  $\text{HCl}$  are controlled using dry injection.

#### **4.13.2 HOW DOES DRY INJECTION WORK?**

Dry injection, often referred to as dry sorbent injection (DSI), involves the addition of a dry reagent to the gas stream to react with acid gases present. The reagent may be injected into the

combustion zone or into the downstream duct. The reaction products are collected in a particulate collection device. In some cases, a portion of the collected reaction products is reinjected to increase acid gas removal and decrease reagent consumption.

#### **4.13.3 WHAT SORBENT MATERIAL IS USED IN DRY INJECTION?**

Hydrated lime  $[\text{Ca}(\text{OH})_2]$  or soda ash  $[\text{Na}_2(\text{CO}_3)]$  is usually used as the sorbent material.

#### **4.13.4 WHAT ISSUES ARE OF CONCERN WHEN USING DRY INJECTION?**

The main issue of concern is determining the proper reagent feed rate appropriate for the level of acid gas in the flue gas stream and making prompt changes, when necessary, in the feed rate to compensate for changes in the acid gas flow rate.

#### **4.13.5 WHAT WASTES RESULT FROM USING DRY INJECTION?**

Dry injection generates dry particulate matter that is collected in a downstream particulate collection device, usually a fabric filter.

### **4.14 CARBON ADSORPTION**

#### **4.14.1 WHAT POLLUTANTS ARE CONTROLLED USING CARBON ADSORPTION?**

Carbon adsorption is applied to control emissions of gaseous pollutants, primarily organic compounds. Carbon adsorption is commonly used to control VOC emissions from dry cleaners, degreasing operations, publication gravure printing plants, chemical processing industry, petroleum industry, and landfills. Carbon systems have also been developed for the adsorption of sulfur oxides.

In contrast to incineration techniques that destroy the organic compounds, carbon adsorption provides a favorable control option when the organic compounds in the emission stream are valuable because recovery of the organics may be possible.

#### **4.14.2 HOW DOES CARBON ADSORPTION WORK?**

Adsorption is the concentration of a substance **on the surface** of a liquid or solid. The adsorbed substance does not penetrate within the crystal lattice of the solid or dissolve within it, but remains entirely on the surface. Adsorption is **not** the same as absorption, in which the substance **passes through the surface** to become distributed throughout the phase.

Carbon adsorption air pollution control techniques are based on the principle that if the intermolecular forces between the adsorbent and the pollutant are greater than those existing between the molecules of the pollutant, the pollutant will condense on the surface of the adsorbent. The adsorptive capacity of the carbon bed tends to increase with the concentration, molecular weight, diffusivity, and boiling point of the gas phase organics and decrease with increased temperature of the flue gas.

To allow gas vent streams containing organic compounds to come into contact with the activated carbon, the carbon granules are usually arranged in either a vertical or horizontal vessel. Small units are manufactured with the carbon in place (canisters). Larger units are constructed so that the carbon granules are loaded after installation; two configurations are common:

- **Fixed-bed systems** are non-moving beds of activated carbon that are alternately placed on-line and regenerated. When a continuous emission stream is being treated, at least one bed is on line and one bed is on stand-by or being regenerated at any given time. When the first bed approaches its capacity, the emission stream is redirected to the second bed and the first bed is regenerated.
- **Fluidized-bed systems** contain one or more beds of loose, beaded activated carbon. The emission stream is directed upward through the bed and the organic compounds are adsorbed onto the carbon. The flow of the emission stream stirs the carbon beads, causing them to fluidize and flow through the adsorber. Fresh carbon beads are continuously metered into the bed and organic compounds-laden carbon is removed for regeneration.

Because the amount of organics that can be adsorbed per unit mass of activated carbon increases as the temperature decreases, the flue gas is often passed through a cooler before entering the adsorbent bed. The cooled gas stream travels through the adsorbent bed where the organic compounds are removed and the remaining flue gas vented or returned to the source process. When the capacity limit of the adsorbent is reached, the carbon granules can be removed and replaced (canister systems), regenerated in place, or removed for regeneration. The saturated carbon bed is regenerated by direct contact with low pressure steam.

Carbon adsorption is sensitive to emission stream conditions. The presence of liquid or solid particles, high boiling organics, or polymerized substances may require pretreatment procedures such as filtration.

#### 4.14.3 WHAT SORBENT MATERIAL IS USED IN CARBON ADSORPTION?

Activated carbon is the preferred adsorbent material to remove organic compounds from gas streams. It is produced by heating wood charcoal to between 350 and 1000°C in a vacuum, or in

air, steam, or other gases. The activation process distills hydrocarbon impurities from the charcoal and exposes a larger free surface for possible adsorption. Activated carbon has a high affinity for:

- Nonpolar compounds;
- High-molecular-weight materials; and
- Compounds with low volatility.

#### **4.14.4 WHAT ISSUES ARE OF CONCERN WHEN USING CARBON ADSORPTION?**

One issue with the carbon adsorption technique is that the capacity of the adsorbent bed for adsorbing organic compounds progressively deteriorates with use.

#### **4.14.5 WHAT WASTES RESULT FROM USING CARBON ADSORPTION?**

Activated carbon beds are usually regenerated with steam. The steam is condensed and the condensate, along with the recovered hydrocarbons, are sent to a wastewater treatment facility.

### **4.15 THERMAL OXIDATION**

#### **4.15.1 WHAT POLLUTANTS ARE CONTROLLED USING THERMAL OXIDATION?**

Thermal oxidation is applied as a post-process technique to control emissions of gaseous pollutants, primarily CO and VOC. Given a high enough temperature and a long enough residence time, combustion can oxidize virtually all hydrocarbons to carbon dioxide and water.

Thermal oxidizers, also known as thermal incinerators, or afterburners, are used for low concentrations of organic compounds. The concentration of the VOC in the flue gas or the concentration of organics in the air must be kept substantially lower than the lower explosive limit.

#### **4.15.2 HOW DOES THERMAL OXIDATION WORK?**

Flue gas, air, and fuel (typically natural gas) are continuously delivered to the reactor, where the fuel and air are combusted in the firing unit. The energy released by combustion of the fuel heats the flue gas which passes through the reactor where the organic pollutants are reacted (oxidized) to harmless endproducts. The oxidation reactions require an elevated temperature (1200 -

2000°F) and a residence time of 0.2 to 2.0 seconds. Figure 12.4-7 shows a typical thermal oxidizer.

#### **4.15.3 WHAT ISSUES ARE OF CONCERN WHEN USING THERMAL OXIDATION?**

Issues that can be associated with thermal oxidation systems include:

- Thermal oxidation is not well suited to gas streams with highly variable flow rates because the reduced residence time, and poor mixing decrease the completeness of the combustion during increased flow rates. This causes the combustion chamber temperature to fall, decreasing the destruction efficiency.
- Combustion of organic gases represents an explosion hazard.
- Thermal oxidizers that are not operating efficiently can produce air pollutants. The incomplete combustion of many organic compounds can result in the formation of aldehydes and organic acids.
- If the heat from the fuel burned is not recovered for process needs, or some useful purpose, it amounts to wasted energy. This also results in extra releases of CO<sub>2</sub>, a greenhouse gas.

#### **4.15.4 WHAT WASTES RESULT FROM USING THERMAL OXIDATION?**

None.

### **4.16 CATALYTIC OXIDATION**

#### **4.16.1 WHAT POLLUTANTS ARE CONTROLLED USING CATALYTIC OXIDATION?**

Catalytic oxidation is applied primarily to control CO and gaseous organic compounds, including organic HAPs. CO oxidation catalysts are typically used on gas turbines that use steam injection which can increase CO and unburned hydrocarbons in the exhaust.

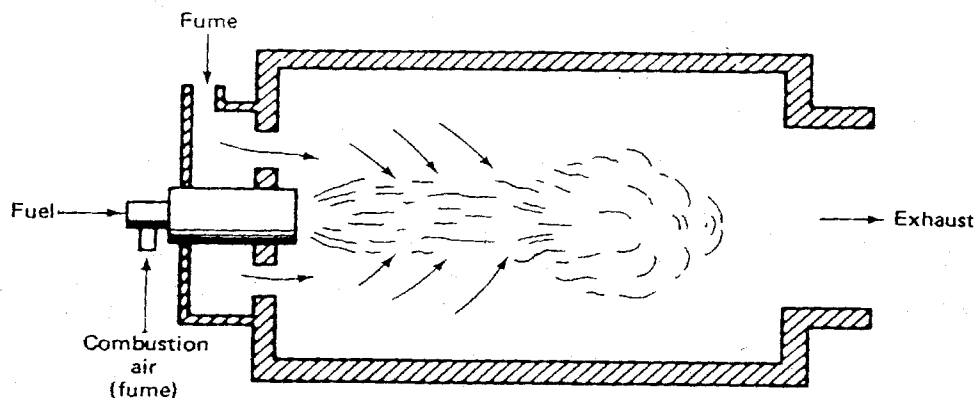


FIGURE 12.4-7. SCHEMATIC OF A THERMAL OXIDIZER (AWMA, 1992)

#### 4.16.2 HOW DOES CATALYTIC OXIDATION WORK?

Catalytic oxidation is very similar to thermal oxidation. In catalytic oxidation the gases pass over a catalyst bed that promotes oxidation at a lower temperature (650 - 800°F) than required for thermal oxidation.

Catalytic oxidation is not applied as widely as thermal oxidation because catalytic oxidation is more sensitive to pollutant characteristics and process conditions than thermal oxidation. Figure 12.4-8 shows a typical catalytic oxidizer.

#### 4.16.3 WHAT CATALYST MATERIAL IS USED IN CATALYTIC OXIDATION?

Catalysts include:

- Metals in the platinum family; and
- Oxides of copper, chromium, vanadium, nickel, and cobalt.



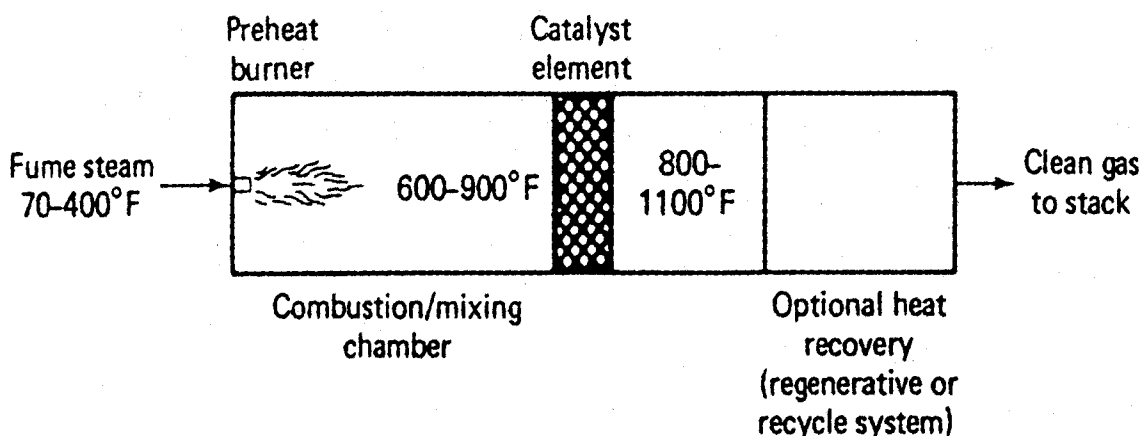


FIGURE 12.4-8. SCHEMATIC OF CATALYTIC OXIDIZER (AWMA, 1992)

#### 4.16.4 WHAT ISSUES ARE OF CONCERN WHEN USING CATALYTIC OXIDATION?

Issues that can be associated with catalytic oxidation systems include:

- Catalysts are subject to poisoning by many elements that are present in industrial emissions, particularly halogens, sulfur compounds, zinc, arsenic, lead, mercury, and particulates;
- High temperatures can decrease catalyst activity;
- Combustion of organic gases represents an explosion hazard; and
- Catalytic oxidizers that are not operating efficiently can produce air pollutants. The incomplete oxidation of many organic compounds can result in the formation of aldehydes and organic acids that may create additional air pollution problems.

#### 4.16.5 WHAT WASTES RESULT FROM USING CATALYTIC OXIDATION?

Spent catalyst should be considered as a potential hazardous pollutant in the solid waste stream.

## 4.17 FLARES

### 4.17.1 WHAT POLLUTANTS ARE CONTROLLED USING FLARES?

Flares are used to control CO and most gaseous organic compounds. Flares are most commonly used for disposal of large quantities of unwanted flammable gases and vapors resulting from process upsets and emergencies. Flares are used when the concentration of organics in the air equals or exceeds the lower explosive limit level or when the heating value of the emission stream cannot be recovered economically because of uncertain or intermittent flows. Flares are primarily used in the petroleum and petrochemical industries.

### 4.17.2 HOW DO FLARES WORK?

Vent gas containing organics is fed to and discharged from a stack. Mixing and combustion of the vent gas, air, and fuel take place above the stack exit in the atmosphere. Complete combustion must occur instantaneously because there is no residence chamber. Flare combustion efficiency is related to flame temperature, residence time of gases in the combustion zone, the amount of oxygen available for combustion, and degree of flue gas/oxygen mixing. Figure 12.4-9 shows a typical flare.

Flare configurations can be classified as:

- **Smokeless** flares introduce steam or air to ensure the efficient gas/air mixing and turbulence necessary for complete combustion. Smokeless flaring is required for the destruction of organic compounds heavier than methane. Steam-assisted smokeless flares are most common.
- **Nonsmokeless** flares are used to destroy organic vapor streams that burn readily and do not produce smoke.
- **Fired, or endothermic**, flares require additional energy to ensure complete oxidation of the waste streams such as sulfur and ammonia.

### 4.17.3 WHAT ISSUES ARE OF CONCERN WHEN USING FLARES?

Issues that can be associated with flares include:

- Combustion of organic gases represents an explosion hazard.

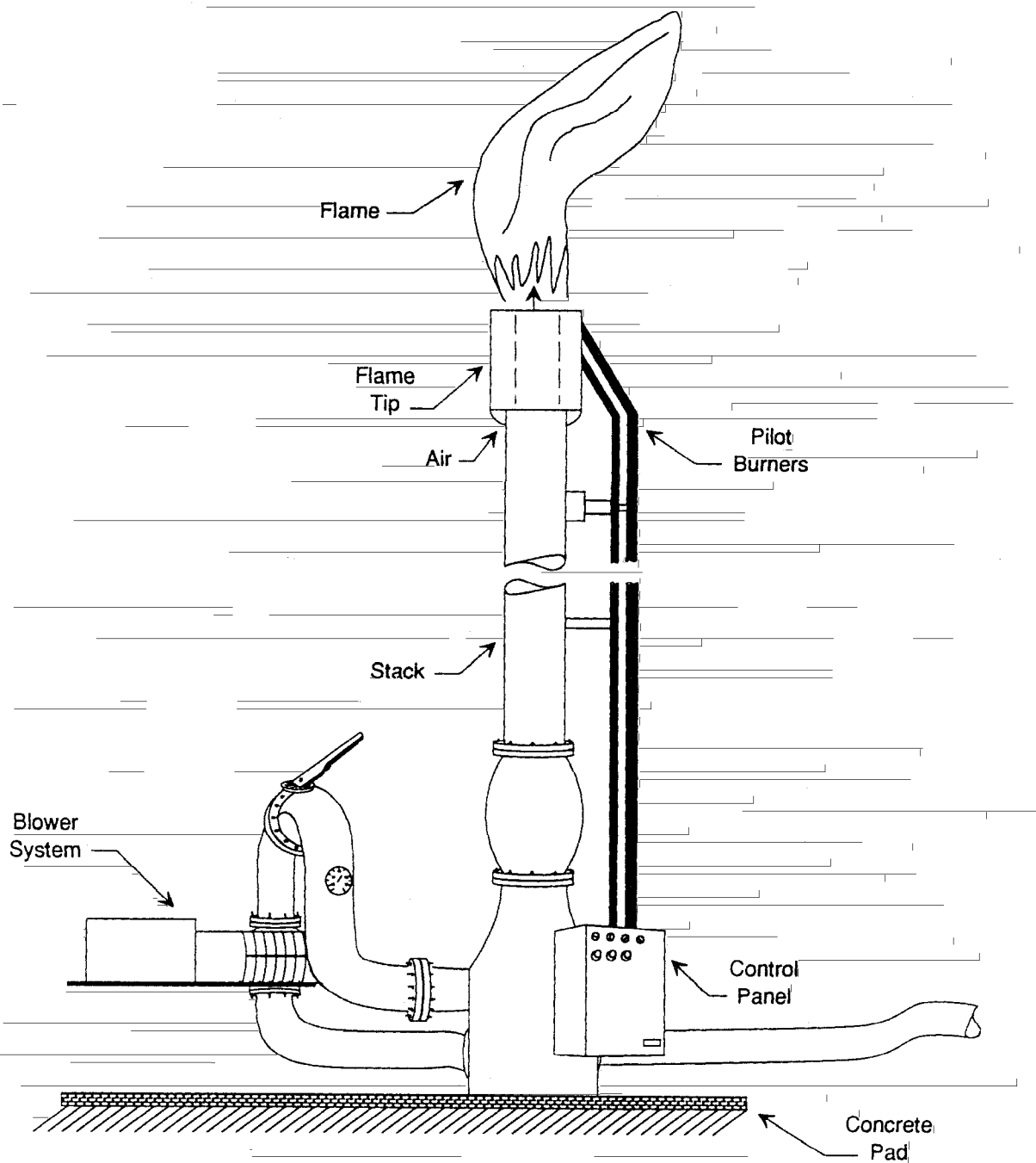


FIGURE 12.4-9. TYPICAL OPEN FLARE ( AWMA, 1992)

- Flares that are not operating efficiently can produce air pollutants.
- When a flare is not operating properly, incomplete combustion can occur. The incomplete combustion of many organic compounds can result in the formation of aldehydes and organic acids that may create additional air pollution problems.

#### 4.17.4 WHAT WASTES RESULT FROM USING FLARES?

None.

### 4.18 FLOATING ROOF SYSTEMS

#### 4.18.1 WHAT POLLUTANTS ARE CONTROLLED USING FLOATING ROOF TANK SYSTEMS?

Floating roof tank systems are used by petroleum producing and refining, petrochemical and chemical manufacturing, bulk storage and transfer operations, and other industries consuming or producing organic liquids to reduce the air emissions of VOC that occur as the result of evaporation.

#### 4.18.2 HOW DO FLOATING ROOF TANK SYSTEMS WORK?

Three designs are used to reduce evaporative loss of liquids and vapors during the storage of organic liquids

- **External floating roof tanks (EFRT)** have an open-topped cylindrical steel shell with a roof that floats on the surface of the stored liquid. The roof rises and falls with the liquid level in the tank. The floating roof consists of a deck, fittings, and a rim seal. The rim seal system is attached to the deck perimeter and contacts the tank wall. The seal system slides against the tank wall as the roof is raised and lowered. The external floating roof design limits evaporative loss of the stored liquid to losses from the rim seal system and deck fittings (standing storage loss) and any exposed liquid on the tank walls (withdrawal loss).
- **Internal floating roof tanks (IFRT)** have both a fixed permanent roof and a floating roof inside. The function of the fixed roof is not to act as a vapor barrier, but to block the wind. The deck in internal floating roof tanks rises and falls with the liquid level and either floats directly on the liquid surface (contact deck) or rests on pontoons several inches above the water (noncontact deck). Noncontact decks are the most common type currently in use. Both contact and noncontact decks incorporate rim seals and deck fittings to reduce evaporative loss of the

stored liquid. These tanks are freely vented by circulation vents at the top of the fixed roof. The vents minimize the possibility of organic vapors accumulating in the tank vapor space to concentration levels that approach the explosive range.

- **Domed External Floating Roof Tanks** are usually the result of the retrofit of an EFRT. These tanks have the same type of deck, deck fittings, and rim seals used in EFRT as well as a fixed roof at the top of the shell like IFRT. Like the IFRT, these tanks are freely vented by circulation vents at the top of the fixed roof.

#### **4.18.3 WHAT ISSUES ARE OF CONCERN WHEN USING FLOATING ROOF TANK SYSTEMS?**

Deterioration of seals; inspection and maintenance are important for continued good service.

#### **4.18.4 WHAT WASTES RESULT FROM USING FLOATING ROOF TANK SYSTEMS?**

None.

### **4.19 MECHANICAL COLLECTORS**

#### **4.19.1 WHAT POLLUTANTS ARE CONTROLLED USING MECHANICAL COLLECTORS?**

Coarse and medium particulate matter are controlled using mechanical collectors.

#### **4.19.2 HOW DO MECHANICAL COLLECTORS WORK?**

The five major types of mechanical collectors are settling chambers, elutriators, momentum separators, centrifugal collectors, and cyclones. These devices are discussed below.

##### ***Settling Chambers***

The simplest mechanical collectors are settling chambers, which rely on gravitational settling as a collection mechanism. Settling chambers prevent excessive abrasion and dust loading in primary collection devices by removing large particles from the gas stream.

There are two primary types of settling chambers: the expansion chamber and the multiple-tray chamber. In an expansion chamber, the velocity of the gas stream is significantly reduced as the gas expands into a large chamber. The reduction in velocity allows larger particles to settle out of the gas stream. A multiple-tray settling chamber is an expansion chamber with a number of thin trays closely spaced within the chamber, which causes the gas stream to flow horizontally between them. An expansion chamber must be very large to collect any small particles, but

multiple-tray chambers have lower volume requirements for collection of small particles (greater than, or equal to, 15 microns).

### ***Elutriators***

Elutriators rely on gravitational settling to collect particles. An elutriator is made up of one or more vertical tubes or towers in series, where the gas stream passes upward through the tubes. Larger particles whose terminal settling velocity is greater than the upward gas velocity are collected at the bottom of the tube, while smaller particles are carried out of the top of the tube. Size classification of the collected particles can be achieved by using a series of tubes with increasing diameters.

### ***Momentum Separators***

Momentum separators utilize both gravity and inertia to separate particles from the gas stream. Separation is accomplished by forcing the gas flow to sharply change direction within a gravity settling chamber through the use of strategically placed baffles. Typically, the gas first flows downward and then is forced by the baffles to suddenly flow upwards. Inertial momentum and gravity act in the downward direction on the particles, which causes larger particles to cross the flow lines of the gas and collect in the bottom of the chamber. Momentum separators are capable of collecting particles as small as 10 microns at low efficiency (10-20 percent).

### ***Centrifugal Collectors***

Centrifugal collectors, sometimes referred to as mechanically aided separators, rely on inertia as a separation mechanism. The gas stream is accelerated mechanically, which increases the effectiveness of the inertia separation. As a result, centrifugal collectors can collect smaller particles than momentum separators. A common type of centrifugal collectors is the modified radial blade fan. In this device, the gas stream enters at the center of the fan, perpendicular to the blade rotation. The blades propel the particles across the gas flow lines, where they are concentrated on the inside wall of the casing. From there, the particles are diverted into a collection hopper while the gas continues out of the separator.

### ***Cyclones***

Cyclones are essentially cylinders with inlet and outlet ducts for the air stream. A vortex is created in the cylindrical section of the cyclone either by injecting the air stream tangentially or by passing the gas through a series of vanes. As the particulate-laden gas is forced to change direction in the vortex, the inertia of the particles forces them to continue in the original direction, collide with the outer wall, and slide downward to the bottom of the device to be collected in a hopper. The cleaned airstream passes upward and out of the cyclone. Particle

separation is a function of gas throughput and the cyclone cylindrical diameter. Particle removal efficiency increases with increased flue gas velocity and decreases with decreased cylinder diameter. However, above an upper limit of flue gas velocity, increased turbulence can reduce particle removal efficiency.

Simple cyclones consist of an inlet, cylindrical section, conical section, gas outlet tube, and a dust outlet tube. Figure 12.4-10 is a schematic diagram of a typical cyclone. A multiple cyclone, or multiclone, consists of a number of small-diameter cyclones operating in parallel. This design takes advantage of the high efficiency of small diameter tubes and is capable of treating large gas volumes.

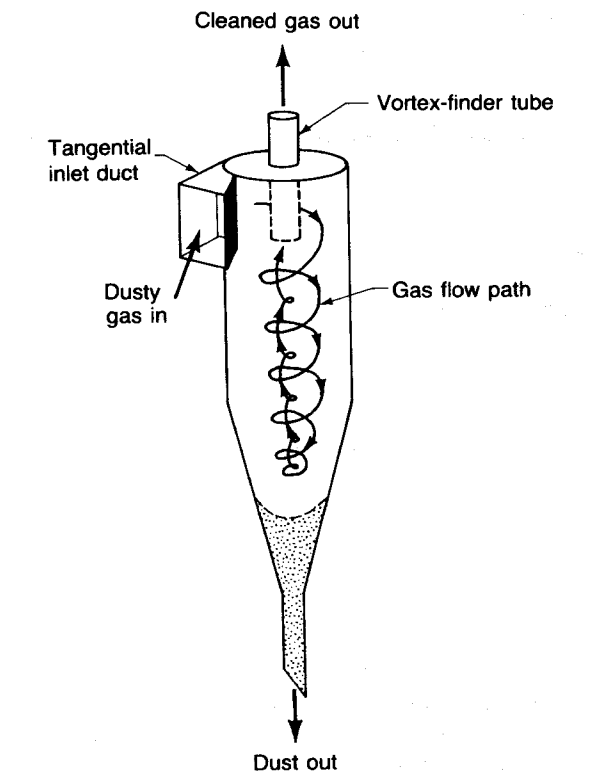
#### **4.19.3 WHAT ISSUES ARE OF CONCERN WHEN USING MECHANICAL COLLECTORS?**

The issues are:

- Plugging of the dust outlet tube can affect the performance of cyclones.
- With cyclones, abrasion can lead to leaks or rough areas on the surface of the cylinder that can cause local turbulence, reducing the effectiveness of the vortex in removing particles.
- The efficiency of multiple cyclones can be decreased by hopper recirculation which occurs when uneven pressure drops across the system result in reversed flow of the exhaust stream in some areas of the multiple cyclone.
- The abrasive wear from large particles and clogging from particles which accumulate on the fan blades can affect the efficiency of centrifugal collectors.

#### **4.19.4 WHAT WASTES RESULT FROM USING MECHANICAL COLLECTORS?**

Mechanical collectors collect dry particulate waste. To decrease the problems associated with handling fine dust, the collected particulate matter can be wetted in a pug mill into a clay-like consistency, or pelletized before it is recycled or landfilled.



**FIGURE 12.4-10. SCHEMATIC FLOW  
DIAGRAM OF A STANDARD CYCLONE  
(COOPER AND ALLEY, 1994)**



## 4.20 ELECTROSTATIC PRECIPITATORS (ESP)

### 4.20.1 WHAT POLLUTANTS ARE CONTROLLED USING ELECTROSTATIC PRECIPITATORS?

Particulate matter emissions are controlled using ESPs.

### 4.20.2 HOW DO ELECTROSTATIC PRECIPITATORS WORK?

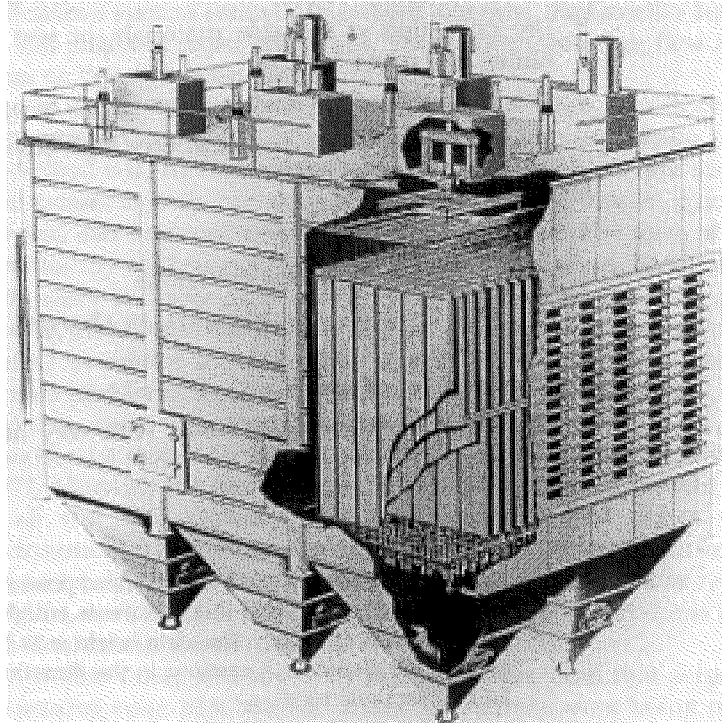
Electrostatic precipitators use an electrostatic field to charge particulate matter in the flue gas stream. The charged particles then migrate to a grounded collection surface. The collected particles are periodically dislodged from the collection surface by vibration or rapping.

An ESP is essentially a large box with a series of electrodes and grounded plates. Figure 12.4-11 is a schematic diagram of a typical ESP. ESPs use electrical forces to move the particles out of the flowing gas stream and onto the collector plates. Voltage is applied to the electrodes causing the gas between the negatively-charged electrodes to break down electrically, forming a “corona.” The ions generated in the corona follow electric field lines from the electrodes to the collecting plates; establishing charging zones through which the particles must pass. Particles passing through the charging zone intercept some of the ions, which become attached. As the particles pass each successive wire, they are driven closer and closer to the oppositely charged collecting walls, but the turbulence of the gas tends to keep them uniformly mixed with the gas. The collection process is a competition between electrical and dispersive forces. Eventually, the particles approach close enough to the walls so that the turbulence drops to low levels and the particles are collected. Refer to Figure 12.4-12.

Once the particles are collected on the plates, they must be removed from the plates without reentraining them into the gas stream. This is usually accomplished by knocking them loose from the plates, allowing the collected layer of particles to slide down into a hopper, from which they are evacuated. Because particulate tends to agglomerate, the ash layer is removed in sheets.

There are several common configurations for electrostatic precipitators:

- **Plate-wire precipitators** are the most common ESP configuration. In a plate-wire ESP, dirty gas flows into a chamber consisting of a series of discharge wire electrodes that are equally spaced along the center line between adjacent collection plates. Charged particles are collected on the plates as dust. Plate-wire ESPs can handle large volumes of gas and are used in coal-fired boilers, cement kilns, solid waste incinerators, paper mill recovery boilers, petroleum refining catalytic cracking units, sinter plants, basic oxygen furnaces, open hearth furnaces, electric arc furnaces, coke oven batteries, and glass furnaces.



**FIGURE 12.4-11. CUTAWAY VIEW OF AN  
ELECTROSTATIC PRECIPITATOR  
(COOPER AND ALLEY, 1994)**

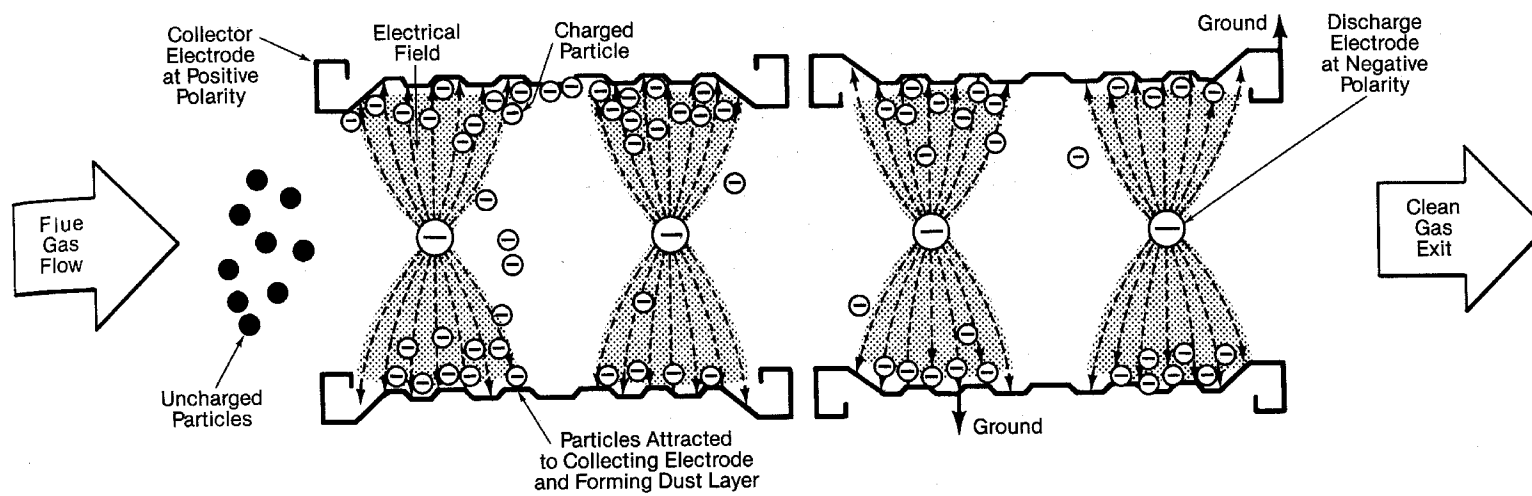


FIGURE 12.4-12. PARTICLE CHARGING AND COLLECTION WITHIN AN ESP  
(BABCOCK & WILCOX, 1992)

- **Rigid discharge electrode (RDE)** units have electrodes suspended from high-voltage frames located in the area above the gas passages. RDEs are currently the most popular configuration of ESPs. The discharge electrodes are centered in the gas passages. In a common form of this design, sharp-pointed needles attached to a rigid structure are used as high-voltage electrodes instead of the electrodes hanging between plates of a plate-wire ESP. RDE units are typically used in the pulp and paper, ferrous and non-ferrous metals, petrochemical, cement, and waste-to-energy industries, as well as, electric power generating plants.
- **Wet precipitators** are plate-wire, flat-plate, or tubular ESPs operated with water flow applied intermittently or continuously to wash the collected particles into a sump for disposal. This configuration has the advantage that it eliminates problems with re-entrainment. Disadvantages of the configuration include increased complexity of the wash system and the fact that the collected slurry is more difficult and more expensive to dispose of than dry particulate matter.

#### 4.20.3 WHAT ISSUES ARE OF CONCERN WHEN USING ELECTROSTATIC PRECIPITATORS?

The main issues affecting the control efficiency of an ESP are the design of the device and proper maintenance. The design of an ESP for a particular application is based on characteristics of the particulate matter that affect its ability to be collected and the gas volume flow rate. The ability of the particulate matter to be collected is affected by the particle migration velocity. The particle migration velocity is the rate at which the particle moves along the electric field lines toward the walls, where they are collected. Particle migration velocity is based on the estimated particle charge, mass of particles in the gas stream, and particle diameter and shape (size). These estimations aren't always exactly correct because the particulate actually consists of particles of a wide range of sizes. Collection efficiency decreases as the particle diameter becomes smaller down to about 0.5 microns when Brownian Motion effects cause movement toward the collection surfaces. Therefore, the collection efficiency of  $PM_{10}$  and  $PM_{2.5}$  is much lower than for total PM. The particle migration velocity is used to determine the specific collecting area (SCA) required to achieve the desired collection efficiency. The SCA is the ratio of the collecting surface area to the gas volume flow rate and is usually expressed in units of square feet of collection area per thousand actual cubic feet per minute of gas flow ( $ft^2/kacfm$ ). The design total collecting area (size of the ESP) is determined by multiplying the SCA by the gas volume flow rate. ESPs are usually designed with more theoretical total collecting area than is required to achieve a guaranteed control efficiency. This minimizes the possibility of not meeting the guarantee because of changes in PM or flue gas characteristics. Thus, if flue gas parameters and particulate matter characteristics are not considered when designing the ESP, the control efficiency will not be at the desired level.

The electrical fields must be properly maintained in order for the ESP to achieve the desired control efficiency. Each electrical field in an ESP is composed of bus sections. If electrical power is lost to a bus due to grounding or other reasons, the bus will be out of service. Bus sections out of service directly in line between fields will reduce the control efficiency because some of the particles miss multiple active fields. To account for this, the number of bus sections per field in industrial ESPs has increased over the last couple of decades.

Simply operating the ESP will reduce the control efficiency over time. Non-removable dust buildup on discharge and collecting surfaces will inhibit current flow and particle charge resulting in fewer particles collected. Warping of components will shorten the distance from discharge to ground, and corrosion will create sharp edges that cause arcing. Both of these conditions reduce the discharge voltage and charge buildup on the particles, reducing the collection ability of the particles.

#### **4.20.4 WHAT WASTES RESULT FROM USING ELECTROSTATIC PRECIPITATORS?**

With the exception of wet precipitators, which generate liquid slurries, ESPs generate dry particulate waste. To decrease the problems associated with handling fine dust, the collected particulate matter can be wetted in a pug mill into a clay-like consistency, or pelletized before it is recycled or landfilled.

### **4.21 FABRIC FILTERS (FF)**

#### **4.21.1 WHAT POLLUTANTS ARE CONTROLLED USING FABRIC FILTERS?**

Fabric filters, also referred to as baghouses, are used to control emissions of particulate matter and are capable of achieving the highest particulate removal efficiencies of all the particulate control devices. They do not have a declining collection effectiveness for smaller particles compared to other control devices. However, fabric filters are generally designed to reduce overall PM emissions to below an expected concentration when the inlet concentrations are within a specified range. The expected outlet concentration remains relatively “constant” even though the inlet concentration varies within the specified range. See Section 1.5 of this document for a discussion of the efficiency of fabric filters when used in series with other control devices.

#### **4.21.2 HOW DO FABRIC FILTERS WORK?**

A fabric filter system consists of several filtering elements (“bags”), a bag cleaning system, and dust hoppers contained in a main shell structure. Fabric filters remove dust from a gas stream by passing the stream through a porous fabric. The fabric does some of the filtering, but plays a more important role by acting as a support medium for the layer of dust that quickly accumulates

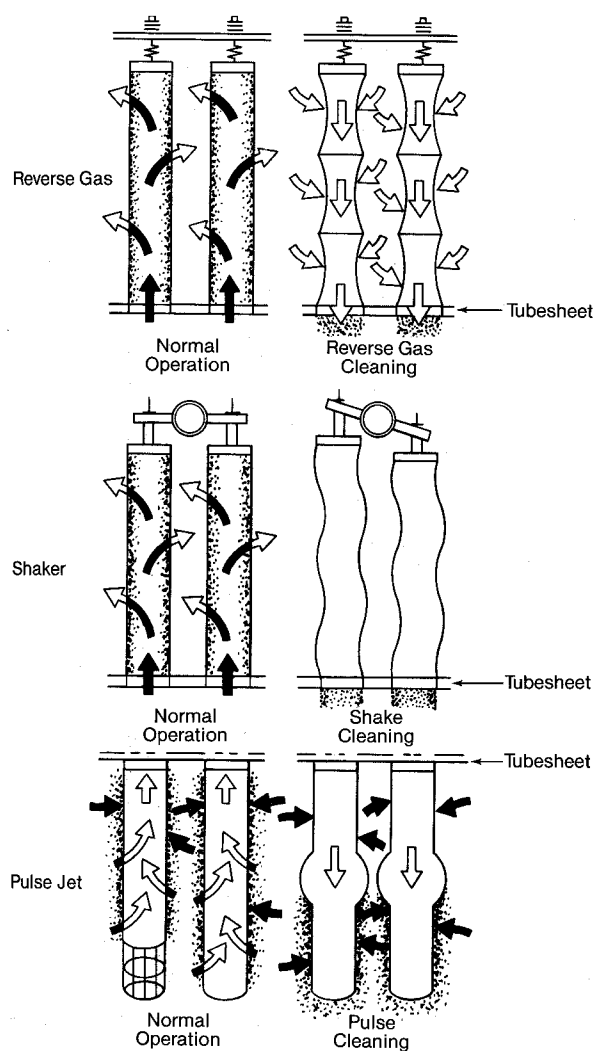
on it. The dust layer (“cake”) is responsible for the highly efficient filtering of small particles, but also increases the resistance to gas flow.

The major particle collection mechanisms of fabric filters are:

- **Inertial impaction** occurs as the flue gas stream flows through the fabric. As the gas stream approaches the fabric fibers, it accelerates and changes direction to pass around the fiber. Inertia will maintain the forward motion of the particles, and they will impact onto the surface of the fabric filter.
- **Collection by diffusion** occurs as a result of both fluid motion and the Brownian (random) motion of particles. Diffusional effects are most significant for particles less than 1 micron in diameter.
- **Interception or sieving** occurs when a particle comes within one particle radius of an obstacle.

There are three common fabric filter configurations; refer to Figure 12.4-13.

- **Reverse air baghouses** operate by directing the dirty flue gas inside the bags so that dust is collected on the inside surface of the bag. The bags are periodically cleaned by reversing the flow of air. This causes the dust cake to fall from the bags to a hopper below. In some configurations, the bags are shaken during the reversed air flow.
- **Shaker baghouses** are similar to reverse air units in that cleaning occurs on the inside surface of the bags. Unlike reverse air units, a mechanical motion is used to shake the bags and dislodge the accumulated dustcake.
- **Pulse jet baghouses** have an internal frame (cages) to allow collection of the dust on the outside of the bags. The dust cake is periodically removed by a pulsed jet of compressed air into the bag that causes a sudden bag expansion. Dust is primarily removed by inertial forces when the bag reaches maximum expansion. The vigorousness of the cleaning method and the fit of the bag against the cage may limit bag life and increase dust migration through the fabric. Pulse jet baghouses sometimes use pleated cartridges instead of bags.



**FIGURE 12.4-13. FABRIC FILTER TYPES  
(BABCOCK & WILCOX, 1992)**

Removal of the dust from the fabric is a crucial factor in the performance of a fabric filter. If the dust cake is not adequately removed, the pressure drop across the system will increase to an excessive level. If too much cake is removed, excessive dust leakage will occur while the new cake develops.

Fabric selection (considering both material and type of weave) is important. The fabric must be matched properly with both the gas stream characteristics, and the type of particulate. The commonly used fabrics have very different abilities with respect to operating temperatures and chemical content of the gas stream. A bag life of 3 to 5 years is common. Refer to Table 12.4-1.

Successful operation of a fabric filter system depends on the proper selection of fabric and cleaning method and on an adequate air-to-cloth ratio. The air-to-cloth ratio (A/C), is a critical design feature of a fabric filter system. The A/C ratio is an important indicator of the amount of air that can be filtered in a given time when considering the dust to be collected, cleaning method, fabric type, and the characteristics of the gas stream to be filtered. The A/C ratio is a measure of the amount of gas driven through each square foot of fabric in the baghouse and is given in terms of the number of cubic feet of gas per minute flowing through 1 square foot of cloth. The A/C ratio is more correctly referred to as the media face velocity because it is not the actual velocity of the gas stream through the openings in the fabric, but the velocity of the gas approaching the cloth. In general, as the A/C ratio increases, the efficiency of impaction collection increases and diffusional collection efficiency decreases. However, as the A/C ratio continues to increase, there is an increased pressure drop, increased particle penetration, blinding of fabric, need for more frequent cleaning, and reduced bag life.

#### **4.21.3 WHAT ISSUES ARE OF CONCERN WHEN USING FABRIC FILTERS?**

While many different types of media are used in fabric filters dust collection is not usually an issue if filter bags are in good condition. Emissions may still vary based on the media used. Bags coated with a porous surface membrane such as Teflon® are extremely effective. Felt tends to be more effective than woven fabric since it collects new particulate better, just after bag cleaning, before the dust cake reestablishes itself.



**TABLE 12.4-1**  
**TEMPERATURE AND CHEMICAL RESISTANCE**  
**OF SOME COMMON INDUSTRIAL FABRICS USED IN FABRIC FILTERS**

Fabric	Recommended Maximum Temperature °F	<u>Chemical Resistance</u>	
		Acid	Base
Dynel <sup>a</sup>	160	Good	Good
Cotton <sup>a</sup>	180	Poor	Good
Nylon <sup>a</sup>	200	Poor	Good
Polypropylene <sup>a</sup>	200	Excellent	Excellent
Dacron <sup>a</sup>	275	Good	Fair
Nomex <sup>®a</sup>	400	Fair	Good
Teflon <sup>®a</sup>	400	Excellent	Excellent
Fiberglass	550	Good	Good
P84 (polyimide) <sup>b</sup>	500	Fair	Good
Ryton (polypropylene sulfide) <sup>b</sup>	375	Good	Good
Expanded PTFE <sup>c</sup>	500	Good	Excellent

<sup>a</sup> Cooper, C.D., and F.C. Alley. 1994.

<sup>b</sup> Manufacturer's literature.

<sup>c</sup> Loeffler, Dietrich, and Flatt. 1988.

Fabric filters have several limitations:

- The media or, in the case of cartridge type filters, glue attaching the cartridge to its end flanges limits flue gas temperature to about 550°F. Many types of material of different properties and cost are available within this range.
- The unit cleaning mechanism must be able to remove the dust cake well enough so that its resistance to gas flow does not cause the pressure differential to exceed the intended value across the bags. Hygroscopic material or condensation of moisture can cause a permanent caking or “blinding” of the media. Some dusts are generally removed from the bag, but enough residual cake is left so that, after cleaning, a permanent flow resistance is provided. This would require a lower gas velocity, meaning more filter media, to maintain the desired pressure drop. High pressure drop across cleaned bags causes a rapid cleaning rate, shortening the life of the bags.
- The filter media may be subject to chemical attack. Acids, alkalis, etc., may attack the media.
- Hot or burning embers may enter the unit and damage the media.
- Combustible dusts can create a fire hazard. Fine dust can create a fire or explosion hazard.

These problems are dealt with in selecting the composition and construction of the filter media. Filter bag cost is also a major consideration in selection.

Dust cleaning causes the bags to weaken and fail over time. It is necessary to maintain a desired pressure drop across the bags to protect the media, to minimize the number of times the bags are cleaned, and possibly to provide a constant gas flow from the emission process. In some units, a single compartment in the fabric filter is cleaned at a time, triggered when a fixed pressure drop is reached. Units with pulse jet cleaning usually clean a small number of bag rows when triggered.

Ensuring control of emissions from a fabric filter is based on inspection and maintenance of the bags and other components. Holes in bags cause jets of dirty gas that rapidly destroy surrounding bags by abrasion. Inspections should be frequent enough to limit this damage. Dust sensors at the compartment outlet may sense this problem during operation or during bag cleaning. Dust falls on top of the tubesheet (see Figure 12.4-13) when a bag leaks during operation. In a pulse jet collector, this may be noticed as a sudden increase on an opacity meter beyond the fabric filter

outlet when the cleaning air pulse suspends dust already on the tubesheet floor. The compartment with filter damage can be determined in this case.

The indications that bags are leaking require a prompt inspection of the bags and replacement of the damaged filters. A delay causes excess emissions and additional bags to fail.

#### **4.21.4 WHAT WASTES RESULT FROM USING FABRIC FILTERS?**

Fabric filters generate dry particulate waste. To decrease the problems associated with handling fine dust, the collected particulate matter can be wetted in a pug mill into a clay-like consistency, or pelletized before it is recycled or landfilled.

### **4.22 WET PM SCRUBBERS**

#### **4.22.1 WHAT POLLUTANTS ARE CONTROLLED USING WET PM SCRUBBERS?**

Wet PM scrubbers control PM and acid gases, with some control of organics. Wet PM scrubbers are applied as a post-process technique to:

- Scrub particulates from incinerator exhausts;
- Control particulate and gaseous emissions simultaneously;
- Control acid gases;
- Control sticky emissions that would otherwise plug filter-type collectors;
- Recover soluble dusts and powders; and
- Control metallic powders such as aluminum dust that tend to explode if handled dry.

#### **4.22.2 HOW DO WET PM SCRUBBERS WORK?**

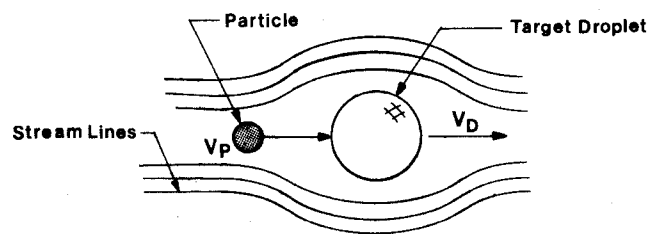
Wet PM scrubbers remove particles from gas by capturing the particles in liquid droplets (usually water) and separating the droplets from the gas stream. Wet PM scrubbers are configured to create a closely packed dispersion of fine droplets to act as targets for particle capture. The goal is to cause the tiny pollutant particle to be lodged inside the collecting droplet and then to remove the larger droplet from the gas stream. In general, the smaller the target droplet, the smaller the size of particulate that can be captured and the more densely the droplets are packed, the greater the probability of capture.

Particles are captured by liquid droplets through three mechanisms; refer to Figure 12.4-14:

- **Impaction** of the particle directly into a target droplet;
- **Interception** of the particle by the target droplet as the particle comes near the droplet; and
- **Diffusion** of the particle through the gas surrounding the target droplet until the particle is close enough to be captured.

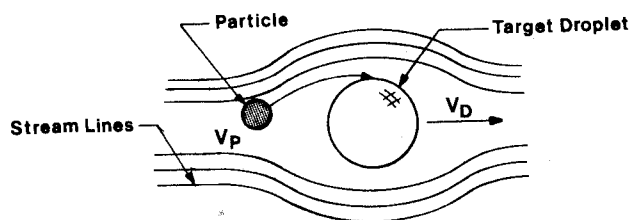
There are several types of wet PM scrubber configurations, differing in the systems used to create the droplet dispersion:

- **Venturi scrubbers** are highly effective particulate control devices, but they consume large amounts of energy, resulting in high operating costs. Venturi scrubbers generate fine droplet dispersion by pneumatically atomizing the scrubbing liquid in a high-velocity zone called the venturi throat. Target droplets are dispersed by accelerating the gas stream to a high velocity and then using this kinetic energy to shear the scrubbing liquid into fine droplets. The accelerating force comes primarily from gas-stream kinetic energy, usually injected into the system by a fan.
- **Mechanically aided scrubbers** create droplet dispersion by a whirling mechanical device, usually a fan wheel or disk. Liquid is injected into or onto the disk and mechanical energy is added to break the liquid into fine droplets. Mechanically aided scrubbers differ from venturi scrubbers in that mechanical energy is applied to the system while venturi scrubbers apply only pneumatic shearing. Mechanically aided devices use lower fan energy than other devices; but on a total energy-input basis use more energy because the collection energy comes from supplemental, driven energy.
- **Pump-aided scrubbers** are eductor-type venturi scrubbers that use high-velocity liquid spray to entrain the gas and pull it through the unit. Most of the energy input comes from the pressurized liquid stream.
- **Wetted filter scrubbers** force the liquid and gas through a medium with small openings. A filtration-like process occurs, with the particulate temporarily



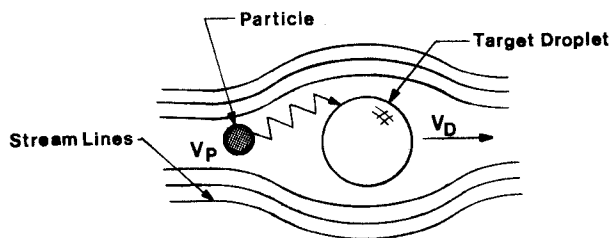
Impaction  $V_P \gg V_D$

**FIGURE 1.** Most Particles Are Removed by Direct Impaction into a Droplet



Interception  $V_P \approx V_D$

**FIGURE 2.** Other Particles Come Close to the Droplet and Are Intercepted



Diffusion  $V_P \approx V_D$

**FIGURE 3.** Smaller Particles Are Captured by Diffusion

**FIGURE 12.4-14. SCHEMATIC OF HOW WET PM SCRUBBERS REMOVE PARTICLES (AWMA, 1992)**

sticking to the filter. Wetted filter scrubbers are sometimes used in series and usually used for low particulate loadings.

- **Tray or sieve scrubbers** have no large gas-directing baffles, but are simply perforated plates (or trays) with small orifices that accelerate the gas stream. The trays are held in a tower, usually immediately downstream of a venturi. A water level is maintained above the trays (there are usually 2 or more trays). The particulate is injected into the liquid stream, using the energy of the gas. The geometrical relationship of the tray thickness, hole diameter and spacing, as well as the impinger details, results in a high-efficiency device for the removal of small particulate of less than  $2\mu\text{m}$  in mean diameter. Refer to Figure 12.4-15.

**Impingement tray scrubbers** are tray scrubbers with target baffles.

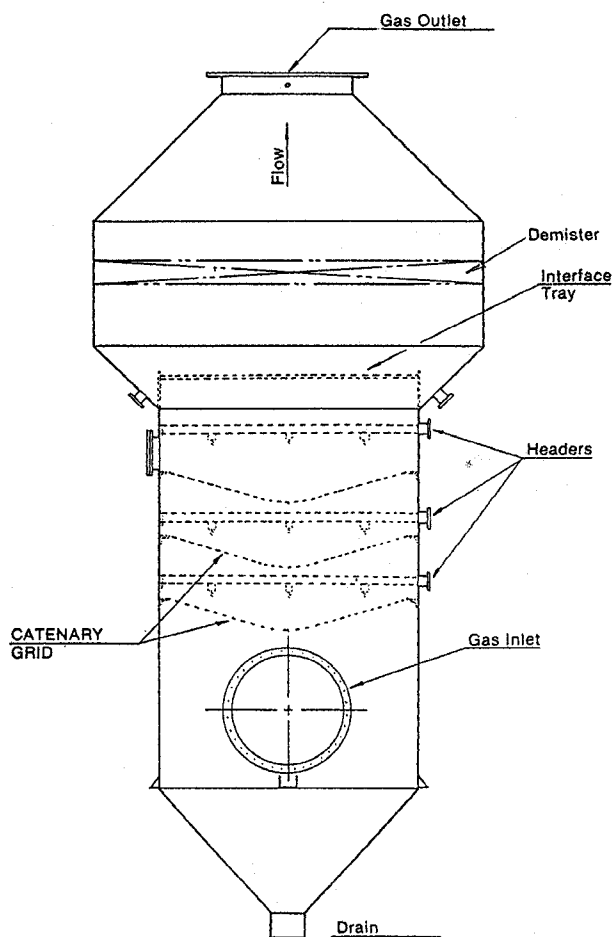
A critical component of effective wet scrubbing for PM is efficient removal of the residual droplets or mist. Common mist eliminator configurations include:

- **Cyclonic droplet removal** which uses centrifugal force. Tangential velocity is created through the use of vanes, rotating elements, or tangential gas inlet into a cylindrical vessel. The cyclonic action throws the liquid against the vessel wall, where it drains by gravity or is trapped.
- **Chevron droplet removal** which is applicable for vertical or horizontal gas flows. Flue is zig-zag shaped, with blades running parallel to the surface. The inertia of the droplet tends to carry it straight ahead, so the droplets impact on the blade surface, accumulate, and drain.
- **Mist pads**, are used to coalesce fine liquid droplets until they enlarge enough to fall, by gravity or capillary action, out of the pad. These are most often used where little or no particulate is present.

#### 4.22.3 WHAT ISSUES ARE OF CONCERN WHEN USING WET PM SCRUBBERS?

The issues are:

- Droplet entrainment in the flue gas can increase the opacity of the plume;
- Wet systems cause more corrosion problems than dry systems; and
- Solids build-up at the wet-dry interface can be a problem.



**FIGURE 12.4-15. TRAY- OR SIEVE-TYPE  
SCRUBBER (CATENARY GRID SCRUBBER™)  
(AWMA, 1992)**

#### **4.22.4 WHAT WASTES RESULT FROM USING WET PM SCRUBBERS?**

Wet PM scrubbers generate a waste slurry. This slurry can present a waste water treatment problem. The chemical and physical routine of the particulate matter being collected determine the ultimate disposal method of the slurry. If a scrubber is used to remove organic vapors, it is important that they are released at the waste water treatment process.

#### **4.23 WHEN ARE MULTIPLE CONTROL DEVICES USED?**

Multiple control device types may be used in combination to control either a single pollutant or multiple pollutants. For example, mechanical collectors are often used with fabric filters to control PM emissions. The mechanical collector collects large particles and the fabric filter collects smaller particles. Also, SCR is often used with fabric filters to control NO<sub>x</sub> and PM emissions. The devices are arranged in series, or tandem, relative to the flue gas stream. The specific types of devices used and the order in which they are arranged is dependent on the process, gas stream, and pollutant characteristics. The overall control efficiency for multiple devices is likely to be around the efficiency of the last device in the series (see Section 1.5 of this document).



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# 5

## EFFECTS OF AIR POLLUTION CONTROL DEVICE MALFUNCTIONS ON EMISSIONS

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Excess emissions due to a malfunctioning control device can significantly increase the annual emissions of a source, even if the malfunctions occur for only a small percentage of the operating time. These emissions can be difficult to quantify, but if they are not accounted for, statewide emission inventories can be understated. For example, the efficiency of an electrostatic precipitator can be altered as a result of changes in process, including feedstock changes, which result in flow variation, changes in particle resistivity or other modifications of pollutant characteristics. The effects of such changes on efficiency are not always analyzed or considered when estimating emissions and compiling inventories. This section provides:

- A brief discussion of how excess emissions from control device malfunctions can affect statewide emission inventories; and
- Methods for calculating excess emissions due to a malfunctioning control device.

### 5.1 EXCESS EMISSIONS FROM AIR POLLUTION CONTROL DEVICE MALFUNCTIONS

#### 5.1.1 WHAT ARE SOME EXAMPLES OF EXCESS EMISSIONS?

The following examples are taken from actual malfunction reports or other reports provided to various state agencies:

##### *Example 1 -- VOC emissions from a loading station*

A malfunction was reported for a truck loading rack for gasoline and diesel in which the pump to the vapor recovery unit (a carbon adsorber) failed for 55 minutes. According to the malfunction report provided to the permitting agency, approximately 199 pounds (lb) of excess VOC emissions were released during this incident. This was the only reported incident for the quarter. While 199 lb of unexpected VOC may not appear significant, the potential accumulated

annual emissions that may result from multiple events at multiple facilities in an inventory area could be significant.

***Example No. 2 -- SO<sub>2</sub> emissions from a manufacturing process.***

A sulfur recovery unit malfunctioned for 3 hours which resulted in an overload of process gases through an oxidizer. The facility estimated that 1 ton of SO<sub>2</sub> in excess of permitted levels was released during this malfunction.

***Example No. 3 -- VOC emissions from a manufacturing process***

In one instance, a dirty flame arrestor on an incinerator reduced the oxidizer chamber temperature for 1 hour and 4 minutes. The facility estimated that 983 lb of VOC in excess of permit levels was released during this malfunction.

### **5.1.2 WHAT ARE SOME SPECIFIC CAUSES OF EXCESS EMISSIONS FROM CONTROL DEVICE MALFUNCTIONS?**

These are just a few examples reported in one state's excess emissions database:

<b>Event</b>	<b>Duration</b>
"The cause of the excursion was due to a bad dust collector pulse valve."	1 hour, 13 minutes
"The LVHC stream was being combusted in the No. 1 combination boiler. The flame scanner on the boiler malfunctioned and the burner flame was not detected by the scanner. The indication of loss of flame by the scanner resulted in the removal of the LVHC."	2 hours, 2 minutes
"The heat exchangers were plugged with pulp."	8 days
"Faulty pump seal."	3 hours, 10 minutes
"Power failure in the system."	13 hours, 53 minutes
"A fuse blew on the control panel for scrubber number 1940sr050, which controls emissions for calciners number 1940ca010 and 1985ca010. The failure of the control panel caused a shutdown of the thermal oxidizers for both calciners and the opening of the designated emergency vent."	20 minutes
"Scrubber not functioning properly."	1 hour, 30 minutes
"The air pressure was lost to the system and the valve failed in the open position."	2 hours, 15 minutes

## **5.2 IMPACT OF EXCESS EMISSIONS**

### **5.2.1 WHY ARE MALFUNCTIONING CONTROL DEVICES A CONCERN?**

Equipment malfunctions result in increased emissions and can be a recurring problem at some facilities because of old or poorly maintained equipment or because of the nature of the process. Excess emissions due to a malfunctioning control device can significantly increase the annual emissions of a source, even if the malfunctions occur for only a small percentage of the operating time.

The seriousness of the excess emissions problem has resulted in regulatory actions in many states which require facilities to report all incidents of excess emissions to the regulatory agency. However, there is no guarantee that all incidents are reported. Some states focus their enforcement actions on sources that operate below their target control level more than 5 percent of the time. Examples presented in this section show malfunction times of even 1 or 2 percent per year can have a significant impact on emissions.

### **5.2.2 WHY IS IT IMPORTANT TO TRACK THESE EMISSIONS?**

A few hours per month of excess emissions can quickly add up to 5 percent, 25 percent, or even more than 50 percent of the expected emissions for the entire year, if the emissions inventory is calculated on the basis of specified control levels.

For example, consider a source that is expected to emit 10 tons tpy of PM calculated on the basis of a 99 percent control level using an ESP and a 1,000 tpy uncontrolled emission rate. If this source operates at 4,800 hours per year, and if the ESP lost partial field voltage for only 4 hours per month (i.e., 1 percent of the total operating hours) resulting in the control efficiency dropping from 99 percent to 75 percent during the malfunction, actual annual emissions would increase from 10 tpy to 11.4 tpy. This equals an increase in emissions of 14 percent. If these conditions were typical for the source category, then the emission inventory for the source category would need to be increased by 14 percent to correct for emissions from the APCD malfunctions.

### **5.2.3 HOW DO EXCESS EMISSIONS FROM AIR POLLUTION CONTROL DEVICE MALFUNCTIONS AFFECT EMISSION INVENTORIES?**

Excluding excess emissions can result in an understated annual emission inventory. Emission inventories are typically based on the “normal” level of emissions specified in rules that apply to a set of sources. However, both federal and state rules may explicitly allow for short-term exceedance of the normal control level or emission limits (whether due to malfunctions, startup and shutdown, or other conditions). One example is the new source performance standard

(NSPS) for electric utility steam generating units (40 CFR Section 60.40 Subpart Da; 44 FR 33613, June 11, 1997). This standard incorporates compliance provisions to allow for PM and SO<sub>2</sub> exceedances during startup, shutdown, or malfunction, given “emergency conditions” are implemented to minimize emissions during these events.

The inventory preparer should be aware that “excess emissions or malfunction” reports are required by most state agencies. When preparing the inventory, these reports should be reviewed for applicable information to determine the duration and degree of malfunctions.

### **5.3 ACCOUNTING FOR EXCESS EMISSIONS IN AN EMISSION INVENTORY**

#### **5.3.1 WHAT IS THE EFFICIENCY OF THE CONTROL DEVICE DURING PROCESS UPSET CONDITIONS?**

Data are not always available to offer quantitative estimates of control device efficiencies during process upsets. Generally, only process upsets that overload the control device system will affect the amount of emissions released. You should consult with process engineers and other experienced emission inventory preparers to determine these effects on emissions. Most often, state compliance and permitting staff will be the best sources of information regarding the expected effects.

#### **5.3.2 HOW CAN RELEASES DURING CONTROL DEVICE MALFUNCTIONS BE CALCULATED?**

If you know or can estimate control efficiencies during malfunction conditions, the emission calculations are straightforward. Appendix E contains two example calculations where malfunction conditions are known. Example E-1 shows the calculated emissions increase for a coke and coal-fired boiler with an ESP that loses partial field voltage for several hours each month. Example E-2 shows the emissions increase for a wood dryer that emits PM<sub>10</sub> and VOC. The tables and figures in Appendix F show the emission increases for other scenarios in which you have an estimate of the emission rate increase during a malfunction.

Note, that some other types of malfunction estimates are more difficult, if not impossible, to calculate accurately. Conditions such as the following will require greater use of engineering judgment in developing estimates:

- PM emission increases that are estimated only by opacity readings;

- VOC emission increases from enclosed systems (e.g., vapor recovery systems) that have partial loss of vacuum or air flow;
- Fugitive losses; and
- Irregular emissions during process startup and shutdown, including particulate emissions shortly after fabric filter shakeout.

### **5.3.3 FOR THOSE CASES IN WHICH EXCESS EMISSIONS FROM CONTROL DEVICE MALFUNCTIONS CAN BE REASONABLY ESTIMATED, HOW CAN YOU COLLECT THE RELEVANT DATA?**

In some cases, these calculations may already be in your inventory. For example, utility boilers will have likely incorporated malfunction emissions into the quarterly emission reports that they must file (required by the NSPS) with your state agency. It is important to make sure that these emission estimates are incorporated into the emission inventory.

If your state requires facilities to estimate emission exceedances during malfunctions, compliance staff may have records of these estimates. However, this type of information for sources other than utility boilers is rarely transferred from the compliance or permitting staff files to the state emission inventory files. You will often have to confer with the compliance or permitting staff to obtain these figures. Compliance or permitting staff are probably the best sources of information regarding how frequently sources operate with malfunctioning control equipment, and regarding the estimated magnitude of these emissions. You can supplement this information with other data from regulations, engineering guidance, and other sources. Appendix G provides a general list of data sources.

## **5.4 CONCLUSION AND COMMENT SOLICITATION**

The information presented in Section 5 of this document has been derived from preliminary conversations with permitting and inventory staff in only a few states. However, it is evident that excess emissions due to control device malfunctions may have a significant impact on individual source emissions and on statewide emission inventories that are based strictly on emission levels specified in regulations or permits. Furthermore, excess emissions from control device malfunctions may have a more severe impact on source compliance than has been previously expected or reported.

The EIIP Point Sources Committee would like to improve our understanding of the actual impact of control device malfunctions on emission inventories and would like to share this data with emission inventory preparers throughout the United States. If you have comments on this document, and particularly if you have data that can refine our understanding of this subject, please contact us.

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## **APPENDIX A**

# **EPA'S DRAFT PAPER *CLEARING UP THE RULE EFFECTIVENESS CONFUSION***

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## Clearing Up The Rule Effectiveness Confusion

### Introduction

Since its formation, EPA has been implementing rules and regulations that require states to reduce the amount of pollution being emitted into the atmosphere. Achieving the air quality anticipated by implementing a particular rule has not always been successful despite imposition of numerous emission controls. In 1987 EPA acknowledged that existing air quality regulations were not resulting in sufficient emission reductions to reach acceptable levels of air quality. The November 24, 1987 Federal Register said “The EPA believes that one reason ozone levels have not declined as much as expected is that reductions from national and local control measures have not been as high as expected.”(1) This Federal Register further stated that “the effectiveness (i.e., the ratio of actual reductions to expected reductions expressed as a percentage) of some rules is much lower than 100 percent.” To correct or compensate for the lower than anticipated amount of reductions, the Federal Register notice stated that “for both new and existing rules, EPA proposes to allow States to assume not more than 80% of full effectiveness unless adequate higher levels are adequately demonstrated.” Said another way, “we don’t believe your rule will get as much reduction as you think it will.” This under-performance can result from:

- \* some sources not implementing (or not implementing all the time) controls required by the rule,
- \* some sources not installing sufficient control equipment to achieve required emission rate,
- \* some sources operating installed control equipment at less than rated control efficiency,
- \* new source being introduced into the local area covered by the rule.

Any of these situations could result in attainment year emissions being higher than anticipated. Even though an individual source’s emission rate is reduced to that specified in a state rule, the overall reduction within the state may not be as great because of the above considerations.

The 1987 Federal Register (1) defines “effectiveness” as:

$$\text{effectiveness} = \frac{\text{Actual Reductions}}{\text{Expected Reductions}} \quad (1)$$

For complete compliance to occur, effectiveness must equal 100%. This Federal Register recognizes however, that effectiveness is usually not 100%. To adjust for non-compliance, the Federal Register limits the amount of reduction that a state can anticipate. This forces policy planners to account for less than complete compliance. For example, if an agency implemented a rule to reduce emissions by 100t/y (expected reduction), the Federal Register suggests that the actual reduction will not be as great as the expected reduction (Equation 1). For the 100t/y goal to be met (i.e., “effectiveness” to be 100%), the actual reduction in Equation 1 must be modified as follows:

$$\text{effectiveness} = \frac{\text{Reduction target} * (\text{Empirical Factor})}{\text{Expected Reduction}} \quad (2)$$

where:

Expected Reduction = Emission reduction required as estimated by modeling to meet air quality standard

In this example, equation 2 becomes:

$$100\% = \frac{\text{Reduction target} * 0.8}{100}$$

Solving for Reduction target: Reduction target = 125t/y

Policy makers then develop control strategies based on this Reduction target value. If an agency implements a rule to reduce emissions by 100t/y, the policy makers must target a 125t/y reduction to be able to achieve the needed 100t/y. Note that the results of equation 2 do not reflect the accuracy of the emission estimates, but only adjust for the past history of complying with a new rule.

The 1992 Federal Register (2) defines rule effectiveness as:

$$\text{Rule Effectiveness (RE)} = \frac{\text{Actual reduction}}{\text{Expected reduction}} \quad (3)$$

where:

$$\text{Actual reduction} = (\text{base year emissions}) - (\text{current year emission estimates})$$

In equation 3, the new term “RE” is an indicator that compares the amount of actual emission reduction to the expected reduction. This metric is useful to decision makers as they evaluate how well their policies are achieving the intended goals or how effective the rule is in achieving expected reductions. For example, assume an agency modeling exercise indicated that 100t/y reduction is needed in 10 years to be able to reach attainment status. Also assume the base year inventory is 200t/y. If a 50t/y reduction is achieved 5 years into the implementation period, then the RE = (200 - 150)/100 = 50%. At the end of 10 years, if the entire 100t/y has been removed, then the RE = (200 - 100)/100 = 100%.

Introducing the factors contained in these equations acknowledges the reality that, in an imperfect world, a rule intended to reduce emissions and improve air quality does not always work as planned. Equation 2 offers, for planning purposes, an empirical solution to this problem while Equation 3 measures the effectiveness of the solution after controls are implemented. The empirical approach assumes that only 80 percent (or higher if an agency can substantiate) of the required control will be achieved. To offset this shortfall, additional controls are needed. This concept was further supported in the April 16, 1992 Federal Register(2). Under III(A)(2)(a)(2) it is stated that “one hundred percent rule effectiveness is the ability of a regulatory program to achieve all the emission reductions at all sources at all times.” The “extra” controls in Equation 2 compensate for parts of the air quality strategy that are not completely implemented “at all of the sources all of the time”.

As the air quality control community became more sophisticated, it realized that other causes could be contributing to the inability to reach acceptable air quality levels. Two areas of concern are the accuracy of air quality model predictions (air quality modeling issues will not be addressed in this discussion) and the accuracy of the emission inventory accounting process (quantity of emissions represented in the inventory). Policy makers use emission estimates to help develop new rules that will cause the removal of a specified quantity of pollutant. They assume that removing this amount of pollutant will lead to acceptable air quality. The amount to be removed is usually selected as a result of various air quality modeling exercises. If the initial quantity of emissions used in the model calculations is incorrect, then the amount of pollutant to be reduced, as calculated by the model, may also be incorrect.

To offset an assumed underestimate of emissions, states are required to apply a compensation factor to facility control device efficiency values. This action has the effect of reducing the assumed efficiency of the control device (a reasonable assumption since control equipment may fail, be off line due to equipment maintenance, and process upsets occur) and increasing individual source emission estimates. This factor, also called Rule Effectiveness, has a default value of 80 percent.

Very few sources measure their emissions directly using Continuous Emission Monitors (CEM). Uncontrolled emissions at sources not monitored by CEMs are estimated using the following equation:

$$\text{emissions} = \text{emission factor} * \text{activity data} \quad (4)$$

If RE is used, the equation to calculate emissions from a facility containing a control device becomes:

$$\begin{aligned} \text{emissions} &= \text{emission factor} * \text{activity data} * (1 - \text{CE} * \text{RE}) \\ \text{where: CE} &= \text{manufacturer stated control efficiency} \end{aligned} \quad (5)$$

The definition of RE in Equations 3 and in Equation 5 are very different. Equation 3 provides policy makers with a method to measure the amount of reduction at a point in time and judge the success of a particular rule. Equation 5 adjusts individual facility estimates to compensate for assessment techniques that do not account for all emissions. Even though the philosophy behind the emission adjustments is different in each case, the same term - RE, is used for both situations.

### Why Confusion Exists

In 1992, EPA issued “Guidelines for Estimating and Applying Rule Effectiveness for Ozone/CO State Implementation Plan Base Year Inventories.”(3) Under section 1.2 the document states “The appropriate method for determining and using RE depends upon the purpose for the determination: compliance program or inventory. RE discussed outside the particular purpose may be generically referred to as control effectiveness. The following three common uses for a control effectiveness estimate have historically been called rule effectiveness:

- \* Identifying and addressing weakness in control strategies and regulations related to compliance and enforcement activities (more accurately call *Compliance Effectiveness*)
- \* Defining or redefining the control strategy necessary to achieve the required emissions reductions designated in the CAAA (more accurately called *Program* or *SIP Design Effectiveness*)
- \* Improving the accuracy or representativeness of emission estimates across a nonattainment area (hereafter called *Rule Effectiveness*)”(3)

“The inventory RE is an adjustment to estimated emissions data to account for the emissions underestimates due to compliance failures and the inability of most inventory techniques to include these failures in an emission estimate. The RE adjustment accounts for known underestimates due to noncompliance with existing rules, control equipment downtime or



operating problems and process upsets. The result is a better estimate of expected emission reductions and control measure effectiveness in future years”.(3)

Previous paragraphs provide definitions of Compliance effectiveness and Rule effectiveness and try to make a distinction between the two. Despite these distinctions, the second sentence of the preceding paragraph inadvisely combines concepts of both rule noncompliance and the problem of overestimating collection efficiency of control equipment. Even though there is a recognition that the two situations are different, the RE term is used interchangeably in each of these examples.

Rule Effectiveness Guidance: Integration of Inventory, Compliance, and Assessment Applications(4) was issued in January 1994. In the Introduction, the document states that “Rule Effectiveness (RE) is a generic term for identifying and estimating the uncertainty in emission estimates caused by failures and uncertainties in emission control programs. It is a measure of the extent to which a rule actually achieves its desired emission reductions.” Implying a second definition, the Introduction further states that “rule effectiveness accounts for identifiable emission underestimates due to factors including noncompliance with existing rules, control equipment downtime, operating and maintenance problems, and upsets.” As was previously noted, the RE term is again used in different contexts within the same section of the same document.

This Guidance document(4) contributes further to the confusion by using apparently different definitions of rule effectiveness. The Glossary defines Rule Effectiveness as “a generic term for identifying and estimating the uncertainties in emission estimates caused by failures and uncertainties in emission control programs. Literally, it is the extent to which a rule achieves the desired emission reductions.”

Based on past history it is understandable that, over time, the inventory community has used RE to describe different situations and often interchanging the definitions during the same discussion. The RE definition has evolved, taking on slightly different meanings, depending on the group using the term and the program to which it is being applied. Confusion results because the inventory community often uses the term RE without indicating the context in which it is being applied. Mangat, in a paper(5) presented at an emission inventory conference in 1992 and in a subsequent EIIP paper (6), recognized that dissimilar definitions were being used and tried to explain the differences.

### Solutions to the Confusion

RE is currently being used to describe and solve unrelated problems. In one case it is being used to address the failure of control equipment to operate at its stated efficiency for 100% of the time. In the second case RE is being used to address the failure of people to implement a rule with the required vigor.

Applying an adjustment factor is a valid approach in each of these situations. Unfortunately, the same term (RE) is used to describe and address both cases. The inventory community does not need more jargon. However, a solution to the current dilemma is to abandon the RE name and replace it with two distinctive terms, each describing specifically the situation in which it applies. Separate definitions should allow those interested in measuring how well a rule is achieving its intended reductions to determine those results. Those interested in adjusting actual emission estimates to compensate for upsets, downtime, etc could also meet their needs. Each new term is described below.

The **Practical Compliance Index (PCI)** is to be used by those in policy positions to measure how well a rule is achieving its intended results. The PCI is a measure of the extent to

which a rule actually accomplishes its desired emission reductions. For example, if a new rule has a PCI of 80%, it has caused 80% of the needed emission reductions to occur. A 100% of the expected reductions did not (has not) occurred because not all facilities implemented controls mandated by the rule, some facilities did not control at the emission rate required by the rule, or unanticipated growth occurred in the area. Additionally, policy makers using historical PCI values can develop realistic control strategies for their area.

The **Operational Adjustment Factor (OAF)** is to be used to adjust control efficiency ratings of control devices. Adjustments are necessary due to control equipment down time, subpar control device operations, and process upsets. Current methods of estimating emissions do not account for these situations. The OAF will not be used to adjust emission factors, activity data, or direct measurement of emissions.

#### How to Apply a PCI and an OAF

### **PCI**

Air quality modeling is performed to support new rule development. Models are run to determine how much pollutant should be removed from the air to reach an acceptable ambient air quality concentration level. When the new rule is implemented, a strategy is developed, based on model results, that describes the sources to be controlled and the acceptable emission rate of each source.

The Practical Compliance Index (PCI) provides policy makers with two tools. The Index measures how well the control strategy is progressing toward reaching the air quality goal. The PCI is calculated by:

$$\text{PCI} = \frac{(\text{Base year emission estimate}) - (\text{Current year emission estimate})}{\text{Expected reduction}} \quad (6)$$

The PCI measures progress toward meeting the new emission target in the designated attainment year. PCI can be calculated periodically to provide policy makers with information on how the policy is being implemented and the extent of compliance with new control requirements.

Past experience has shown that, even if after a new rule is fully implemented, the ambient air quality level still exceeds the standard. One reason for this failure is lack of compliance with a new rule. Policy makers can use this information to increase the likelihood that future emission targets will be met. This can be done by using an empirically derived factor that is used to adjust Equation 6. Even though the air quality modeling indicates a certain number of tons of pollutant are needed to be removed to reach the standard, practical experience shows that, without additional emphasis, this target will not be reached. The compensation factor in equation 6a offsets this lack of compliance. If the goal is to achieve a 100% PCI, then equation 6 becomes:

$$\text{PCI} = \frac{\text{Reduction target} * \text{Compensation factor}}{\text{Expected reduction}} \quad (6a)$$

Where: Compensation factor has a default value of 80%

The denominator is the amount of reduction necessary, as calculated by air quality modeling, to achieve acceptable ambient air pollutant levels. By setting the PCI to 1 (100%) and solving for the Reduction target in the numerator, policy makers will know how much pollutant reduction should be targeted for their control strategies. The compensation factor is analogous to the definition of RE in equation 3. Guidance currently being used to calculate a RE factor can be used to estimate the compensation factor in equation 6a.

**OAF**

An inventory is composed of data that are used to estimate emissions. It contains information on control efficiencies of the devices connected to the processes being inventoried. Actual emissions are estimated either from direct measurements of the source or from calculations using variables contained in the inventory. The most common approach to estimating emissions is to select an emission factor associated with a process and combine it with the activity (thruput) of the operations. This amount is adjusted by the control efficiency of the devices attached to the process. The final product is an estimate of pollutant emitted to the atmosphere. Actual emissions are calculated by:

$$\text{Actual emissions} = (\text{emission factor}) * (\text{activity data}) * (1 - \text{control efficiency}) \quad (7)$$

There are several inaccuracies associated with this approach. Even though the precision of the emission factor or activity estimate may be poor, there is usually no quantifiable bias associated with these values. However, because of operational process upsets, down time of the control device, and maintenance of the control equipment, overall control efficiency of the devices attached to the process is not as great as stated by the manufacturers. This introduces a bias into the emission estimating process that is known qualitatively, but is not accounted for in the inventory.

Equation 7 assumes there is no bias in the emission factor or activity data and that the control device operates at 100 percent of its design efficiency all the time the process is running. To reflect reality, control efficiency should be adjusted for process upsets and control device downtime. Equation 7 then becomes:

$$\text{Actual emissions} = (\text{emission factor})_{\text{unctl}} * (\text{activity data}) * (1 - \text{control efficiency} * \text{OAF}) \quad (8)$$

$$\text{where: OAF} = 1 - \frac{\text{Tons by-passing control device (t/y)}}{[\text{Tons collected (t/y)}] + [\text{Tons by-passing control device (t/y)}]}$$

The OAF is determined by examining operating records for a control device or family of devices. The amount of time it is operating, the number of process upsets, and the quantity of pollutant that bypasses the control device during these periods can be used to create the OAF.

Recently, some emission rates are being combined with process control efficiencies to form an emission factor that consists of a process-control device combination. Equation 8a is used when the emission factor incorporates control efficiency.

$$\text{Actual emissions} = (\text{emission factor})_{\text{ctl}} * (\text{activity data}) * (1/\text{CE} - \text{OAF}) \quad (8a)$$

### Summary

The emission inventory community has been using RE for almost a decade. Even though the term has been used interchangeably in totally different applications, the distinctions have been poorly understood. New terminology proposed in this paper should correct this problem. The PCI measures the degree to which a rule is being implemented (by measuring the amount of actual reduction and comparing it to the expected reduction). It is based on historical results from past rule implementation efforts or from recent surveys that indicate the degree of compliance to be expected. The PCI compensates for the failure of people to fully implement a rule.

The OAF is a function of control equipment efficiency, the adequacy of equipment maintenance, equipment reliability, and the stability of a process. This information is available from records maintained at each facility. The OAF compensates for the failure of equipment to perform at its stated capacity.

### Next Steps

- determine how this proposed approach affects existing data
- determine how existing guidance must be changed to reflect new approach
- decide what to do about previously reported data that has RE applied
- develop new guidance explaining use of PCI and OAF.

### References

- (1) Federal Register, Vol 52, No. 226, Tuesday, November 24, 1987, p45059
- (2) Federal Register, Vol 57, No. 74, Part III, Thursday, April 16, 1992
- (3) "Guidelines for Estimating and Applying Rule Effectiveness for ozone/CO State Implementation Plan Base year Inventories", November 1992, EPA-452/R-92-010
- (4) "Rule Effectiveness Guidance: Integration of Inventory, Compliance, and Assessment Applications", January 1994, EPA-452/4-94-001
- (5) "Developing Present and Future Year Emissions Inventories Using Rule Effectiveness Factors", presented at the International Conference and course, Emission Inventory Issues, Durham, NC, October 1992.
- (6) "Emission Inventories and Proper Use of Rule Effectiveness",  
<http://www.epa.gov/ttn/chief/eiip/pointsrc.htm>, draft report, October 1998.

## **APPENDIX B**

# **EIIP'S TECHNICAL PAPER *EMISSION INVENTORIES AND PROPER USE OF RULE EFFECTIVENESS***



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# **EMISSION INVENTORIES AND PROPER USE OF RULE EFFECTIVENESS**

**Prepared by:**

**Emission Inventory Improvement Program  
Point Sources Committee**



**September 23, 1998**

## PURPOSE

The purpose of this document is to discuss Rule Effectiveness (RE) and explore its applicability in a base year and a projected year emission inventory development process. This document also presents how RE can be built into an electronic database to develop inventories.

## BACKGROUND

Emission inventories for criteria pollutants are required by state and federal statutes. They have many uses including developing control strategies to reduce emissions. Inventory data (current and projected) are also used in air quality models that attempt to relate emissions in the inventory to the ground-level pollutant concentrations recorded by instruments. To design effective control strategies, inventories showing actual emissions for the period of concern are required.

Over the years, inventories have shown emission reductions due to adopted rules (regulations) but air quality measurement data have not shown corresponding reductions in pollutant levels. Therefore, the U.S. Environmental Protection Agency (EPA) concluded that the calculated emissions reported in inventories were too low because the level of control efficiencies applied to the calculations was too high.

EPA assumed that the emission inventory preparers were using the level of controls specified by the rules and were not giving any consideration to less than full compliance. EPA thus developed a solution to lower the level of control by multiplying the control efficiency by a correction factor called Rule Effectiveness (RE). When no better information was available, EPA guidance suggested a default 80% RE value. This guidance has been implemented inconsistently by the states with unintended consequences.

Inventories reporting actual emissions are in fact only estimates of those emissions. EPA had concerns that the emission factors for pollutant sources and abatement devices provided in AP-42 underestimate emissions because these factors do not account for equipment malfunctions and abatement device downtime. Emissions could also be underestimated due to ignorance of rules or circumvention of controls, process upsets, spills, and other day-to-day operating parameters. These parameters can significantly affect the estimates of actual emissions. Many of these parameters apply to all pollutant sources and not only to sources subject to rules. RE can not and should not be applied to uncontrolled sources. Therefore, the use of correction factors to account for these problems and unknown parameters in the emission calculation procedure is very

appealing. There is a need for guidance to improve emission calculation procedures to account for the parameters mentioned above. These issues will be addressed in another document titled *Effects of Source Operational Problems*, being prepared by the Point Sources Committee of the Emission Inventory Improvement Program (EIIP).

However, RE plays an important role in emission inventory and rule development. Rules are adopted to reduce emissions by specified amounts. RE is a function of actual emissions and the emissions estimates calculated using limits specified in a rule. Actual estimated emissions should take into account various operational problems such as equipment malfunction and abatement device downtime. RE measures how well emission controls called for by a rule are being achieved in the real world. Therefore, RE measures the degree to which the actual estimated emissions approaches the expected emissions called for by a rule. If the actual estimated emissions are equal to the expected emissions based on rule limits specified in a rule, then the effectiveness for that rule is 100%. If the actual estimated emissions are higher than the expected emissions based on rule limits, then the RE is less than 100%. If the actual estimated emissions are lower than the expected emissions based on rule limits, then the RE is greater than 100% (i.e., over compliance).

### BASE YEAR EMISSION CALCULATIONS AND RE

The purpose of adopting and implementing rules is to reduce emissions. Emissions can be reduced by lowering a source's activity, or the emission factor that represents that activity, or adding control devices. Permit conditions are sometimes imposed on a facility to lower or limit activity levels. There are two ways to lower emission factors (final rate of emissions) for a source:

- The processes can be modified to inherently low emissions rates; or,
- Pollution control equipment can be incorporated into the process.

In either case, emissions estimated before and after regulatory changes will show actual emission changes due to controls. The actual estimated emissions when compared with the expected emissions based on rule limits will give the RE.

*The final controlled emission factor = uncontrolled emission factor x (1 - % reduction specified in the rule/100 x % RE /100)*

Actual estimated emissions from sources subject to a rule can be calculated using two different methods. The first method uses actual data, and the second uses values stated in the rule(s) to estimate the actual emissions after rule implementation. These two methods will be described in detail in the subsections below and will show that when actual data are used, RE is not part of the emission calculations. When actual data are not available, estimated RE is used to calculate emissions.

**Estimating Emissions Using Actual Data:** Emission calculations from point sources usually fall in this category because detailed source and throughput information is usually collected and stored in a database. One emissions calculation procedure for a process is to multiply the activity (throughput) by an emission factor, and by the control equipment efficiency if control equipment is used. The emissions can be updated by updating throughput, as long as control equipment has not changed. Emission factors are obtained from source tests, AP-42, engineering estimates, or other sources. If continuous monitoring is available, emission factors can be calculated and stored in the database. Source-specific emission factors, when available, are preferred to generalized factors. Emission factors are not derived from any rule, rather they represent best estimates of actual factors for the source and should account for any operational problems. The selection of emission factors for use in an inventory should be left to the estimator's judgment. Guidance in selecting emission factors is also available in EIIP documents where preferred emission estimation methods are recommended.

The control equipment efficiency used can be either specific or general. The control efficiency for actual emission calculations should be based on design specifications, testing, or estimated values for the equipment. The control efficiency selected should be adjusted to reflect actual conditions. If a given type of equipment has problems operating continuously, design values should be adjusted to reflect the problems. This gives the estimated actual emissions. When a general control efficiency is used, it is not based on the design specification but is a "best judgment" value that takes into account deterioration, maintenance needs, and other day-to-day issues encountered. Emissions thus calculated are not the same as emissions estimated using values in rules, but represent actual estimates for emission inventories.

Emissions from some area source categories also can be calculated using actual data. For example, using the EIIP preferred method, emissions from the architectural coatings category can be calculated by obtaining the coating usage data and the solvent content for each type of coating by surveys.

Note that RE is not used in emission calculation procedures using actual data. RE can be calculated from the actual estimated emissions and emissions calculated using limits in the rule. For rulemaking or for emission inventories (by source categories), there may be some value in estimating RE for individual sources; emissions from all sources subject to a rule should be aggregated by categories. The composite emission factor obtained by dividing the total actual

emissions by the total throughput when compared with the rate of emissions specified in the rule will give the estimated RE. Consistent units must be used in these calculations and comparisons. RE can also be obtained using the emissions instead of the emission factors as discussed above.

**Estimating Emissions Using Information from Rules:** Emissions from area source categories are sometimes calculated using emission rate data from rules. Emissions for area sources are usually calculated by categories instead of by individual sources and are based on estimated emission factors and activity data. Activity levels are usually derived from available surrogate data, and the emission factors selected generally will change over the years. If there are changes in a category (e.g., new technology or operational changes), then the emission factors should be reevaluated. The activity usually changes with changes in the surrogates used.

When a rule is adopted and implemented, new emission factors to account for the controls are usually not developed. Lower emissions are accounted for in the control efficiency. It is usually not easy to determine the percentage of control called for by a rule, but the emission inventory estimators must estimate the level of controls called for by a rule. It is important to remember that the emissions are estimated for a category and not for individual sources.

For example, emissions from underground gasoline storage tanks can be calculated by adjusting the uncontrolled emission factor by the percent control specified in the rule and the estimated RE. This is not the best or the preferred method, but is commonly used. This method can be used to calculate emissions from, for example, the architectural coatings category because the final controlled emission factor(s) are estimated using controls specified in the rule instead of obtaining actual emission factors independently.

## EMISSION PROJECTIONS

The estimated RE value obtained in the base year calculations can be used to develop a future year RE value. The base year inventory, as discussed above, may or may not include RE in emission calculations. To prepare projections for categories subject to rules with future implementation dates, the estimated net controls for the rule (controls specified in the rules and the estimated RE) are required. Some sources in the category may comply before the rule's specified implementation date and others may comply after the implementation date. Also, as time passes, more sources comply and the RE increases. Therefore, changing the RE by specific dates will result in better estimates for future year emissions. Future year emissions for categories subject to rules are calculated by the following equation:

$$\text{Future year emissions} = \text{base year emissions} \times \text{growth factors} \times \text{control factors}$$

The control factors represent the net controls, based on the controls specified in the rule and the anticipated RE. Similarly, historical emissions can be recalculated using the above equation.

## EMISSION INVENTORY SYSTEM

An emission calculation system using RE data is shown in this section. This system works for calculating future and historical emissions for all point and area sources and also for base year calculations for area source categories. In this system, two separate files are used to estimate the net emission factors for any given year, an emission factor file and an emission control file. Only the area source categories will have emission factors in the emission factor file, and only the categories subject to rules will have control information in the emission control file as described below.

**Emission Factor File:** Data in this file are organized by categories and are only for area sources. Categories with major point sources will not have any entry in this file because their emissions are calculated source-by-source using actual data. Only the uncontrolled emission factors for area sources (with known generation dates) are kept in this file. Changes in emission factors over the years due to reasons other than rulemaking (e.g., changes in technology) should be reflected in this file. Therefore, more than one record can exist for a given category with different emission factors and their corresponding effective dates.

**Emission Control File:** Data in this file are for categories subject to a rule. This file contains data for point as well as area source categories. Each record will have a unique identification number for each category, the percentage of reduction of the pollutant (maximum achievable) specified by the rule, and the percent RE (% RE) as shown in Table 1. A category can have more than one record to represent different dates with changing % RE as shown in Table 1, as well as to represent different geographic areas of rule applicability.

**TABLE 1**  
**EXAMPLE OF EMISSION CONTROL FILE**

Category Identification	% Control	Date	Pollutant	% RE
10	60	Jan 1, 1998	VOC	20
10	60	Jan 1, 1999	VOC	70
10	60	Jan 1, 2000	VOC	95

This file can be expanded to store additional information about the rule if desired (date of adoption, rule description, etc.). The example in Table 1 is for category identification number 10 that is subject to a rule requiring 60% VOC control. The percent RE improves from 20% to 95% over 3 years and assumes there is no rule requiring control prior to January 1, 1998.

**Emission Calculation:** For the emission calculation procedure, the latest emission factor should be selected and used for all years after this date except when data in the emission control file exist. In such a case, the net emission factor is calculated by multiplying the emission factor(s) from the emission factor file and the control(s) and the effectiveness from the emission control file. With this method, past and future emissions can be calculated if throughput data (or growth rates) are available for various years.

Base year emissions for area source categories are similarly calculated by multiplying the base year throughput with the appropriate emission factors from the same files. A simple system of files can be set up for the data requirements stated above. For a more elaborate system, refer to the paper *Developing Present and Future Emissions Inventories Using Rule Effectiveness Factors* by T. Mangat, T. Story, and T. Perardi. This paper was presented at the October 1992 Emission Inventory Conference sponsored by the Air & Waste Management Association in Durham, North Carolina.

**Rule Penetration:** When a rule for a source category is adopted with a stated level of control, some sources may be exempted or may have limits set at higher levels (lower level of control). This can lower the overall control achieved for a source category subject to a rule. Frequently, some sources in a category will not comply or will be late in complying with the limits in the rule. All of these factors should be considered when determining the RE for a source category. It simplifies calculations if the maximum control achieved from the rule is kept constant and only the RE is varied to indicate the effectiveness of controls. The net control for the source category is then obtained by multiplying the percentage of control and the RE. There is no need to store a separate rule penetration factor in the database.

## RECOMMENDATIONS

It is desirable to know the level of controls and the RE being achieved from rules. If the RE is determined and found to be lower than 100%, measures such as stepping up enforcement can be taken to correct the deficiencies. Knowing the actual controls (controls x RE) achieved in the base year will help in estimating future controls from the rule. Similarly, base year level of control when backtracked correctly should yield historical control information. RE should be tracked at a source category level. When base year emissions are estimated using actual data, RE



and the controls specified in the rules are not required for calculating actual estimated emissions. Actual estimated emissions can also be directly calculated from source test data or by mass balance. To calculate actual estimated emissions from point sources, consideration should be given to uncertainties associated with various factors that affect emissions. Many area source categories may use controls specified in rules and the RE to calculate base year emissions.

For forecasting emissions, all source categories subject to a rule should track the controls specified by the rule and the RE. The estimated RE should account for rule penetration if the source category contains sources exempt from the rule. This adjustment to RE to account for rule penetration is not needed if the exempt sources are grouped under a different source category showing no controls.

Can RE be used in calculating emission inventories? The answer is yes, and when used correctly, it can help in calculating actual estimated emissions--especially in forecasts and backcasts. Is it important to know the RE for a rule? The answer is yes, even if it is difficult to calculate or estimate. To evaluate the effects of a promulgated rule, emission controls specified by the rule and the RE should be estimated.

## **APPENDIX C**

# **CROSS REFERENCE OF AIR POLLUTION CONTROL DEVICE NAMES**

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## **AIR POLLUTION CONTROL DEVICE NAMES**

Some control devices are known and referred to by more than one name. For example, a fabric filter is also referred to as a baghouse. To assist readers in correlating the name of a specific control device of interest where the name is not one of those used in this document to the name of the device as used in this document, a list of cross reference names is provided in the following table. The Control Device column in the table presents the different names used for specific control devices. For each name in the Control Device column, the name for the device that is used in this document is provided on the same row in the Cross Reference column. For example, where “baghouse” is presented in the Control Device column, the Cross Reference column lists “fabric filter”, which is the name used in this document.

**APPENDIX C****CROSS REFERENCE OF AIR POLLUTION CONTROL DEVICE NAMES**

<b>Control Device</b>	<b>Cross Reference Name</b>
Absorbers (Scrubbers)	Wet acid gas scrubber
Absorption	Wet acid gas scrubber
Ammonia Injection	Selective Noncatalytic Reduction (SNCR)
Annular Orifice Venturi Scrubber	Wet PM scrubber
Baghouse	Fabric filter
Butadiene Adsorber	Carbon adsorber
Catalytic Afterburners	Catalytic Incinerator
Centrifugal Collector	Mechanical Collector
Centrifugal Cyclone	Mechanical Collector
Cyclone/Fabric Filter	Mechanical Collector/Fabric Filter
Cyclones	Mechanical Collector
Dry Cyclones	Mechanical Collector
Dry Scrubbers	Spray Dryer Absorber
Dry Sorbent Injection	Dry Injection
Dry Sorbent Scrubber	Spray Dryer Absorber
Dual Cyclones	Mechanical Collector
Duct Injection	Dry Injection
ESP	Electrostatic Precipitator
FGR	Flue Gas Recirculation
Fuel Cell Incineration	Thermal Incinerator
Impingement Scrubbers	Wet PM Scrubber
Incineration	Thermal Incinerator
LEA	Low Excess Air
LNB	Low NO <sub>x</sub> Burner (LNB)
Multiple cyclones in series	Mechanical Collector
Multiple cyclones	Mechanical Collector
Multiclones	Mechanical Collector
NSCR	Nonselective Catalytic Reduction (NSCR)
OFA	Over-Fire Air
Reburn	Natural Gas Burners/Reburn
SCR	Selective Catalytic Reduction (SCR)
SNCR	Selective Noncatalytic Reduction (SNCR)
Sodium Scrubbers	Spray Dryer Absorber
SOFA	Staged Overfired Air

**APPENDIX C****CONTINUED**

<b>Control Device</b>	<b>Cross Reference Name</b>
Spray Drying	Spray Dryer Absorber
Thermal Afterburners	Thermal Incinerator
Thermal Oxidation	Thermal Incinerator
Venturi Scrubbers	Wet PM Scrubber
Wet FGD	Wet Acid Gas Scrubber
Wet Scrubbers	Wet Acid Gas Scrubber, or Wet PM Scrubber
Urea Injection	Selection Noncatalytic Reduction (SNCR)
Staged Combustion for Gas Turbines	Dry-Low NO <sub>x</sub> (DLN), Dry-Low Emissions (DLE), or SoLo NO <sub>x</sub>

# **APPENDIX D**

## **DATA COMPILATION FOR SECTION 3**

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## DESCRIPTION OF HOW THE DATA WERE COMPILED

### D.1 CONTROL EFFICIENCIES TABLE

- Individual table included for each pollutant of interest-CO, NO<sub>x</sub>, PM, SO<sub>x</sub>, VOC.
- Tables present control efficiencies (CE) for selected control devices for each unique combination of emission source and control device reported in the references. Where one or more references report an average CE, or CE range, for the same combination of emission source and control device, the references are examined to determine which one provides the best quality data and the data from that reference are selected and shown in the table. (The “best” data are determined using professional experience and judgment.)
- Each pollutant table contains columns that show an average CE and CE range for each unique combination of emission source and control device for which data are provided in the references.
  - The emission source is identified in the Process and Operation columns. For example, where a reference reported a CE for a boiler burning coal, “Fuel Combustion-Coal” is shown in the Process column and “Boiler” is shown in the Operation column.
  - A single column (Control Device Type) is used to identify the type of control device. The description of the control device provided in the reference was used to assign a control device type.
  - The average CE is presented in the column labeled Average CE (%). The reference citation for the average CE is shown in the column to the right labeled Reference. Two columns are used to show a range with the lower value on the left in the column labeled CE Range (%) Minimum and the upper value on the right in the column labeled Maximum. The reference citation for the range is shown in the column to the right labeled Reference. It should be noted that the average CE and CE range could be from two separate references. Where data were not available, the column is empty.
  - Where only a minimum value for the CE was available from the references, the value is presented in the Minimum column. The Maximum column is left empty. Where only a maximum value was available, the

value is presented in the Maximum column and the Minimum column is left empty.

- Where one reference provided only one value of a range (minimum or maximum) and a second reference provided both values (minimum and maximum), the data from the second reference are presented in the table. The data from the first reference were not used.

## D.2 DATA FOR CONTROL DEVICES NOT EVALUATED

- Table D-1 presents control efficiencies (CE) reported in the references for control devices not evaluated in this document.
- Individual table included for each pollutant of interest-CO, NO<sub>x</sub>, PM, SO<sub>x</sub>, VOC.
  - Each pollutant table contains columns that show an average CE and CE range by emission source and control device for which data are provided in the references.
  - The reference citation for each row of data in the table is indicated in the Reference column.
  - The emission source is identified in the Process and Operation columns. For example, where a reference reported a CE for a boiler burning coal, “Fuel Combustion-Coal” is shown in the Process column and “Boiler” is shown in the Operation column.
  - The description of the control device provided in the reference is included in the Control Device Description column.
  - The description of the control device provided in the reference was used to assign a control device type which appears in the Control Device Type Column.
  - Where a reference provided an average CE, the CE is shown in the Average CE (%) column. Where a reference provided a minimum or maximum CE, or both, they are shown in the CE Range (%) Minimum and Maximum columns, respectively. Because the data in the table are “as entered” and have not been evaluated, an Average CE and a range CE obtained from the same reference will appear in two separate rows.

TABLE D-1

## CONTROL EFFICIENCIES FOR CONTROL DEVICES NOT EVALUATED IN THIS DOCUMENT

Pollutant	Process	Operation	Control Device Type	Average CE (%) <sup>a</sup>	Reference	CE Range (%)		Reference
						Minimum Value	Maximum Value	
CO	Wood Industry	Dryer/Press Exhaust	Biofilter			30	50	EPA, 1995
NO <sub>x</sub>	Fuel Combustion- Coal	Boiler	Limestone Injection Multi-stage Burner			50	60	EPA, 1992b
NO <sub>x</sub>	Fuel Combustion- Coal	Boiler	WAS-SNOX				90	EPA, 1992b
NO <sub>x</sub>	Fuel Combustion- Coal	Boiler	GR-SI				70	EPA, 1992b
NO <sub>x</sub>	Petroleum Industry	Process Heaters	Natural Air Lances			10	20	EPA, 1992b
NO <sub>x</sub>	Petroleum Industry	Process Heaters	Forced Air Lances			50	60	EPA, 1992b
NO <sub>x</sub>	Wood Industry	Dryer/Press Exhaust	Biofilter			80	95	EPA, 1995
PM	Aluminum Industry	Baking Furnaces	Fabric Filter With Reduction Cell				99	EPA, 1995
PM	Fuel Combustion- Wood	Boiler	Granular-bed Moving Filter			90	95	AWMA, 1992
PM	Fuel Combustion- Wood	Boiler	Granular-bed Moving Filter with Electrostatic Precipitator			98	99.2	AWMA, 1992
PM	Fuel Combustion- Wood	Boiler	Gravel Bed Filter	95	EPA, 1995			

TABLE D-1

## CONTROL EFFICIENCIES FOR CONTROL DEVICE NOT EVALUATED IN THIS DOCUMENT (CONTINUED)

Pollutant	Process	Operation	Control Device Type	Average CE (%) <sup>a</sup>	Reference	CE Range (%)		Reference
						Minimum Value	Maximum Value	
PM	Fuel Combustion- Wood	Boiler	Gravel Bed Filter	95	EPA, 1995			
PM	Fuel Combustion- Wood	Boiler	Gravel Bed Filter	95	AWMA, 1992			
PM	General	General	Core Separator			95	98	EPA, 1998
PM	Metallurgical Industry	Waste Heate Boiler	Tubular Cooler			70	80	AWMA, 1992
SO <sub>x</sub>	Fuel Combustion- Coal	Boiler	Duct Injection			25	>50	AWMA, 1992
SO <sub>x</sub>	Fuel Combustion- Coal	Boiler	Furnace Injection			25	50	AWMA, 1992
SO <sub>x</sub>	Fuel Combustion- Coal	Boiler	Limestone Injection Multi-stage Burner			50	60	EPA, 1992b
SO <sub>x</sub>	Fuel Combustion-Coal	Boiler	NOXSO	90	EPA, 1992b			
SO <sub>x</sub>	Fuel Combustion- Coal	Boiler	WAS-SNOX	95	EPA, 1992b			
SO <sub>x</sub>	Fuel Combustion- Oil	Boiler	Duct Injection			25	>50	AWMA, 1992
SO <sub>x</sub>	Fuel Combustion- Oil	Boiler	Furnace Injection			25	50	AWMA, 1992
SO <sub>x</sub>	Metallurgical Industry	Lead Smelters	DMA Absorber			92	95	AWMA, 1992
VOC	Aluminum Industry	Baking Furnaces	Fabric Filter with Reduction Cell				99	EPA, 1995
VOC	Chemical Manufacturing	SOCMI Reactor	Condenser			50	95	EPA, 1992a

TABLE D-1

## CONTROL EFFICIENCIES FOR CONTROL DEVICES NOT EVALUATED IN THIS DOCUMENT (CONTINUED)

Pollutant	Process	Operation	Control Device Type	Average CE (%) <sup>a</sup>	Reference	CE Range (%)		Reference
						Minimum Value	Maximum Value	
VOC	Degreasing- Cold Cleaner	General	Hot Vapor Recycle			62	69	AWMA, 1992
VOC	Degreasing- In-line Cleaner	General	Above-Freezing Freeboard Refrigeration			61		AWMA, 1992
VOC	Degreasing- Open Top Vapor Cleaner	Idling Losses	Below-Freezing Freeboard Refrigeration			11	58	AWMA, 1992
VOC	Degreasing- Open Top Vapor Cleaner	Idling Losses	Increased Freeboard Ratio			27	47	AWMA, 1992
VOC	Degreasing- Open Top Vapor Cleaner	Working Losses	Above-Freezing Freeboard Refrigeration			18	50	AWMA, 1992
VOC	Degreasing- Open Top Vapor Cleaner	Working Losses	Below-Freezing Freeboard Refrigeration			26	54	AWMA, 1992
VOC	Degreasing- Open Top Vapor Cleaner	Working Losses	Increased Freeboard Ratio			25		AWMA, 1992
VOC	Degreasing- Open Top Vapor Cleaner	Working Losses	Refrigerated Primary Condenser			18	52	AWMA, 1992
VOC	Fabric Coating	General	Inert Gas Condensation System	99	EPA, 1992a			
VOC	Food Industry	Fermentor	Scrubber, Wet with Biofilter			90		EPA, 1995
VOC	Food Industry	Smokehouses	Scrubber, Vortex	51	EPA, 1995			
VOC	Gasoline Marketing	Loading	Submerged Filling	60	AWMA, 1992			
VOC	Gasoline Marketing	Service Stations	Vapor Balancing Stage I	90	AWMA, 1992			AWMA, 1992
VOC	Gasoline Marketing	Service Stations	Vapor Balancing Stage II			95		AWMA, 1992

TABLE D-1

## CONTROL EFFICIENCIES FOR CONTROL DEVICES NOT EVALUATED IN THIS DOCUMENT (CONTINUED)

Pollutant	Process	Operation	Control Device Type	Average CE (%) <sup>a</sup>	Reference	CE Range (%)		Reference
						Minimum Value	Maximum Value	
VOC	General	General	Condenser	90	EPA, 1991	50	95	EPA, 1992a
VOC	General	Natural Gas Processing	Vapor Recovery				98	EPA, 1992a
VOC	Magnetic Tape Manufacture	Drying Ovens	Condenser	95	AWMA, 1992			
VOC	Surface Coating	Polymeric Coating	Vapor Recovery	95	AWMA, 1992			
VOC	Surface Coating	Vinyl Coating/Primer	Vapor Recovery			90		EPA, 1992a
VOC	Wood Industry	Dryer/Press Exhaust	Biofilter			70	90	EPA, 1995

# **APPENDIX E**

## **EXAMPLE CALCULATIONS**

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**Example E-1--Coke and Coal Fired Boilers**

For this example, consider a coal-fired boiler that operates as follows:

Throughput: 1,764 MMBTU/hr  
 Operating Hours: 8,500 hr/yr  
 Permitted emissions: 0.03 lb particulate/MMBTU  
 Control Device: Electrostatic precipitator  
 Assumed CE: 99 percent (from Table 12.3-6)

If this process and its associated control equipment operated exactly as designed for the entire 8,500 hr/yr, the expected emissions would be:

expected annual  
 particulate emissions =  $1,764 \text{ MMBTU/hr} \times 8,500 \text{ hrs/yr} \times 0.03 \text{ lb particulate/MMBTU}$   
 = ~450,000 lbs/yr  
 = ~225 tons/yr

However, low voltage or other malfunctions might cause the ESP to occasionally operate at 95 percent efficiency rather than 99 percent efficiency. During such events, the emission rate would be 0.12 lb particulate/MMBTU (four times the “normal” emission rate of 0.03 lb particulate/MMBTU). If these anomalous conditions occurred during 5 percent of the total operating hours (i.e., 425 of the 8,500 hrs per year) for the plant, annual particulate emissions would be:

actual annual  
 particulate emissions =  $1,764 \text{ MMBTU/hr} \times (8,500 \text{ hrs/yr} \times 95\%) \times 0.03 \text{ lb/MMBTU}$   
 +  $1,764 \text{ MMBTU/hr} \times (8,500 \text{ hrs/yr} \times 5\%) \times 0.12 \text{ lb/MMBTU}$   
 = 517,293  
 = 258 tpy

Thus, in this example, a 4 percent reduction in ESP efficiency for 5 percent of the operating time would increase actual annual particulate emissions by 33 tpy (20 percent) over the permitted amount. If the state’s emission inventory estimate for this facility is based only on the permitted figures, the 33 tpy (20 percent) actual increase for this facility would be missed.

**Example E-2--Wood Products Dryer/Press**

For this example, consider a wood products dryer/press that operates as follows:

Operating schedule:	7,920 hr/yr
Process exhaust flow rate:	8,000 dscf/min
Permitted emissions:	0.01 gr/dscf
Control Device:	Fabric filter
Permitted emissions:	27.4 lb/hr VOC (based on NSPS)
Assumed CE:	94 percent wet ESP and thermal oxidizer,

If this process and its associated control equipment meet the emission limits when operated normally and the process and control equipment operate normally for the entire 7,920 hr/year, emissions would be:

$$\begin{aligned}\text{Expected annual PM}_{10} \text{ emissions} &= 0.01 \text{ gr/dscf} \times 8,000 \text{ dscf/min} \times 60 \text{ min/hr} \times \\ &\quad 1 \text{ lb/700 gr} \\ &= 0.686 \text{ lb/hr} \\ &= 0.686 \text{ lb/hr} \times 7,920 \text{ hr/yr} \\ &= 5,430 \text{ lb/yr} \\ &= 2.71 \text{ tpy} \\ \text{Expected annual VOC emissions} &= 27.4 \text{ lb/hr} \times 7,920 \text{ hrs/yr} \\ &= 217,008 \text{ lb/yr} \\ &= 108.5 \text{ tpy}\end{aligned}$$

In this example, if the thermal oxidizer were to fail for 4 hours per month, resulting in a reduction from 94 percent efficiency to 50 percent efficiency for VOC, VOC emissions will increase by 113.3 tpy, or an increase of 4.4 percent over expected annual emissions.

Occasional bag wear and tear will cause the fabric filter to malfunction. The malfunction of a fabric filter is immediately apparent as it results in accumulation of particles in the vicinity of the device, as uncontrolled gas escapes through holes in the fabric. Emissions resulting from the malfunction can be estimated by collecting and weighing the amount of dust escaping through the filter.

## **APPENDIX F**

# **EXAMPLE ANNUAL EMISSION INCREASES FOR VARIOUS SCENARIOS**

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A general formula for calculating increases in annual emissions due to malfunctioning control devices is:

$$I = t_a \times (CE_n - CE_a) / (100\% - CE_n)$$

where:

I	=	Increase in annual emissions due to a malfunctioning control device (%)
CE <sub>n</sub>	=	Normal control efficiency (%)
CE <sub>a</sub>	=	Malfunction control efficiency (%) [note: use the actual control efficiency. Do not express as a percent of the normal control efficiency.]
t <sub>a</sub>	=	Operating time under malfunction conditions (% of total hours)

The three examples in this appendix use the above formula to calculate annual emission increases for three hypothetical examples. In each example, we assume a specific malfunction efficiency (e.g., assume that a malfunctioning fabric filter operates at 97.5 percent efficiency) and show the annual emission increases that would result under different combinations of design efficiencies and percentage malfunction time.

**EXAMPLE F-1: VERY HIGH DESIGN EFFICIENCY AND SLIGHT DECREASES IN ACTUAL EFFICIENCY RESULT IN SIGNIFICANT ANNUAL EMISSION INCREASES**

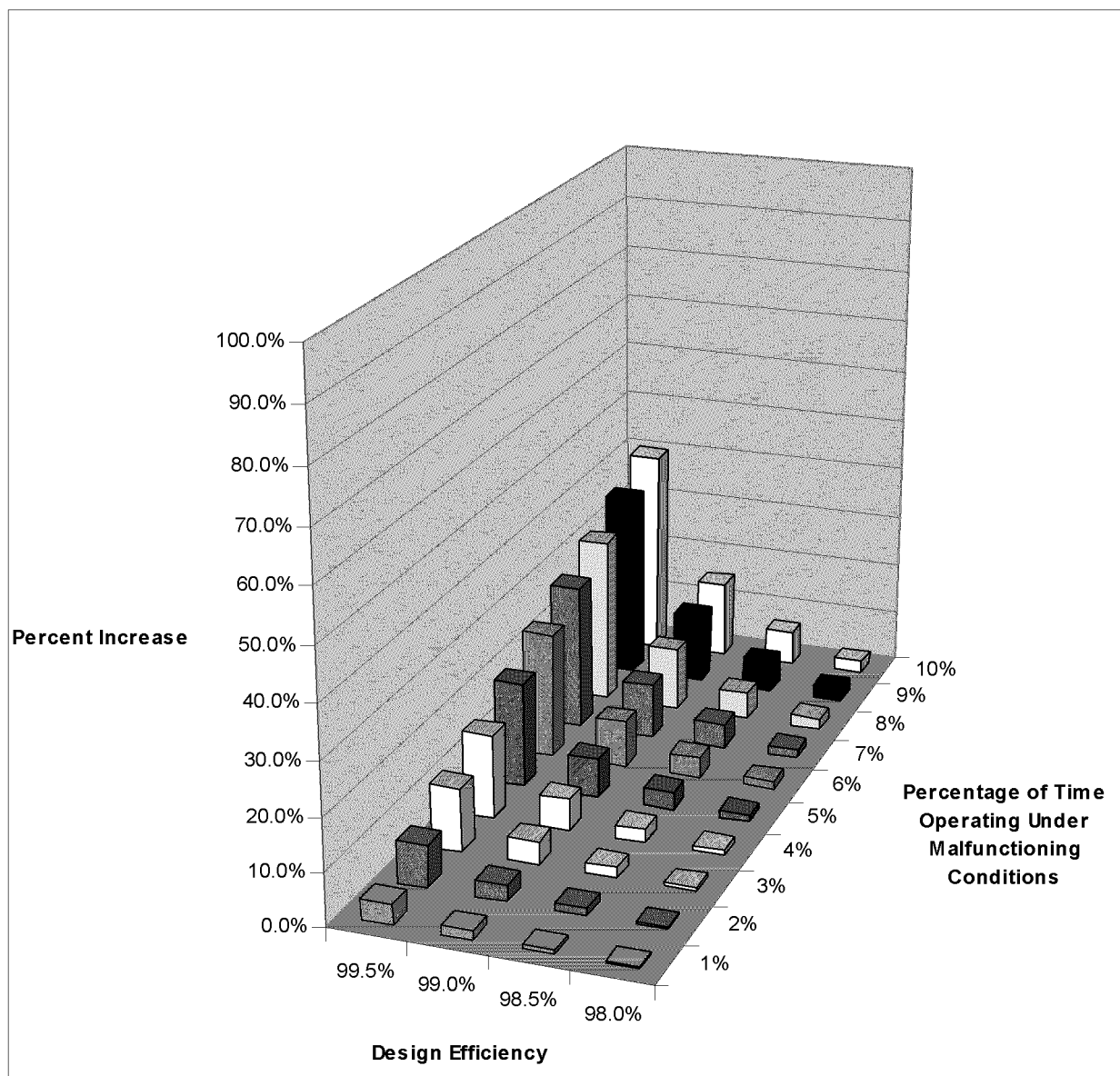
Consider a hypothetical ESP that operates under 97.5 percent efficiency during a minor malfunction. Table F-1 shows the emission increases that would occur if the device operated under malfunction conditions from 1 to 10 percent of the time, and if the ESP was otherwise expected to operate at design efficiencies between 98 and 99.5 percent.

For example, if the control device design efficiency is 99.5 percent, and the control device operates under malfunction conditions (at 97.5 percent efficiency) for 5 percent of the time, the increased emissions due to the malfunction would add 20 percent to the expected annual emission. The data in Table F-1 are presented graphically in Figure F-1.

As you can see in the example of Table F-1, small decreases in the control percentage can result in large percentage increases in actual emissions if the design efficiency is high.

**Table F-1. Percentage Increase Over Expected Annual Emissions for an ESP Operating at 97.5% Efficiency During Malfunction**

Design Efficiency	Percentage Downtime									
	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
99.5%	4.0%	8.0%	12.0%	16.0%	20.0%	24.0%	28.0%	32.0%	36.0%	40.0%
99.0%	1.5%	3.0%	4.5%	6.0%	7.5%	9.0%	10.5%	12.0%	13.5%	15.0%
98.5%	0.7%	1.3%	2.0%	2.7%	3.3%	4.0%	4.7%	5.3%	6.0%	6.7%
98.0%	0.3%	0.5%	0.8%	1.0%	1.3%	1.5%	1.8%	2.0%	2.3%	2.5%



**Figure F-1. Percent Increase in Actual Annual Emissions with Malfunction Efficiency at 97.5%**

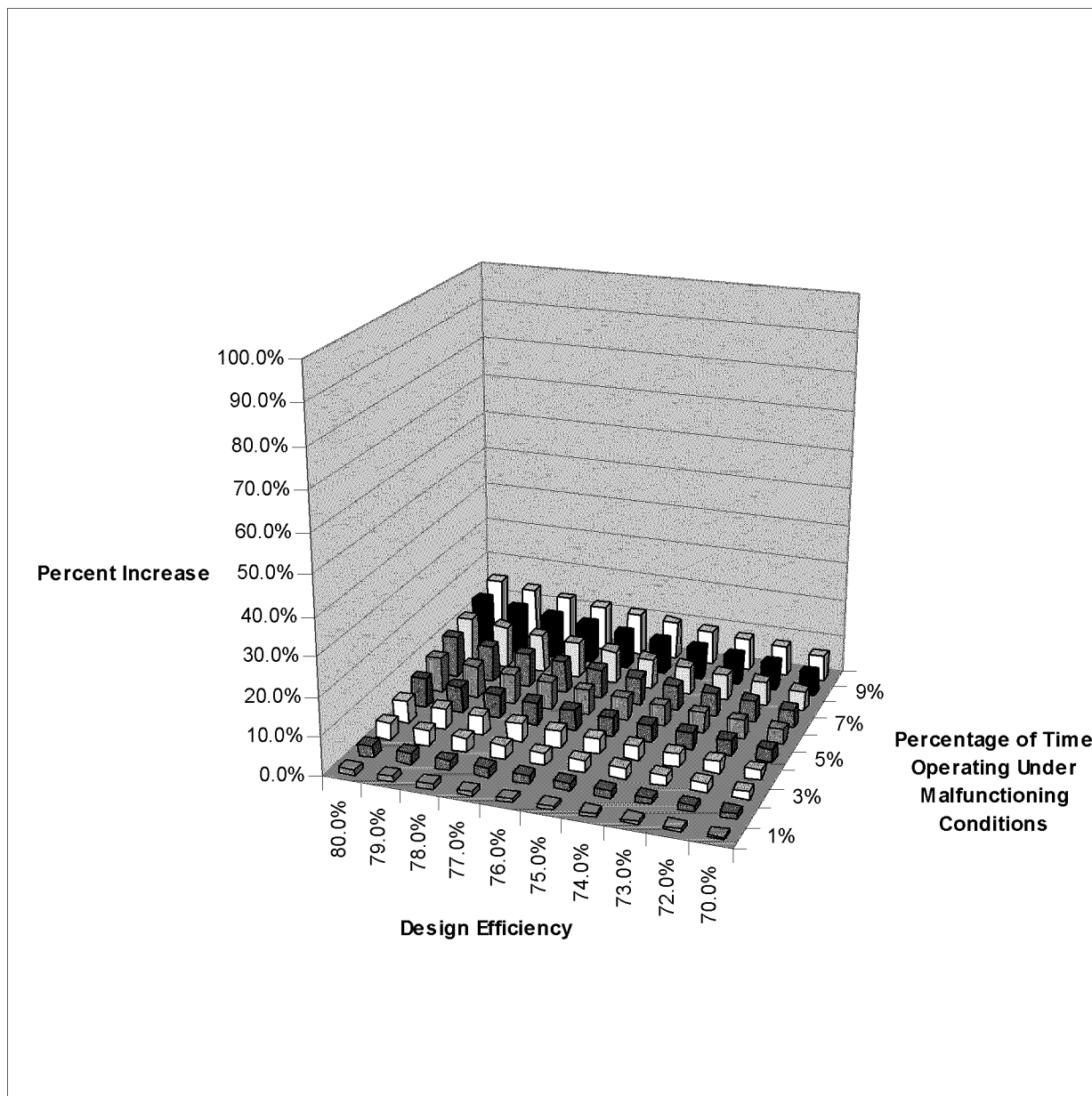
**EXAMPLE F-2: LOW DESIGN EFFICIENCY AND LARGE DECREASES IN ACTUAL EFFICIENCY RESULT IN LESS SIGNIFICANT EMISSION INCREASES**

In contrast to the case in Example F-1, emission changes are less significant if the design efficiency is low, as might be the case with a NO<sub>x</sub> scrubber designed to operate at control efficiencies between 80 - 70 percent. If, for example, a NO<sub>x</sub> scrubber with a design efficiency of 80 percent actually operated at 50 percent efficiency during malfunction conditions 5 percent of the year, actual annual emissions would only be 7.5 percent over the expected annual emissions. Table F-2 and Figure F-2 show the percentage increase for various scenarios in which the NO<sub>x</sub> scrubber operates at 50 percent control efficiency during malfunction.

**Table F-2. Percentage Increase Over Expected Actual Emissions for NO<sub>x</sub> Scrubber Operating at 50% Efficiency During Malfunction**

Design Efficiency	Percentage Downtime									
	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
80.0%	1.5%	3.0%	4.5%	6.0%	7.5%	9.0%	10.5%	12.0%	13.5%	15.0%
79.0%	1.4%	2.8%	4.1%	5.5%	6.9%	8.3%	9.7%	11.0%	12.4%	13.8%
78.0%	1.3%	2.5%	3.8%	5.1%	6.4%	7.6%	8.9%	10.2%	11.5%	12.7%
77.0%	1.2%	2.3%	3.5%	4.7%	5.9%	7.0%	8.2%	9.4%	10.6%	11.7%
76.0%	1.1%	2.2%	3.3%	4.3%	5.4%	6.5%	7.6%	8.7%	9.8%	10.8%
75.0%	1.0%	2.0%	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%
74.0%	0.9%	1.8%	2.8%	3.7%	4.6%	5.5%	6.5%	7.4%	8.3%	9.2%
73.0%	0.9%	1.7%	2.6%	3.4%	4.3%	5.1%	6.0%	6.8%	7.7%	8.5%
72.0%	0.8%	1.6%	2.4%	3.1%	3.9%	4.7%	5.5%	6.3%	7.1%	7.9%
70.0%	0.7%	1.3%	2.0%	2.7%	3.3%	4.0%	4.7%	5.3%	6.0%	6.7%





**Figure F-2. Percentage Increase in Actual Annual Emissions with Malfunction Efficiency at 50%**

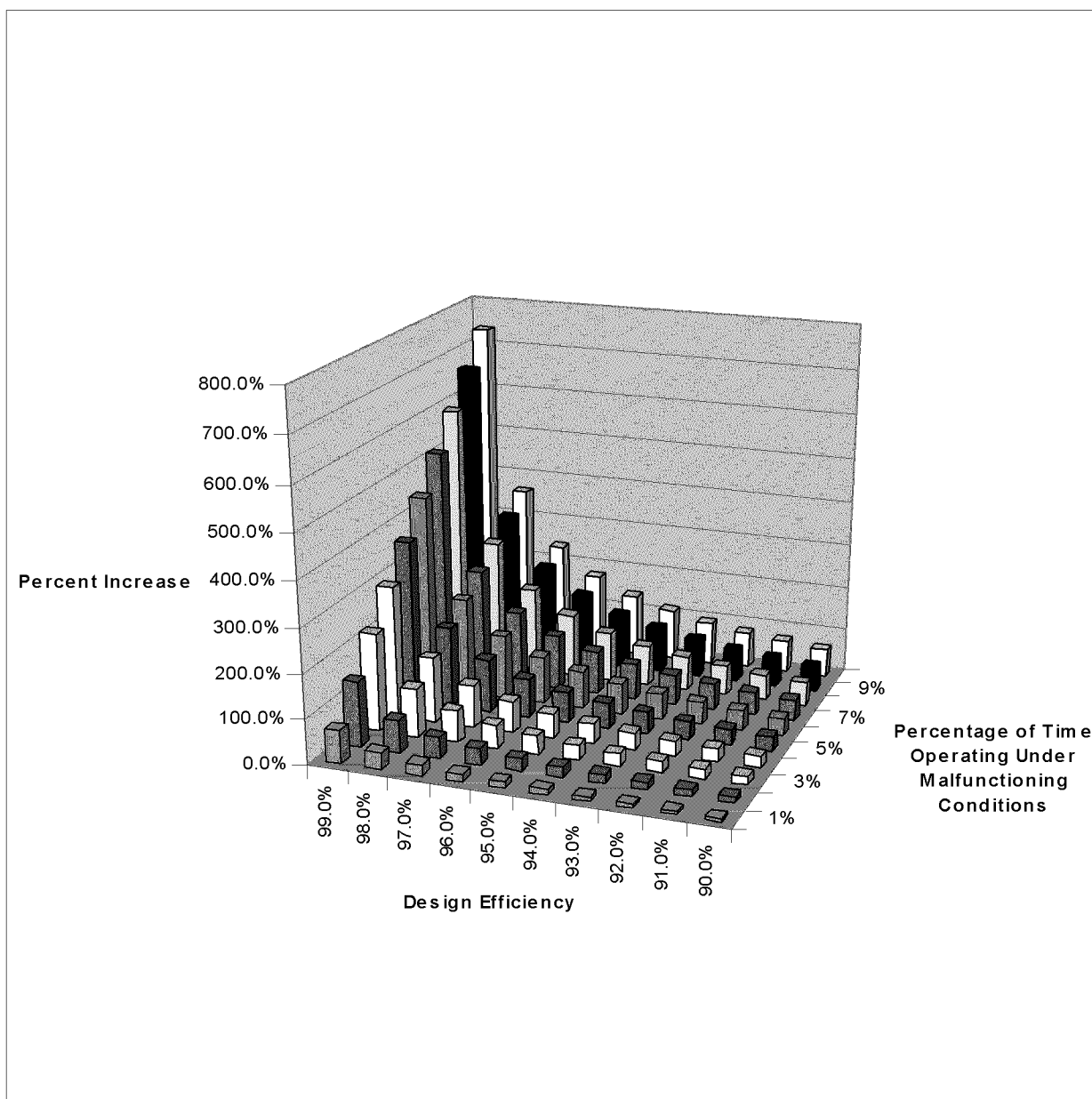
**EXAMPLE F-3:      MODERATELY HIGH DESIGN EFFICIENCY AND LARGE  
DECREASES IN ACTUAL EFFICIENCY RESULT IN VERY HIGH  
INCREASES IN ACTUAL ANNUAL EMISSIONS**

As would be expected, there will be very high increases in actual annual emissions if the design efficiency is high and the actual efficiency greatly decreases for even a short while. Failure of a VOC control system (e.g., due to flame out or pump failure) can result in large efficiency drops that may go undetected if the VOC is odorless or colorless, or if the stack does not vent near people. For example, if a malfunctioning control device operates at only 25 percent efficiency for 1 percent of the year, but is supposed to operate at 95 percent efficiency year round, the annual emissions will increase by 14 percent. If the control device is supposed to operate at 99 percent efficiency year round, the annual emissions will increase by 74 percent!

Table F-3 and Figure F-3 show the percentage increase for various scenarios in which a malfunctioning control device operates at only 25 percent control efficiency.

**Table F-3. Percentage increase Over Expected Annual Emissions for VOC Adsorber  
Operating at 25% Efficiency During Malfunction**

Design Efficiency	Percentage Downtime									
	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
99.0%	74.0%	148.0	222.0	296.0	370.0%	444.0%	518.0%	592.0%	666.0%	740.0%
98.0%	36.5%	73.0%	109.5	146.0	182.5%	219.0%	255.5%	292.0%	328.5%	365.0%
97.0%	24.0%	48.0%	72.0%	96.0%	120.0%	144.0%	168.0%	192.0%	216.0%	240.0%
96.0%	17.8%	35.5%	53.3%	71.0%	88.7%	106.5%	124.3%	142.0%	159.8%	177.5%
95.0%	14.0%	28.0%	42.0%	56.0%	70.0%	84.0%	98.0%	112.0%	126.0%	140.0%
94.0%	11.5%	23.0%	34.5%	46.0%	57.5%	69.0%	80.5%	92.0%	103.5%	115.0%
93.0%	9.7%	19.4%	29.1%	38.9%	48.6%	58.3%	68.0%	77.7%	87.4%	97.1%
92.0%	8.4%	16.8%	25.1%	33.5%	41.9%	50.3%	58.6%	67.0%	75.4%	83.8%
91.0%	7.3%	14.7%	22.0%	29.3%	36.7%	44.0%	51.3%	58.7%	66.0%	73.3%
90.0%	6.5%	13.0%	19.5%	26.0%	32.5%	39.0%	45.5%	52.0%	58.5%	65.0%



**Figure F-3. Percentage Increase in Actual Annual Emissions with Malfunction Efficiency at 25%**

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# **APPENDIX G**

## **DATA SOURCES FOR SECTION 5**

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Data Needed	Data Source	Comments
Target Control Level or Emission Rate	NSPS, MACT, NESHAP, or other Federal regulations  State regulations  Permit Conditions	Regulations and permit conditions may list the target control level or emission rate. These values may be included in the (RACT/BACT/LAER Clearinghouse) accessible via the EPA website.
	EIIP guidance	The EIIP guidance provides calculation methods and expected control levels for numerous source categories.
Actual Control Level of Emission Rates	NSPS, MACT, NESHAP, or other Federal regulations guidance on maximum downtime  State regulations for maximum downtime  Permit conditions for maximum downtime	Regulations and permit conditions may indicate maximum allowable downtimes or maximum allowable excess emissions that are below the target control rate but still within compliance with the rule.
	Quarterly CEM reports where required by Federal or state rules (e.g., for utility boilers)	Some sources (e.g., utility boilers) must file quarterly CEM reports with the state agency. Data in these reports might not make it to the emission inventory branch unless you specifically request them.
	EIIP guidance	The EIIP guidance provides calculation methods and expected control levels for numerous source categories.
	Facility reports for excess emissions	Facilities may file reports of excess emissions with state permitting or compliance staff, particularly if permit conditions require.
	State databases (e.g., DEERS in South Carolina) for tracking excess emissions	Some states (e.g., Texas and South Carolina) keep databases of excess emissions reported by facilities.
	State compliance or permitting staff	State compliance and permitting staff will be the best sources of information regarding the expected amount of downtime and the expected degree of reduced control.

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**VOLUME II: CHAPTER 13**

# **TECHNICAL ASSESSMENT PAPER: AVAILABLE INFORMATION FOR ESTIMATING AIR EMISSIONS FROM STONE MINING AND QUARRYING OPERATIONS**

**May 1998**



Prepared by:  
Eastern Research Group, Inc.

Prepared for:  
Point Sources Committee  
Emission Inventory Improvement Program

## **DISCLAIMER**

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

## ACKNOWLEDGEMENT

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# 1

## INTRODUCTION

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The purpose of this paper is to summarize the activities performed by the Point Sources Committee (PSC) of the Emission Inventory Improvement Program (EIIP) to identify available emission estimation guidance information for the stone mining and quarrying source category. Stone mining and quarrying falls under the Non-metallic Mineral Mining Industry Group (U.S. Census Bureau, 1997). The Non-metallic Mineral Mining Industry Group is defined by Standard Industrial Classification (SIC) as Division B: Mining, Major Group 14: Mining and Quarrying of Non-metallic Minerals, except fuels (Occupational Safety and Health Administration [OSHA], 1997). The stone mining and quarrying source category consists of the following SIC industry groups:

- 1411 - Dimension Stone;
- 1422 - Crushed and Broken Limestone;
- 1423 - Crushed and Broken Granite;
- 1429 - Crushed and Broken Stone, including Riprap; and
- 1499 - Miscellaneous Non-metallic Minerals, except fuels.

It should be noted that SIC Major Group 14 includes other industry groups (four-digit SICs) that are not considered to be part of the stone mining and quarrying source category. Descriptions for these categories may be found at the SIC web address (OSHA, 1997).

In 1995, there were nearly 1,600 companies in operation with more than 3,200 active surface quarries and underground mines. These quarries produced 1.26 billion tons of crushed stone valued at \$6.92 billion dollars (National Stone Association, 1997).

Section 2 of this paper presents a description of the source category, and Section 3 briefly describes the information collection activities. Section 4 provides a description of each guidance document acquired. Examples for estimating emissions from stone mining and quarrying using the acquired methodology are included in Section 5. NOTE: the methods used for these examples do not constitute endorsement as either a preferred or alternative method for estimating emissions by the Point Sources Committee. The purpose is to simply present available information. A



comparison of estimates based upon the use of the different available methods is also included in Section 5. References are listed in Section 6.

# 2

## SOURCE CATEGORY DESCRIPTION

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This section describes the various stone mining and quarrying processes and identifies emission points, control devices, and the variables that can influence emissions.

### 2.1 PROCESS DESCRIPTION

Operations within the stone mining and quarrying industry are facility specific and may vary according to environmental conditions, rock type, and work practices. However, some major processes are common to most facilities and may be described in general terms. These descriptions are provided in *AP-42* and are presented in the following sections (U.S. Environmental Protection Agency [EPA], 1995).

#### 2.1.1 PRE-PROCESSING (BLASTING, TRANSPORTING, AND DUMPING)

Rock and crushed stone products generally are loosened by drilling and blasting, and then are loaded by a power shovel or front-end loader into large haul trucks that transport the material to the processing operations. Quarried stone normally is delivered to the processing plant by truck, and is dumped into a hoppers feeder, usually a vibrating grizzly type, or onto screens. The feeder or screens separate large boulders from finer rocks that do not require primary crushing, thus reducing the load to the primary crusher.

#### 2.1.2 CRUSHING

##### ***Primary Crushing***

Jaw, impactor, or gyratory crushers are usually used for initial reduction. The crusher product, normally 7.5 to 30 centimeters (3 to 12 inches) in diameter, and the grizzly throughs (undersize material) are discharged onto a belt conveyer and usually are conveyed to a surge pile for temporary storage, or are sold as coarse aggregates.

##### ***Secondary Crushing***

Cone crushers are commonly used for secondary crushing (although impact crushers are sometimes used), which typically reduces material to about 2.5 to 10 centimeters (1 to 4 inches) in diameter. The material (throughs) from the second level of the screen bypasses the secondary

crusher because it is sufficiently small for the last crushing step. The output from the secondary crusher and the throughs from the secondary screen are transported by conveyor to the tertiary circuit, which includes a sizing screen and a tertiary crusher.

### ***Tertiary Crushing***

Tertiary crushing is usually performed using cone crushers or other types of impactor crushers. Oversize material from the top deck of the sizing screen is fed to the tertiary crusher. The tertiary crusher output, which is typically 0.50 to 2.5 centimeters (3/16 to 1 inch) in diameter, is returned to the sizing screen. Some stone crushing plants produce manufactured sand, with a maximum diameter of 0.50 centimeters (3/16 inch).

### ***Fines Crushing***

Oversized material is processed in a cone crusher or a hammermill (fines crusher) adjusted to produce small diameter material. The output is then returned to the fines screen for resizing.

## **2.1.3 SCREENING**

### ***Screening (Primary, Secondary, or Tertiary)***

The stone from the surge pile is conveyed to a vibrating inclined screen called the scalping screen. This unit separates oversized rock from the smaller stone. The stone that is too large to pass through the top deck of the scalping screen is processed in a subsequent crusher.

### ***Fines Screening***

Crushed stone from the tertiary sizing screen is sized in a vibrating inclined screen (fines screen) with relatively small meshes.

## **2.1.4 MATERIAL HANDLING AND STORAGE OPERATIONS**

In certain cases, as with concrete aggregate processing, stone washing is required to meet particular end product specifications. Conveyor belts move rocks between the crushing and screening stages.

The following table describes typical stone size classifications that occur as a result of crushing and screening processes:

**TABLE 13.2-1**

**TYPICAL SIZE CLASSIFICATIONS**

Primary crushing	7.5 to 30 centimeters
Secondary crushing	2.5 to 10 centimeters
Tertiary crushing	0.50 to 2.5 centimeters
Fines screening	<0.50 centimeters
Fines crushing	<0.50 centimeters

## **2.2 EMISSION POINTS**

Each of the operations at stone mining and quarrying plants described in Section 2.1 is a potential emission source. Whether or not an operation is an actual emission source depends on plant-specific operating conditions, work practices, and emissions controls based at the plant.

## **2.3 VARIABLES THAT INFLUENCE EMISSIONS**

Several environmental conditions (variables) may affect uncontrolled emission levels and their effects should be taken into consideration when estimating emissions. This is usually accomplished by including in the emission estimation calculation a term (factor or adjustment) for each variable that affects emission levels. Environmental conditions that may significantly affect uncontrolled emission levels are:

- Wind - Fugitive emission levels typically will increase with high wind. Some facilities will build an enclosure or barrier to reduce the effects of wind.
- Material moisture content - Process and fugitive emissions are greater in arid regions of the country than in temperate ones, and greater during the summer months because of a higher evaporation rate. Surface wetness causes fine particles to agglomerate on, or adhere to, the faces of larger stones, with a resulting dust suppression effect. Moisture content of a mined rock may range from nearly zero to several percent.

- Season - Evaporative emission levels are usually higher during the summer.
- Rock type - Emissions can vary according to rock type, such as volcanic, limestone, sandstone, and granite.
- Local weather conditions - Emissions can vary according to changes in humidity and air and ground temperature.
- Traffic - Vehicle's weight (both empty and loaded), number of tires, speed of vehicles, silt and moisture content of roadway.

## INFORMATION GATHERING ACTIVITIES

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Using the County Business Patterns Database, a query was performed to identify the number of stone mining and quarrying facilities in each state (U.S. Census Bureau, 1993). Air quality agencies in the 16 states with the most facilities (listed in Table 13.3-1) were then contacted to determine if guidance documents were available for estimating emissions from stone mining and quarrying facilities (processes).

In California, three local air quality agencies and the California Air Resources Board (CARB) were contacted. In the other states, state air quality agencies were contacted. A total of 13 agencies were surveyed representing 10 of the initial 16 states. Available emission estimation methodologies and guidance for estimating emissions were requested from each agency. The staff members and associated agencies contacted are listed in Table 13.3-2.

Through the informal survey, one result was that air quality personnel typically estimated emissions using emission factors and equations from *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources (AP-42)*. Eleven of the 13 agencies contacted used emission factors from the 5th edition of the *AP-42*, and one state agency used factors from *AP-42*, 4th edition. The issue of applicability of the *AP-42* 5th edition factors for stone mining and quarrying is a concern for some state and local agencies. Only one of the 13 agencies contacted had developed its own emission factors and equations for estimating emissions. Most agencies contacted maintain a publicly available emissions database for this industry.

Results of the information gathering activities show that 6 of the 13 agencies contacted provide some type of emissions estimation guidance to industries. Copies of the guidance documents were obtained from four of the six agencies: San Diego Air Pollution Control District (APCD), the Texas Natural Resource Conservation Commission (TNRCC), the Wisconsin Department of Natural Resources (DNR), and the Mojave Desert Air Quality Management District (AQMD). The guidance documents are described in Section 4.

**TABLE 13.3-1****STATES WITH THE MOST STONE MINING AND QUARRYING FACILITIES<sup>a</sup>**

<b>State Contacted</b>	<b>Number of Facilities</b>
Missouri <sup>b</sup>	143
Pennsylvania	133
Iowa <sup>b</sup>	100
Illinois	95
Virginia	78
Ohio <sup>b</sup>	77
Tennessee <sup>b</sup>	76
North Carolina	72
Kentucky <sup>b</sup>	71
California <sup>b,c</sup>	67
New York	67
Georgia <sup>b</sup>	64
Indiana	64
Texas <sup>b</sup>	57
Florida <sup>b</sup>	51
Wisconsin <sup>b</sup>	50

<sup>a</sup> Source: Census Bureau, 1993.

<sup>b</sup> Responded to the informal telephone survey.

<sup>c</sup> Three local air agencies and the Air Resources Board in California were contacted.

**TABLE 13.3-2****PERSONNEL AND AGENCIES CONTACTED**

<b>Name</b>	<b>Agency</b>
Marcia Banks	San Diego Air Pollution Control District
John Castanis	Kentucky Division of Air Quality
Emily Chen	Iowa Department of Natural Resources
Qui Chiu	Tennessee Air Pollution Control
Rita Felton	Florida Department of Environmental Protection
Dennis Goodenow	California Air Resources Board
Tom Kalman	Ohio Environmental Protection Agency
Richard McDonald	Georgia Environmental Protection Division
Judy Mobrice	Missouri Air Pollution Control Division
Ralph Patterson	Wisconsin Department of Natural Resources
Terry Thomas	Ventura County Air Quality Management District
Richard Wales	Mojave Desert Air Quality Management District
Dois Webb	Texas Natural Resource Conservation Commission



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# 4

## AVAILABLE INFORMATION FOR ESTIMATING EMISSIONS

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The following sections provide a description of each guidance document that was obtained. Table 13.4-1 summarizes the available guidance for estimating emissions from stone mining and quarrying processes found in the five documents.

### 4.1 INFORMATION IN AP-42

*AP-42* describes some of the major processes used at stone mining and quarrying facilities. These processes include pre-processing, crushing, screening, material handling, and storage operations (EPA, 1995). Particulate Matter (PM) and PM with an aerometric diameter less than or equal to 10 micrometers (PM<sub>10</sub>) emissions are the primary pollutants emitted from these processes. *AP-42* presents controlled and uncontrolled emission factors for screening operations, crushing operations, conveyor transfer point, drilling, and material unloading (EPA, 1995). These factors were developed from crushing plants in North Carolina, Virginia, and Tennessee (EPA, 1994).

Emissions generally were considered to be uncontrolled if the raw material moisture content was less than 1.5 percent and controlled if the raw material moisture content was greater than or equal to 1.5 percent. Variables identified that affect emissions include (but are not limited to) wind, material moisture content, stone type, throughput rate, humidity, temperature, and climate (EPA, 1995).

### 4.2 INFORMATION PROVIDED BY THE SAN DIEGO APCD

The San Diego APCD provides guidance to its engineering staff on the uniform application of *AP-42* emission factors (with some modifications) (Lake, 1996). The guidance addresses emission calculations for conveyor transfer points, crushing operations, screening operations, and paved and unpaved haul roads. Each of these emission points has an associated emission factor.

Industries using these guidance procedures must provide the APCD with information about hourly throughputs for transfer points, crushing systems, and screening systems, as well as process flow diagrams.

**TABLE 13.4-1****SUMMARY OF AVAILABLE GUIDANCE<sup>a</sup>**

<b>Emission Source</b>	<b>AP-42</b>	<b>San Diego APCD</b>	<b>TNRCC</b>	<b>Wisconsin DNR</b>	<b>Mojave Desert AQMD</b>
Blast Hole Drilling	X				X
Blasting					X
Bulldozing, Scraping, and Grading					X
Conveyor Transfer Point	X	X	X	X	X
Crushing	X	X	X	X	X
Drop Point			X		X <sup>b</sup>
Material Loading (or Handling)			X		X
Material Unloading (or Handling)	X		X		X
Mobile and Vehicular Exhaust					X
Paved Roads		X	X	X	X
Screening	X	X	X	X	X
Stationary Equipment Exhaust					X
Stockpiles			X		X
Unpaved Roads		X	X	X	X
Wind Erosion from Unpaved Operational Areas and Roads					X

<sup>a</sup> The X indicates that emissions estimation guidance materials are available for this emission point from the agency noted.

AP-42 = Compilation of Air Pollutant Emission Factors

APCD = Air Pollution Control District

TNRCC = Texas Natural Resource Conservation Commission

DNR = Department of Natural Resources

AQMD = Air Quality Management District

<sup>b</sup> The Mojave Desert AQMD uses the emission estimation methods described for "Conveyor Transport Point" for "Drop Point," as well.

### 4.3 INFORMATION PROVIDED BY THE TNRCC

A technical guidance package applicable to any non-metallic mining industry was obtained from the TNRCC (TNRCC, 1994). This package contains guidance on completing permit applications, identifying standard exemptions, and using the TNRCC-approved emission estimation equations. Rules and regulations pertaining to the State of Texas are included in the package for reference and benefit to the facility.

Step-by-step guidance is provided for facilities filling out an initial permit application and for those renewing a permit. A sample permit is included, along with guidance on work practices and operational limitations. Guidance for facilities submitting confidential information is also included.

In the calculation section of the guidance package, appropriate emission estimation equations are listed. Example calculations are provided for emission estimates from crushing, screening, material loading and unloading, material transfer and drop points, stockpiles, and haul roads. A brief description on applying the equations is included as well.

The calculation section also includes tables of TNRCC-approved emission factors and emission control efficiencies. These factors are mostly from *AP-42*, but a few were derived by the TNRCC. Similarly, most of the emission control efficiencies are from *AP-42* except those for road emissions, which were also derived by the TNRCC.

### 4.4 INFORMATION PROVIDED BY THE WISCONSIN DNR

The Wisconsin DNR, in an effort to standardize criteria for estimating emissions from stone mining and quarrying facilities, established a Non-metallic Mining Air Emissions Work Group. Both the Wisconsin Road Builders Association and the Aggregate Producers of Wisconsin agreed to participate as members of this work group and a "Rock Crushing Agreement" was created in December 1997 (Wisconsin DNR, 1997). This agreement outlines emissions-related issues and describes DNR's training program for a responsible person at the facility to recognize when appropriate dust control measures should be taken.

A table describing the criteria a facility must meet in order to receive the desired credit for emissions reductions for each process is included in the agreement. The processes that the agreement applies to are screening, primary crushing, secondary crushing, tertiary crushing, fines crushing, conveyor transfer points, and haul roads. Definitions of key terms are included for uniformity and clarity among stakeholders.

## 4.5 INFORMATION FROM MOJAVE DESERT AQMD

The Mojave Desert AQMD published a draft document entitled *Emissions Inventory Guidance on Mineral Handling and Processing* in an attempt to standardize the method for estimating emissions from a large number of operations and processes (Mojave Desert AQMD, 1997). It is Mojave Desert AQMD's plan to make the "Emission Inventory Guidance" a living document that will be expanded and modified as needed. Each method provides several levels of increasing complexity and accuracy. At the lowest level of complexity, an emission factor is simply multiplied by a process activity rate. The greatest level of complexity and accuracy involves the use of data from a source test. If feasible, facilities are encouraged to perform source tests in lieu of the methods presented in the guidance document.

Each method, presented in the same format, begins with a detailed discussion of the applicable processes and operations. The method and equations are then provided, beginning with the most conservative and least complex (requiring minimal inputs and level of effort), and followed by increasingly complex methods and equations (requiring more inputs and level of effort). The Mojave Desert AQMD encourages facilities to strive for more accurate emissions, which would require in-depth documentation and use of more complex methods and equations. The least complex method uses very conservative factors that result in the highest emission rate. When using a more complex method, the emissions typically are lower than when a less complex method is used. However, the more complex the method, the more information the facility must collect. The benefit is that total emissions will be lower using the more complex methods and equations.

The guidance document contains tables that present various common inputs to emissions calculations, such as percentage of silt content and blasting and drilling activity. Each method discussed includes applicable control strategies and appropriate calculations methods. The equations presented for each method are derived principally from *AP-42* or from other South Coast AQMD information sources. Methods are available for the following emission points: blast hole drilling; blasting; bulldozing, scraping, and grading of materials; drop point; material handling operations; material crushing and screening operations; wind erosion from stockpiles; stationary equipment exhaust; mobile equipment and vehicular exhaust; dust entrainment from paved roads; dust entrainment from unpaved roads; and wind erosion from unpaved operational areas and roads.

# 5

## EXAMPLE CALCULATIONS USING THE GUIDANCE PROVIDED

The purpose of this section is to provide the user with example calculations for determining emissions from stone mining and quarrying facilities based on the information described earlier. NOTE: the methods used for these examples do not constitute endorsement as either a preferred or alternative method for estimating emissions by the EIIP Point Sources Committee. The purpose is to simply present available information.

Table 13.5-1 lists the variables and symbols used in the discussions that follow.

**TABLE 13.5-1**

### LIST OF VARIABLES AND SYMBOLS

Variable	Symbol	Units
Hourly emissions of pollutant x	$E_x$	lb/hr; ton/hr
Emission factor for pollutant x	$EF_x$	lb/units
Activity factor for process	AF	units/hr
Annual emissions of pollutant x	$E_{x(annual)}$	lb/yr; ton/yr
Operating hours for process	OH	hr/yr
Controlled hourly emissions of pollutant x	$E_{c,x}$	lb/hr; ton/hr
Controlled annual emissions of pollutant x	$E_{c,x(annual)}$	lb/yr; ton/yr
Control efficiency	C	%
Tier i emissions of pollutant x, where i = 1 to 3	$E_{tier\ i,x}$	lb/yr
Control efficiency of Tier i scenario, where i = 1 to 3	$CE_{tier\ i,x}$	%
Sum of Tier i emissions (lb/yr), where i = 1 to 3	$E_{total,x}$	lb/yr
Number of transfer points from initial application for a specific control technique	n	unitless

When using emission factors, the general equation for estimating emissions is:

$$E_x = EF_x * AF \quad (13.5-1)$$

where:

$E_x$  = Hourly emissions of pollutant x (lb/hr)  
 $EF_x$  = Emission factor for pollutant x (lb/units)  
 $AF$  = Activity factor for process (units/hr)

Assuming the number of operating hours is known for an entire year, then an annual emission can be estimated:

$$E_{x \text{ (annual)}} = E_x * OH \quad (13.5-2)$$

where:

$E_{x \text{ (annual)}}$  = Annual emissions for pollutant x (lb/yr)  
 $E_x$  = Hourly emissions for pollutant x (lb/hr)  
 $OH$  = Operating hours for process (hr/yr)

If control techniques are used and a control efficiency is known, then a controlled emissions can be estimated:

$$E_{c,x} = E_x * (1 - C/100) \quad (13.5-3)$$

where:

$E_{c,x}$  = Controlled hourly emissions for pollutant x (lb/hr)  
 $E_x$  = Hourly emissions for pollutant x (lb/hr)  
 $C$  = Control efficiency (%)

As a means of comparison of the guidance material obtained, emissions from screening operations will be estimated using methods listed in Section 4. Section 5.1 will develop estimates for both uncontrolled and controlled emissions. The methods used by the San Diego APCD and the TNRCC are similar and will be considered as one example.

## 5.1 EXAMPLE CALCULATION USING AP-42 EMISSION FACTORS

*AP-42* contains emission factors for nine processes: screening, primary crushing, secondary crushing, tertiary crushing, fines crushing, fines screening, conveyor transfer point, wet drilling, and truck unloading. The following example calculations show how those emission factors (controlled and uncontrolled) can be used to estimate emissions.

### Example 13.5-1

This example shows how  $PM_{10}$  uncontrolled emissions from screening processes can be estimated by using Equation 5-1.

Given:

$$\begin{aligned} EF_{PM_{10}} &= 0.015 \text{ lb/ton rock crushed} \\ AF &= 100 \text{ tons rock crushed/hr} \end{aligned} \quad (13.5-1)$$

$$E_x = EF_x * AF$$

$$E_{PM_{10}} = (0.015 \text{ lb/ton rock crushed})(100 \text{ tons rock crushed/hr})$$

$$E_{PM_{10}} = 1.5 \text{ lb/hr}$$

## 5.2 EXAMPLE CALCULATION USING SAN DIEGO APCD AND TNRCC GUIDANCE

Both the San Diego APCD and TNRCC provide guidance on applying appropriate emission factors and control efficiencies for different processes. When a control efficiency is applied to an emissions estimate or factor, an emissions reduction results.

For example, *AP-42* provides “Dry” and “Wet” emission factors for screening of “Process” and “Fine” materials. The “Wet” factors are lower than the “Dry” factors (0.00084 lb/ton vs 0.015 lb/ton, respectively) for “Process” material (EPA, 1995). In the San Diego APCD guidance



for estimating screening operations, “Process” material is defined as an aggregate stream composed of at least 70 percent by weight of aggregate larger in size than a number four MESH (which is the size of the screen). The “Wet” emission factor for “Process” material is used for “Process” material streams having a moisture content of at least 1.5 percent. Otherwise, the “Dry” emission factor must be used. No additional reduction for control technology is applied for “Wet” material streams. The guidance provides appropriate control efficiencies to be used for “Dry” material screening where a control technology is employed.

Similarly, TNRCC lists the acceptable control technologies with respective control efficiencies and emission factors that can be used in determining emissions estimates for nine emission points.

### Example 13.5-2

This example shows how  $PM_{10}$  hourly emissions can be converted to annual emissions using Equation 13.5-2 when annual operating hours are known.

Given:

$$\begin{aligned} E_{PM_{10}} &= 1.5 \text{ lb/hr emission of } PM_{10} \\ OH &= 1,040 \text{ operating hr/yr} \end{aligned}$$

$$E_{x \text{ (annual)}} = E_x * OH \quad (13.5-2)$$

$$E_{PM_{10} \text{ (annual)}} = 1.5 \text{ lb/hr} * 1,040 \text{ hr/yr}$$

$$E_{PM_{10} \text{ (annual)}} = 1,560 \text{ lb/yr}$$

Similarly, the controlled emissions estimate for screening processes can be calculated using the same technique (note that Equations 13.5-1 and 13.5-2 were combined):

Given:

$$\begin{aligned} EF_{PM_{10}} &= 0.00084 \text{ lb/ton rock crushed} \\ AF &= 100 \text{ tons rock crushed/hr} \\ OH &= 1,040 \text{ hr/yr} \end{aligned}$$

$$E_x = EF_x * AF * OH$$

$$E_{PM_{10} \text{ (annual)}} = (0.00084 \text{ lb/ton rock crushed}) * (100 \text{ tons rock crushed/hr}) * (1,040 \text{ hr/yr})$$

$$E_{PM_{10} \text{ (annual)}} = 87.36 \text{ lb/yr}$$

Example 13.5-3

This example shows how controlled PM<sub>10</sub> hourly emissions from screening can be calculated using Equation 13.5-3. The control device is a covered screen with surfactant added.

$$\begin{aligned} E_{\text{PM}_{10}} &= 1.5 \text{ lb/hr PM}_{10} \text{ emissions} \\ C &= 90 \% \end{aligned}$$

$$E_{c,x} = E_x * (1 - C/100) \quad (13.5-3)$$

$$E_{c,\text{PM}_{10}} = 1.5 \text{ lb/hr} * (1 - 90/100)$$

$$E_{c,\text{PM}_{10}} = 0.15 \text{ lb/hr}$$

For annual emissions,

$$E_{c,\text{PM}_{10}(\text{annual})} = E_{c,\text{PM}_{10}} * \text{OH} \quad (13.5-2)$$

where,

$$\text{OH} = 1,040 \text{ hr/yr}$$

$$\begin{aligned} E_{c,\text{PM}_{10}(\text{annual})} &= (0.15 \text{ lb/hr}) * (1,040 \text{ hr/yr}) \\ E_{c,\text{PM}_{10}(\text{annual})} &= 156 \text{ lb/yr} \end{aligned}$$

### 5.3 EXAMPLE CALCULATION USING THE WISCONSIN DNR GUIDANCE

The requirements for obtaining credit for control efficiencies to be applied to emissions estimates prepared using the Wisconsin DNR guidance document are more stringent than those in the San Diego and TNRCC guidance documents. The credit for the level of control a facility receives on its emissions is related to the amount of “extra effort” by the facility. Automatically, a facility will receive a 50 percent control efficiency credit in Tier 1 of a three-tiered system, leading to a corresponding 50 percent reduction in emissions. Under Tier 2, a facility may receive a 75 percent control credit, while under Tier 3, a facility may receive a credit for greater than 90 percent control.

To gain Tier 2 credit, the facility must follow specific housekeeping, recordkeeping, and control equipment requirements as determined by DNR. Additionally, the facility must have a “Trained Person” on-site during any stone mining or quarrying operations, otherwise the operation is not eligible for the 75 percent control credit. The “Trained Person” must review a videotape developed by DNR or complete a training program to recognize when fugitive dust control measures need to be taken, and what measures are appropriate.

To gain Tier 3 credit, the facility must again follow specific housekeeping, recordkeeping, and control equipment requirements. However, unlike Tier 2, the facility must have a certified “Visible Emissions Reader” on-site in addition to the “Trained Person.” The “Visible Emissions Reader” assigned to the facility must be certified once each calendar year to identify varying levels of visible emissions using U.S. EPA Method 9 criteria.

#### Example 13.5-4

This example shows the calculation of annual emissions under the Wisconsin DNR three-tiered system.

Company A is a stone mining and quarrying facility that operates at 1,040 hours per year. For 150 hours, there was a “Trained Person” on-site but not adequate recordkeeping, thus the facility can receive only Tier 1 credit for those hours. For 115 hours, there was a “Trained Person” on-site and the recordkeeping requirements satisfied the regulatory agency, thus the facility can receive Tier 2 credit for the 115 hours. For the remaining 775 hours, Company A satisfied the recordkeeping requirements and had both a “Trained Person” a certified “Visible Emissions Reader” on-site during operations, thus the facility can receive Tier 3 credit for 775 hours. Company A crushed stone at a rate of 100 tons/hr during all three time periods.

The  $PM_{10}$  emissions from screening processes may be calculated using Equations 13.5-1 to 13.5-3 and the respective control efficiency for each tier.

$$E_x = EF_x * AF \quad (13.5-1)$$

$$E_{x \text{ (annual)}} = E_x * OH \quad (13.5-2)$$

$$E_{c,x} = E_x * (1 - C/100) \quad (13.5-3)$$

Combining terms and substituting  $CE_{\text{tier } i, x}$  for C, a new equation is developed for a facility on a tier basis:

$$E_{\text{tier } i, x} = AF * EF_x * OH * (1 - CE_{\text{tier } i, x}/100) \quad (13.5-4)$$

where:

$$\begin{aligned} E_{\text{tier } i, x} &= \text{Tier } i \text{ emissions of pollutant } x, \text{ where } i = 1 \text{ to } 3 \text{ (lb/yr)} \\ CE_{\text{tier } i, x} &= \text{Tier } i \text{ control efficiency of pollutant } x, \text{ where } i = 1 \text{ to } 3 \text{ (lb/yr)} \end{aligned}$$

Example 13.5-4 (Continued)

Summing the Tier i emissions provides an annual estimate, and letting i = 1 to 3:

$$E_{\text{total}} = E_{\text{tier 1,x}} + E_{\text{tier 2,x}} + E_{\text{tier 3,x}} \quad (13.5-5)$$

Given, for a

Tier 1 scenario:

$$\begin{aligned} \text{AF} &= 100 \text{ tons rock crushed/hr} \\ \text{EF}_{\text{PM10}} &= 0.015 \text{ lb/ton rock crushed} \\ \text{OH} &= 150 \text{ hr/yr} \\ \text{CE}_{\text{tier 1,PM10}} &= 50\% \end{aligned}$$

For a Tier 2 scenario:

$$\begin{aligned} \text{AF} &= 100 \text{ tons rock crushed/hr} \\ \text{EF}_{\text{PM10}} &= 0.015 \text{ lb/ton rock crushed} \\ \text{OH} &= 115 \text{ hr/yr} \\ \text{CE}_{\text{tier 2,PM10}} &= 75\% \end{aligned}$$

For a Tier 3 scenario:

$$\begin{aligned} \text{AF} &= 100 \text{ tons rock crushed/hr} \\ \text{EF}_{\text{PM10}} &= 0.015 \text{ lb/ton rock crushed} \\ \text{OH} &= 775 \text{ hr/yr} \\ \text{CE}_{\text{tier 3,PM10}} &= 90\% \end{aligned}$$

$$E_{\text{tier "i",PM10}} = \text{AF} * \text{EF}_{\text{PM10}} * \text{OH} * (1 - \text{CE}_{\text{tier "i",x}}/100) \quad (13.5-4)$$

$$\begin{aligned} E_{\text{tier 1,PM10}} &= (100 \text{ tons rock crushed/hr}) * (0.015 \text{ lb/ton rock crushed}) * (150 \text{ hr/yr}) * (1 - 50/100) \\ E_{\text{tier 1,PM10}} &= 112.5 \text{ lb/yr} \end{aligned}$$

$$\begin{aligned} E_{\text{tier 2,PM10}} &= (100 \text{ tons rock crushed/hr}) * (0.015 \text{ lb/ton rock crushed}) * (115 \text{ hr/yr}) * (1 - 75/100) \\ E_{\text{tier 2,PM10}} &= 43.15 \text{ lb/yr} \end{aligned}$$

$$\begin{aligned} E_{\text{tier 3,PM10}} &= (100 \text{ tons rock crushed/hr}) * (0.015 \text{ lb/ton rock crushed}) * (775 \text{ hr/yr}) * (1 - 90/100) \\ E_{\text{tier 3,PM10}} &= 116.25 \text{ lb/yr} \end{aligned}$$

$$E_{\text{total}} = E_{\text{tier 1,PM10}} + E_{\text{tier 2,PM10}} + E_{\text{tier 3,PM10}}$$

$$\begin{aligned} E_{\text{total}} &= (112.5 + 43.15 + 116.25) \text{ lb/yr} \\ E_{\text{total}} &= 271.9 \text{ lb/yr} \end{aligned}$$

## 5.4 EXAMPLE CALCULATION USING THE MOJAVE DESERT AQMD GUIDANCE

The Mojave Desert AQMD derived emission factors or emission equations for 15 emission points. The guidance document lists each equation and all the applicable emission factors. In general, the least complex method is similar to Equation 5-1.

Equation 13.5-6 allows estimating emissions from screening operations using their “most complex” method:

$$E_{c,x} = EF_x * AF * (1 - (C - (5 * n))/100) \quad (13.5-6)$$

where:

C = Control efficiency based upon daily opacity readings and control technique used  
n = number of transfer points from initial application for a specific control technique

### Example 13.5-5

This example shows the use of the Mojave Desert AQMD’s “most complex” method in determining emissions from screening operations. The daily opacity reading is less than 10% and the control technique used is a water spray (downstream effect).

$EF_{PM10}$  = 0.017 lb/ton rock crushed  
 $AF$  = 104,000 tons rock crushed/yr  
 $C$  = 90%  
 $n$  = 2

$$E_{c,PM10} = EF_{PM10} * AF * (1 - (C - (5*n))/100) \quad (13.5-6)$$

$E_{c,PM10}$  = (0.017 lb/ton rock crushed)\*(104,000 tons rock crushed)\*(1-(90-(5\*2))/100)  
 $E_{c,PM10}$  = 353.6 lb/yr

## 5.5 COMPARISON OF THE DIFFERENT METHODS

The following summary compares the different examples with their different methods for estimating annual emissions of  $PM_{10}$  from only the screening process.

Emission Point	Estimate Using <i>AP-42</i> Guidance: Uncontrolled (lb/yr)	Estimate Using <i>AP-42</i> Guidance: Controlled (lb/yr)	Estimate Using San Diego APCD and TNRCC Guidance (lb/yr)	Estimate Using Wisconsin DNR Guidance (lb/yr)	Estimate Using Mojave Desert AQMD Guidance (lb/yr)
Screening	1,560	87.36	156	271.9	353.6

All of these estimates were based on 1,040 operating hours. If a control device was used, then a 90 percent control efficiency was chosen for comparison purposes. The San Diego APCD and TNRCC use *AP-42* default control efficiencies. The Wisconsin DNR weighs emission estimates heavily on satisfying recordkeeping requirements and having trained personnel on-site. The Mojave Desert AQMD developed its own factors and equations to estimate emissions. As the comparison indicates, depending on the method chosen, an emission estimate from screening operations for a controlled scenario can range from 87.36 to 353.6 lb/yr.

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# 6

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**VOLUME II: CHAPTER 14**

# **UNCONTROLLED EMISSION FACTOR LISTING FOR CRITERIA AIR POLLUTANTS**

**July 2001**



Prepared by:  
Eastern Research Group, Inc.

Prepared for:  
Point Sources Committee  
Emission Inventory Improvement Program

## **DISCLAIMER**

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

## DISCLAIMER

**Note:** The emission factors presented in this document were taken from the Factor Information Retrieval (FIRE) database management system, version 6.23. The information in this document is not intended to serve as new guidance or policy and does not take the place of *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, Fifth Edition, AP-42*.

## ACKNOWLEDGMENT

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# ABBREVIATIONS, ACRONYMS, AND SYMBOLS

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A	Ash content of fuel, by weight percent, or for fuel oil, specific factor
bbbl	Barrels
BOF	Basic Oxygen Furnace
CO	Carbon Monoxide
H.S.S.	Horizontal Stud Soderberg
Lb	Pound
LPG	Liquified Petroleum Gas
MMBtu/Yr	Million British Thermal Units per Year
NO <sub>x</sub>	Nitrogen Oxides
PM	Particulate Matter
RVP	Reid Vapor Pressure, the absolute pressure of gasoline at 100°C in psia as determined by ASTM Method D323-72
S	Sulfur content of fuel, by weight percent
SCC	Source Classification Code
SCFM	Standard Cubic Feet per Minute
SIC	Standard Industrial Classification
SO <sub>x</sub>	Sulfur Oxides
Sq. Ft.	Square Feet
tpy	tons per year
V.S.S.	Vertical Stud Soderberg
VOC	Volatile Organic Compounds
w/	with
w/o	without

# CONVERSION FACTORS

---

To Convert from	To	Multiply By
Barrel (bbl) - Petroleum*	Gallon (gal)	42
Barrel (bbl)	Liter (l)	159
Gallon (gal)	Liter (l)	3.785
Inch (in)	Centimeter (cm)	2.54
Feet (ft)	Meter (m)	0.3048
Square feet (ft <sup>2</sup> )	Square meter (m <sup>2</sup> )	0.0929
Cubic feet (ft <sup>3</sup> )	Cubic meter (m <sup>3</sup> )	0.0283
Cubic feet (ft <sup>3</sup> )	Liters (l)	28.316
Cubic feet/minute	Cubic centimeter/second	472.0
Cubic yard (yd <sup>3</sup> )	Cubic meter (m <sup>3</sup> )	0.77
Board foot	Cubic meter (m <sup>3</sup> )	0.0024
Btu	Gram/calorie (g/cal)	251.98
Pound steam/hour <sup>†</sup>	Btu/hour	1400.0
Btu/hour	Watt	0.293
Pound (lb)	Kilogram (kg)	0.45
Ton	Kilogram (kg)	907.1
Pound/ton (lb/ton)	Gram/kilogram (g/kg)	0.496

\* 42 gal/bbl is the standard as used in the oil industry. For other industries, different gallons/bbl apply.

† Typical value based on common boiler design parameters. Value will vary depending upon steam temperature and pressure.

# KEY TO EMISSION FACTOR LISTING

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1. An “A” accompanying an emission factor means that this factor is the weighted average ash content of the fuel burned, expressed as a percent. See, for example, SCC 1-01-001-01 on page 14.A-2. If the weighted average ash content of the pulverized anthracite coal burned were five percent (5%), then the  $PM_{10}$  emission factor would become  $2.3 \times 5$ , or 11.5 pounds, of  $PM_{10}$  emitted per ton of anthracite coal burned (before control).
2. An “S” accompanying an emission factor means that this factor is the weighted average sulfur content of the fuel burned, expressed as a percent. See, for example, SCC 1-01-004-01 on page 14.A-3. If the weighed average sulfur content of the Grade 6 oil burned were three percent (3%), then the  $SO_x$  emission factor would become  $157 \times 3$ , or 471 pounds of  $SO_x$  emitted per one thousand gallons of Grade 6 oil burned (before control).
3. The entry “---” means that, as yet, we have no emission factor for this SCC and pollutant combination. See, for example, SCC 1-01-002-17 on page 14.A-2.
4. PM, filterable refers to **all** filterable particulate matter of **all** sizes. PM, condensible refers to all condensible particulate matter of all sizes.  $PM_{10}$  refers only to particulate matter of aerodynamic diameter less than or equal to 10 micrometers.  $PM_{2.5}$  refers to particulate matter of aerodynamic diameter less than or equal to 2.5 micrometers.

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# 1

## INTRODUCTION

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The Clean Air Act directs the U.S. Environmental Protection Agency (EPA) to identify and set National Ambient Air Quality Standards (NAAQS) for the most common air pollutants. EPA uses these “criteria pollutants” as indicators of air quality. These pollutants are:

- Ozone (O<sub>3</sub>);
- Carbon monoxide (CO);
- Nitrogen oxides (NO<sub>x</sub>);
- Sulfur dioxide (SO<sub>2</sub>);
- Particulate matter with aerodynamic diameter less than or equal to 10 micrometers (PM<sub>10</sub>);
- Particulate matter with aerodynamic diameter less than or equal to 2.5 micrometers (PM<sub>2.5</sub>); and
- Lead (Pb).

In addition to these pollutants, EPA also regulates emissions of volatile organic compounds (VOC) under criteria pollutant programs. VOC are ozone precursors—they react with nitrogen oxides in the atmosphere to form ozone. VOC are emitted from motor vehicle fuel distribution, chemical manufacturing, and a wide variety of industrial, commercial, and consumer solvent uses.

EPA’s current regulatory definition of VOC (40 CFR § 51.100) exempts constituents considered to be negligibly photochemically reactive. These include: methane; ethane; methylene chloride; 1,1,1-trichloroethane (TCA); several Freon compounds; acetone; perchloroethylene; and others. It is anticipated that additional compounds may be exempted from this VOC definition. The exempt compounds are considered negligibly photochemically reactive, although some can influence the formation of ozone when present in sufficient amounts. If you encounter a situation where your emission estimation methodology includes emissions exempted from EPA’s definition of VOC, you should consult with your EPA Regional Office for guidance, and document exactly what compounds you are reporting as VOC.

## 1.1 HOW WILL THIS DOCUMENT HELP ME?

This document will help state, local, and tribal air pollution control agency personnel compile an inventory of criteria air pollutant emissions from stationary point sources using the emission factor estimation approach. The information contained in this document is intended to serve as a reference guide only, and is not intended to serve as new guidance or policy.

## 1.2 WHAT IS THE PURPOSE OF THIS DOCUMENT?

The purpose of this document is to provide uncontrolled emission factors from the Factor Information Retrieval (FIRE) database management system, version 6.23 to inventory preparers in an easy-to-use format. Data for only criteria air pollutants are included; this document does NOT provide emission factors for hazardous air pollutants nor does it take the place of *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, Fifth Edition, AP-42*.

## 1.3 WHAT ASSUMPTIONS WERE MADE IN PREPARING THIS DOCUMENT?

This document was prepared based on the following assumptions:

- That agency personnel using this document are experienced in developing emission inventories using the emission factor estimation approach;
- That inexperienced agency personnel have access to helpful technical information within their agency and have experienced staff available as technical resources;
- That agency personnel are familiar with EPA and Emission Inventory Improvement Program (EIIP) published procedures for compiling emission inventories; and
- That agency personnel who are not familiar with these published procedures have access to these guidance materials through the World Wide Web or other means.

For the inexperienced inventory preparer, please visit the following websites and review the emission inventory guidance materials.

- <http://www.epa.gov/ttn/chief/>
- <http://www.epa.gov/ttn/chief/eiip/>



One useful document found on the CHIEF website is *Handbook for Criteria Pollutant Inventory Development: A Beginner's Guide for Point and Area Sources*. This represents the EPA's most recent guidance on preparing criteria air pollutant inventories. The EIIP website has a series of emission inventory development guidance documents available for downloading as well. In fact, this document that you are reading is also available on the EIIP website. Most, if not all, of the documents available on the above listed websites are also available in hard copy from the National Technical Information Service (NTIS).

## 1.4 HOW WAS THIS DOCUMENT PREPARED?

All of the uncontrolled emission factors presented in this document were taken from the FIRE database management system, version 6.23. FIRE is a database management system containing EPA's recommended emission factors for criteria and hazardous air pollutants. In addition to emission factors, FIRE includes information about industries and their processes and the chemicals emitted. FIRE allows access to criteria and hazardous air pollutant emission factors obtained from *AP-42*, the *Locating and Estimating (L&E)* document series, and the retired AFSEF and XATEF documents. For those that want to access FIRE directly, you may download the database management system at <http://www.epa.gov/ttn/chief/>.

Users can browse through records in the database or can select specific emission factors by source classification code (SCC), by pollutant name or Chemical Abstract Services (CAS) registry number, or by control device type or code. SCCs are 8-digit codes used to categorize individual processes or unit operations which generate air emissions. A code may correspond to a particular boiler type, a process heater, a reactor vent, etc. A single boiler may have two or more SCCs if it burns more than one fuel oil. FIRE 6.23 contains all of the emission factors from *AP-42* through Supplement F (through September 30, 2000) of the Fifth Edition.

The criteria air pollutant emission factors from FIRE 6.23 were consolidated by SCC and major standard industrial classification (SIC) code. The SIC Codes categorize the U.S. economy by numbered segments. The nine major categories are: agriculture, forestry, and fishing; mining; construction; manufacturing; transportation, communications, and public utilities; wholesale trade; retail trade; finance, insurance, and real estate; and services. Each SCC represents a unique process or function within a source category logically associated with a point of air pollution emissions. Any operation that causes air pollution can be represented by one or more of these SCCs. Without an appropriate SCC, a process or operation cannot be properly identified and classified for accurate emissions estimations.

Because FIRE does not contain SIC codes, a database linking SIC codes to SCC codes was developed. This database was then used to associate each uncontrolled emission factor in FIRE with an SIC/SCC combination. For example, electric generating boilers (those whose SCCs beginning with 1-01 and 2-01) relate to SIC Code 4911, Electric Services, because they are

located in establishments engaged in the generation, transmission, and/or distribution of electric energy for sale.

This database was compiled using a multi-step process. In the first step, the established SIC/SCC combinations were obtained from the document *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*.

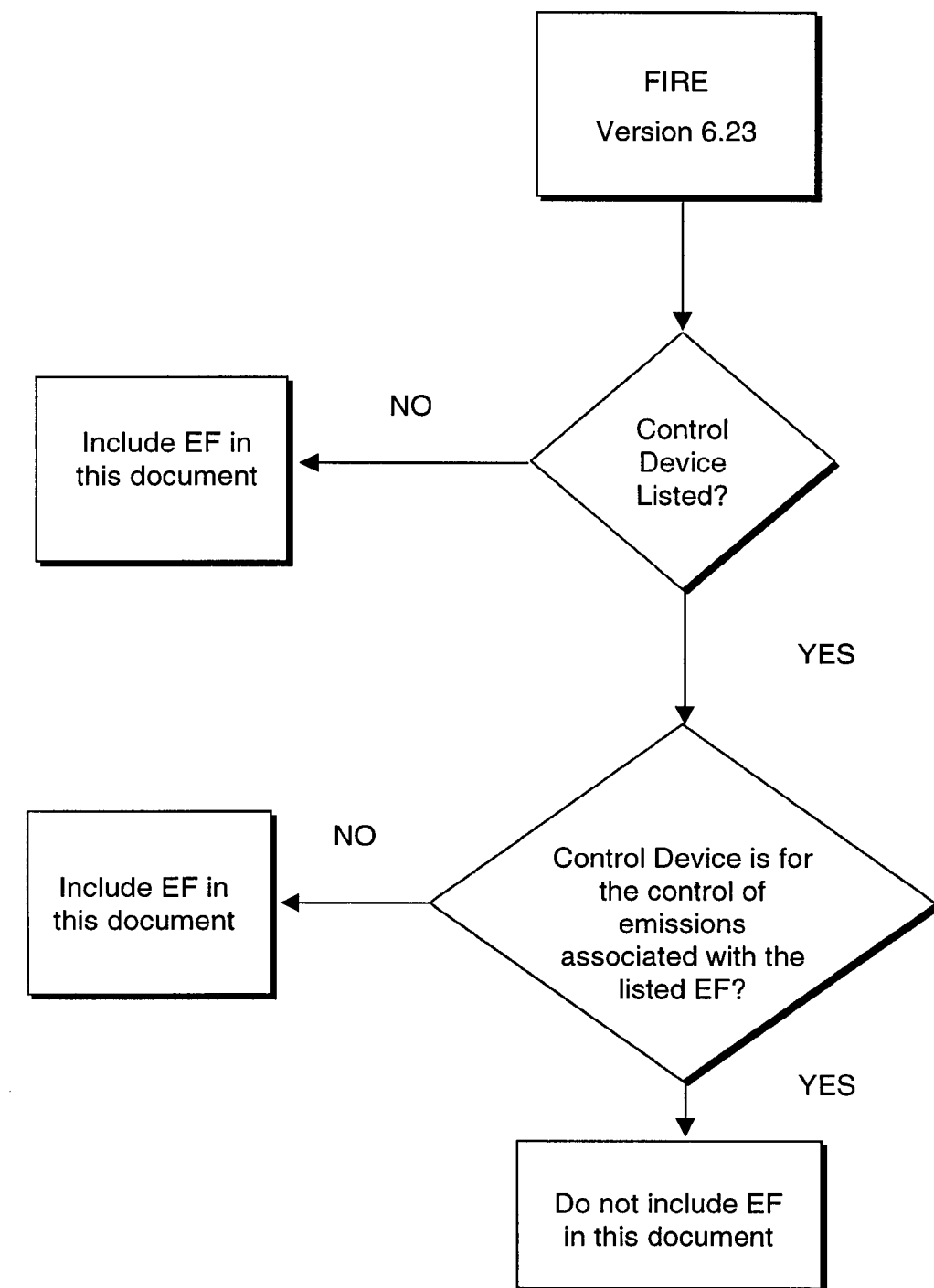
In the second step, the database was supplemented with SIC/SCC combinations that were included in the 1996 National Emissions Trends (NET) system. In the third step, SIC/SCC combinations were obtained from records in the 1996 National Toxics Inventory (NTI). Finally, for all other SCCs, a corresponding SIC code was identified using keyword searches based solely on the description of the SCC. In this last step, the following website was used to identify applicable SIC codes: <http://www.osha.gov/oshstats/sicser.html>.

The uncontrolled emission factors presented in this document were extracted from FIRE 6.23 following a two-step process as shown in Figure 14.1-1. In the first step, the emission factors listed in FIRE with no associated control device were identified and incorporated into this document. In the second step, emission factors with associated control device(s) in FIRE were analyzed further to determine whether the listed control device actually controls the associated pollutant, or whether the listed control device controls emissions of other pollutants from this same process. For example, in FIRE, emission factors for five pollutants emitted from a boiler equipped with a multicyclone appeared as controlled factors. However, in this case, the multicyclone only controls PM and Pb emissions, not CO, NO<sub>x</sub>, or VOC. Thus, the controlled emission factors for PM and Pb were omitted from this document, and the uncontrolled emission factors for CO, NO<sub>x</sub>, and VOC were incorporated.

## 1.5 HOW IS THIS DOCUMENT ORGANIZED?

This document is divided into two major parts. The main body consists of the supporting text and example calculations. The second part of this document contains the appendices that complement the main body.

- Appendix A contains the uncontrolled criteria pollutant emission factor listing.
- Appendix B contains the limited number of uncontrolled emission factors (from FIRE 6.23) for PM<sub>2.5</sub>.



**FIGURE 14.1-1. DECISION PROCESS FOR INCLUDING CRITERIA POLLUTANT EMISSION FACTORS**

- Appendix C contains SCCs for which more than one emission factor was available. Additional information is included to help the user decide which emission factor he/she should select for their particular situation.
- Appendix D contains six-digit SCCs with multiple SIC linkings.
- Appendix E contains a list of MACT Source Classification Codes.

## 1.6 HOW DO I USE THE INFORMATION IN THIS DOCUMENT?

The information presented in this document can be used to estimate emissions using the emission factor methodology approach. Figure 14.1-2 shows how to use the data contained in Appendix A, Uncontrolled Emission Factor Listing.

If no uncontrolled criteria pollutant emission factors are available for a particular SCC (see SCC 1-01-002-38), then the default SCC Unit Description is listed. The reader should note that there may be multiple unit descriptions.

Emission factors allow the development of generalized estimates of emissions from source categories or individual sources within a category. Emission factors, used extensively in point source inventories, estimate the rate at which a pollutant is released to the atmosphere as a result of some process activity. For example, the emission factor for NO<sub>x</sub> emissions from the combustion of anthracite coal is 9 pounds of NO<sub>x</sub> per 1 ton of coal burned (9 lb/ton). If you know the emission factor and the corresponding activity level for a process, you can estimate the emissions. In most cases, emission factors are expressed simply as a single number, with the underlying assumption that a linear relationship exists between emissions and the specified activity level over the probable range of application. The use of emission factors is straightforward when the relationship between process data and emissions is direct and relatively uncomplicated. Note, however, that emission factors may be developed assuming no control device is in place. These are referred to as “uncontrolled emission factors” and are what appear in this document. When emission factors are derived from data that were obtained from facilities with a control device in place, then emission factors are referred to as “controlled emission factors.” Controlled emission factors are not included in this document.

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM10 Lbs/Unit	<sup>5</sup> PM cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>External Combustion Boilers - Electric Generation</u>										
<u>Anthracite Coal - 4911</u>										
1-01-001-01	Pulverized Coal	10 A	2.3A	--	39 S	18	0.07	0.6	0.0089	Tons Burned
1-01-001-02	Traveling Grate (Overfeed) Stoker	0.8 A	4.8	0.08A	39 S	9	0.07	0.6	0.0089	Tons Burned
<u>Bituminous Coal - 4911</u>										
1-01-002-01	Pulverized Coal: Wet Bottom	7A	2.6 A	--	38 S	31		0.5	0.000507	footnote 12
1-01-002-02	Pulverized Coal: Dry Bottom	10 A	2.3 A	--	38 S	See App. C		0.5	0.000507	footnote 12
1-01-002-03	Cyclone Furnace	2 A	0.26 A	--	38 S	33		0.5	0.000507	footnote 12
1-01-002-04	Spreader Stoker	66	13.2	--	38 S	11		5	0.000507	footnote 12

**Unique SCC Code** (points to SCC 1-01-002-04)

**Source Category Process** (points to Process Name Spreader Stoker)

**Industry/Source Category** (points to SCC 1-01-002-04)

**Footnote which indicates important information** (points to footnote 12)

**4-Digit SIC Code** (points to SCC 1-01-002-04)

**Indicates more than one SCC-pollutant emission factor available. See Appendix C** (points to See App. C)

**Emission Factor** (points to 0.07 for SOx in row 1-01-001-01)

**Emission Factor not Available** (points to blank cell for VOC in row 1-01-002-01)

**Units of measure for the emission factor\*** (points to Tons Burned in row 1-01-001-01)

**Footnote in this column indicates multiple units of measure per SCC. See Appendix D** (points to footnote 12 in row 1-01-002-01)

\*If no uncontrolled criteria pollutant emission factors are available for a particular SCC (see SCC1-01-002-38), then the default SCC unit description is listed.

FIGURE 14.1-2. HOW TO INTERPRET THE DATA IN THIS DOCUMENT

Emission factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant. To calculate emissions using emission factors, three basic inputs to the estimation algorithm are required:

- Activity information for the process as specified by the relevant emission factor;
- An emission factor to translate activity information into uncontrolled or controlled emission estimates; and
- When applicable, information on capture and control efficiencies<sup>1</sup> of any control device when using an “uncontrolled” emission factor, such as those presented in this document.

**The basic emission estimation equation when using an uncontrolled emission factor is:**

$$E = A \times EF$$

where:

E	=	emission estimate for the process
A	=	activity level such as throughput
EF	=	emission factor assuming no control

---

<sup>1</sup> For a discussion about control device efficiencies, see EIIP Volume II: Point Sources Chapter 12, *How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates*.

**Example 1--Coal-fired Industrial Boiler**

This example illustrates the procedures to calculate emissions from an industrial boiler firing anthracite coal.

**Assumed Operating Parameters**

Coal type: Anthracite  
Annual coal consumption: 928,000 tons per year (tpy)  
Ash content of coal: 7 percent  
Sulfur content of coal: 1.87 percent

Particulate emissions are controlled with a 75 percent efficient cyclone.  
Sulfur oxide emissions are controlled with a 93 percent efficient limestone injection system. (Reference: EIIP Point Sources Committee. Volume II, Chapter 12, *How to Incorporate the Effects of Air Pollution Control Device Efficiencies and Malfunctions Into Emission Inventory Estimates*.)

Boiler Type: Traveling grate stoker (SCC 1-01-001-02)

**Emission Factors**

Appendix A, page A.2 provides emission factors for pollutants from anthracite coal combustion in stoker fired boilers:

Particulate matter (PM): = 0.8A lb/ton for PM where A is the ash content of coal in weight percent  
Lead (Pb): = 8.9E-03 lb/ton  
Nitrogen oxides (NO<sub>x</sub>): = 9 lb/ton  
Sulfur dioxide (SO<sub>2</sub>): = 39S lb/ton where S is the weight percent of sulfur in the coal  
Carbon monoxide (CO): = 0.6 lb/ton

**Example 1--Coal-fired Industrial Boiler (Continued)**Estimating Uncontrolled Emissions

The general equation for estimating uncontrolled emissions of Pb, NO<sub>x</sub>, and CO from anthracite coal combustion in boilers is as follows:

$$\text{Boiler Emissions} = \text{Annual Coal Consumption} \times \text{Emission Factor}$$

$$\text{Pb} = 928,000 \text{ tons/year} \times 8.9\text{E-}03 \text{ lb/ton} = 8,259 \text{ lb/year} = 4.1 \text{ tpy}$$

$$\text{NO}_x = 928,000 \text{ tons/year} \times 9 \text{ lb/ton} = 8,352,000 \text{ lb/year} = 4,176 \text{ tpy}$$

$$\text{CO} = 928,000 \text{ tons/year} \times 0.6 \text{ lb/ton} = 556,800 \text{ lb/year} = 278 \text{ tpy}$$

The general equation for estimating uncontrolled emissions of PM from anthracite coal combustion in boilers is as follows:

$$\text{PM Emissions} = \text{Annual Coal Consumption} \times (\text{Emission Factor} \times \text{Coal Ash Content})$$

$$\begin{aligned} \text{PM} &= 928,000 \text{ tons/year} \times (0.8 \text{ lb/ton} \times 7) = 5,196,800 \text{ lb/year} \\ &= 2,598 \text{ tpy} \end{aligned}$$

The general equation for estimating uncontrolled emissions of SO<sub>2</sub> from anthracite coal combustion in boilers is as follows:

$$\text{SO}_2 \text{ Emissions} = \text{Annual Coal Consumption} \times (\text{Emission Factor} \times \text{Coal Sulfur Content})$$

$$\begin{aligned} \text{SO}_2 &= 928,000 \text{ tons/year} \times (39 \text{ lb/ton} \times 1.87) = 67,679,040 \text{ lb/year} \\ &= 33,840 \text{ tpy} \end{aligned}$$



**Example 1--Coal-fired Industrial Boiler (Continued)**Estimating Controlled Emissions

Particulate emissions are controlled with a 75 percent efficient cyclone and SO<sub>2</sub> emissions are controlled with a 93 percent efficient limestone injection system. The general equation for estimating controlled emissions of PM and SO<sub>2</sub> is as follows:

$$\text{Controlled Emissions} = \text{Uncontrolled Emissions} \times (1 - \text{Control Efficiency}/100)$$

$$\text{PM} = 2,598 \text{ tpy} \times (1 - 75/100) = 2,598 \text{ tpy} \times (0.25) = 650 \text{ tpy}$$

$$\text{SO}_2 = 33,840 \text{ tpy} \times (1 - 93/100) = 33,840 \text{ tpy} \times (0.07) = 2,369 \text{ tpy}$$

**Example 2--Natural Gas And Number 6 Fuel Oil Fired Electric Generating Boiler Emissions**

This example illustrates the use of emission factors to estimate emissions from an electric generating non-tangential boiler with an overall heat input of 14 MMBtu per hour firing natural gas and Number 6 fuel oil. This boiler was constructed in 1990.

Assumed Operating Parameters*Natural Gas* (SCC 1-01-006-01)

Annual Consumption: 99,885 MMBtu/year

Heating Value: 1,032 Btu/scf

Usage: 81% of the time

*Number 6 Fuel Oil* (SCC 1-01-004-01)

Annual Consumption: 147,983 gal/year

Heating Value: 150,000 Btu/gal

Sulfur Content: 1 percent

Nitrogen Content: 0.4 percent

Usage: 19% of the time

Emission Factors

Appendix A, pages A-3 and A-4 provides emission factors for pollutants from electric generating boilers firing Number 6 fuel oil and natural gas, respectively.

*Natural Gas*

PM: 1.9 lb/10<sup>6</sup> scf of gas burned

SO<sub>x</sub> as SO<sub>2</sub>: 0.6 lb/10<sup>6</sup> scf of gas burned

NO<sub>x</sub>: 190 lb/10<sup>6</sup> scf of gas burned

CO: 84 lb/10<sup>6</sup> scf of gas burned

### Example 2--Natural Gas And Number 6 Fuel Oil Fired Electric Generating Boiler Emissions (Continued)

#### Number 6 Fuel Oil

All emission factors for Number 6 fuel oil are obtained from Appendix A on page A-8:

PM:  $[9.19(S) + 3.22]$  lb/10<sup>3</sup> gal burned where S is the weight percent of sulfur in the oil  
 PM emission factor =  $[9.19(1) + 3.22]$  lb/10<sup>3</sup> gal  
 = 12.41 lb/10<sup>3</sup> gal of oil burned

SO<sub>x</sub> as SO<sub>2</sub>: 157(S) lb/10<sup>3</sup> gal where S is the weight percent of sulfur in the oil  
 SO<sub>2</sub> emission factor = 157(1) = 157 lb/10<sup>3</sup> gal of oil burned

SO<sub>x</sub> as SO<sub>3</sub>\*: 2(S) lb/10<sup>3</sup> gal where S is the weight percent of sulfur in the oil  
 SO<sub>3</sub> emission factor = 2(1) = 2 lb/10<sup>3</sup> gal of oil burned

NO<sub>x</sub>: 47 lb/10<sup>3</sup> gal of oil burned

CO: 5 lb/10<sup>3</sup> gal of oil burned

#### Estimating Uncontrolled Emissions by Fuel Type

##### *Natural Gas*

The general equation for estimating natural gas consumption in scf/year is as follows:

$$\begin{aligned} \text{Annual Consumption} &= \frac{\text{Annual Heat Input}}{\text{Natural Gas Heating Value}} \\ &= \frac{99,885 \times 10^6 \text{ Btu/year}}{1,032 \text{ Btu/scf}} = 96.8 \times 10^6 \text{ scf/year} \end{aligned}$$

\* Refer to AP-42 Section 1.3 for SO<sub>3</sub> emission factors.

**Example 2--Natural Gas And Number 6 Fuel Oil Fired Electric Generating Boiler Emissions (Continued)**

The general equation for estimating uncontrolled emissions from natural gas combustion follows:

$$\text{Natural Gas Emissions} = \text{Annual Gas Consumption} \times \text{Emission Factor}$$

PM	=	96.8x10 <sup>6</sup> scf/year x 1.9 lb/10 <sup>6</sup> scf = 184 lb/year = 0.09 tpy
SO <sub>x</sub>	=	96.8x10 <sup>6</sup> scf/year x 0.6 lb/10 <sup>6</sup> scf = 58 lb/year = 0.03 tpy
NO <sub>x</sub>	=	96.8x10 <sup>6</sup> scf/year x 190 lb/10 <sup>6</sup> scf = 18,392 lb/year = 9.2 tpy
CO	=	96.8x10 <sup>6</sup> scf/year x 84 lb/10 <sup>6</sup> scf = 8,131 lb/year = 4.07 tpy

*Number 6 Fuel Oil*

The general equation for estimating uncontrolled emissions from Number 6 fuel oil combustion in an industrial boiler is as follows:

$$\text{Number 6 Fuel Oil Emissions} = \text{Annual Fuel Oil Consumption} \times \text{Emission Factor}$$

PM	=	147,983 gal/year x 12.41 lb/10 <sup>3</sup> gal = 1,836 lb/year = 0.92 tpy
SO <sub>x</sub> as SO <sub>2</sub>	=	147,983 gal/year x 157 lb/10 <sup>3</sup> gal = 23,233 lb/year = 11.6 tpy
SO <sub>x</sub> as SO <sub>3</sub>	=	147,983 gal/year x 2 lb/10 <sup>3</sup> gal = 296 lb/year = 0.15 tpy
NO <sub>x</sub> as NO <sub>2</sub>	=	147,983 gal/year x 47 lb/10 <sup>3</sup> gal = 6,955 lb/year = 3.5 tpy
CO	=	147,983 gal/year x 5 lb/10 <sup>3</sup> gal = 740 lb/year = 0.37 tpy

Total SO<sub>x</sub> emissions from the combustion of Number 6 fuel oil is given by the following equation:

$$\text{SO}_x \text{ Emissions} = \text{SO}_2 \text{ emissions} + \text{SO}_3 \text{ emissions} = 11.6 + 0.15 = 11.75 \text{ tpy}$$

**Example 2--Natural Gas And Number 6 Fuel Oil Fired Electric Generating Boiler Emissions (Continued)**Estimating Total Uncontrolled Emissions

Total Emissions = Natural Gas Emissions + Number 6 Fuel Oil Emissions

Total PM = 0.09 tpy + 0.92 tpy = 1.01 tpy  
Total SO<sub>x</sub> = 0.03 tpy + 11.75 tpy = 11.78 tpy  
Total NO<sub>x</sub> = 9.2 tpy + 3.5 tpy = 12.7 tpy  
Total CO = 4.07 tpy + 0.37 tpy = 4.44 tpy

## **1.7 WHOM DO I CONTACT FOR HELP?**

### **Emission Factors**

Comments, questions, or requests for assistance should be addressed to:

InfoCHIEF Hotline  
Phone: (919) 541-1000 or  
E-mail: [info.chief@epa.gov](mailto:info.chief@epa.gov)

### **Source Classification Codes**

Comments, questions, or requests for assistance should be addressed to:

Roy Huntley  
U.S. Environmental Protection Agency  
Emission Factor and Inventory Group  
Phone: (919) 541-1060  
E-mail: [huntley.roy@epa.gov](mailto:huntley.roy@epa.gov)

# 2

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EPA. 1990. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina.

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# **APPENDIX A**

## **UNCONTROLLED EMISSION FACTOR LISTING**

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## KEY TO EMISSION FACTOR LISTING

1. An “A” accompanying an emission factor means that this factor is the weighted average ash content of the fuel burned, expressed as a percent. See, for example, SCC 1-01-001-01 on page 14.A-2. If the weighted average ash content of the pulverized anthracite coal burned were five percent (5%), then the  $PM_{10}$  emission factor would become  $2.3 \times 5$ , or 11.5 pounds, of  $PM_{10}$  emitted per ton of anthracite coal burned (before control).
2. An “S” accompanying an emission factor means that this factor is the weighted average sulfur content of the fuel burned, expressed as a percent. See, for example, SCC 1-01-004-01 on page 14.A-3. If the weighed average sulfur content of the Grade 6 oil burned were three percent (3%), then the  $SO_x$  emission factor would become  $157 \times 3$ , or 471 pounds of  $SO_x$  emitted per one thousand gallons of Grade 6 oil burned (before control).
3. The entry “---” means that, as yet, we have no emission factor for this SCC and pollutant combination. See, for example, SCC 1-01-002-17 on page 14.A-2.
4. PM, filterable refers to all filterable particulate matter of **all** sizes. PM, condensible refers to all condensible particulate matter of all sizes.  $PM_{10}$  refers only to particulate matter of aerodynamic diameter less than or equal to 10 micrometers.  $PM_{2.5}$  refers to particulate matter of aerodynamic diameter less than or equal to 2.5 micrometers.

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
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## **EXTERNAL COMBUSTION BOILERS**

### **EXTERNAL COMBUSTION BOILERS -Electric Generation**

#### **Anthracite Coal - 4911**

1-01-001-01	Pulverized Coal	10A	2.3A	---	39S	18	0.07	0.6	0.0089	Tons Burned
1-01-001-02	Traveling Grate (Overfeed) Stoker	0.8A	4.8	0.08A	39S	9	0.07	0.6	0.0089	Tons Burned

#### **Bituminous Coal - 4911**

1-01-002-01	Pulverized Coal: Wet Bottom	7A	2.6A	---	38S	31	---	0.5	0.000507	Footnote 12
1-01-002-02	Pulverized Coal: Dry Bottom	10A	2.3A	---	38S	See App. C	---	0.5	0.000507	Footnote 12
1-01-002-03	Cyclone Furnace	2A	0.26A	---	38S	33	---	0.5	0.000507	Footnote 12
1-01-002-04	Spreader Stoker	66	13.2	---	38S	11	---	5	0.000507	Footnote 12
1-01-002-05	Traveling Grate (Overfeed) Stoker	16	6	---	38S	7.5	---	6	0.000507	Footnote 12
1-01-002-11	Wet Bottom (Tangential)	---	---	---	38S	14	---	0.5	---	Tons Burned
1-01-002-12	Pulverized Coal: Dry Bottom (Tangential)	10A	2.3A	---	38S	See App. C	---	0.5	---	Tons Burned
1-01-002-15	Cell Burner	---	---	---	38S	31	---	0.5	---	Tons Burned
1-01-002-17	Atmospheric Fluidized Bed Combustion: Bubbling Bed	17	12.4	---	Footnote 13	15.2	---	18	---	Tons Burned
1-01-002-18	Atmospheric Fluidized Bed Combustion: Circulating Bed	17	12.4	---	Footnote 13	5	---	18	---	Tons Burned

#### **Subbituminous Coal - 4911**

1-01-002-21	Pulverized Coal: Wet Bottom	7A	2.6A	---	35S	24	---	0.5	0.000507	Footnote 14
1-01-002-22	Pulverized Coal: Dry Bottom	10A	2.3A	---	35S	See App. C	---	0.5	0.000507	Footnote 14
1-01-002-23	Cyclone Furnace	2A	0.26A	---	35S	17	---	0.5	0.000507	Footnote 14
1-01-002-24	Spreader Stoker	66	13.2	---	35S	8.8	---	5	0.000507	Footnote 14
1-01-002-25	Traveling Grate (Overfeed) Stoker	16	6	---	35S	7.5	---	6	0.000507	Footnote 14
1-01-002-26	Pulverized Coal: Dry Bottom Tangential	10A	2.3A	---	35S	See App. C	---	0.5	---	Tons Burned
1-01-002-35	Cell Burner	---	---	---	35S	14	---	0.5	---	Tons Burned
1-01-002-38	Atmospheric Fluidized Bed Combustion - Circulating Bed	---	---	---	---	---	---	---	---	Tons Burned

#### **Lignite - 4911**

1-01-003-00	Pulverized Coal: Wet Bottom	---	---	---	---	---	---	---	---	Tons Burned
1-01-003-01	Pulverized Coal: Dry Bottom, Wall Fired	<sup>15</sup> 5.2A	<sup>16</sup> 0.79*(2.3A)	---	<sup>17</sup> 30S	See App. C	---	0.25	---	Tons Burned
1-01-003-02	Pulverized Coal: Dry Bottom, Tangential Fired	<sup>15</sup> 6.5A	<sup>15</sup> 2.3A	---	<sup>17</sup> 30S	7.1	---	0.6	---	Tons Burned
1-01-003-03	Cyclone Furnace	<sup>15</sup> 6.7A	---	---	<sup>17</sup> 30S	15	---	0.6	---	Tons Burned
1-01-003-04	Traveling Grate (Overfeed) Stoker	<sup>15</sup> 3.4A	---	0.04	<sup>17</sup> 30S	6	---	6	---	Footnote 18

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Lignite - 4911</u>										
1-01-003-06	Spreader Stoker	<sup>15</sup> 8A	<sup>15</sup> 1.6A	0.04	<sup>17</sup> 30S	5.8	---	5	---	Footnote 18
1-01-003-16	Atmospheric Fluidized Bed (See 101003-17 & -18)	---	---	---	<sup>19</sup> 10S	3.6	---	0.15	---	Tons Burned
1-01-003-17	Atmospheric Fluidized Bed Combustion - Bubbling Bed	---	---	---	<sup>17</sup> 10S	3.6	---	---	---	Tons Burned
1-01-003-18	Atmospheric Fluidized Bed Combustion - Circulating Bed	---	---	---	---	3.6	---	0.15	---	Tons Burned
<u>Residual Oil - 4911</u>										
1-01-004-01	Grade 6 Oil: Normal Firing	<sup>20</sup> 9.19S + 3.22	<sup>20</sup> 6.61S + 2.18	1.5	<sup>21</sup> 157S	47	---	5	0.00151	1000 Gallons Burned
1-01-004-04	Grade 6 Oil: Tangential Firing	<sup>20</sup> 9.19S + 3.22	<sup>20</sup> 6.61S + 2.18	1.5	<sup>21</sup> 157S	32	---	5	0.00151	1000 Gallons Burned
1-01-004-05	Grade 5 Oil: Normal Firing	10	<sup>22</sup> 5.9A	---	<sup>21</sup> 157S	47	---	5	0.0024	1000 Gallons Burned
1-01-004-06	Grade 5 Oil: Tangential Firing	10	<sup>22</sup> 5.9A	---	<sup>21</sup> 157S	32	---	5	---	1000 Gallons Burned
<u>Distillate Oil - 4911</u>										
1-01-005-01	Grades 1 and 2 Oil	2	1	1.3	143.6S	24	0.2	5	0.000009	Footnote 23
1-01-005-04	Grade 4 Oil: Normal Firing	7	<sup>22</sup> 5.9A	---	<sup>21</sup> 150S	47	---	5	---	Footnote 24
1-01-005-05	Grade 4 Oil: Tangential Firing	7	5	---	<sup>21</sup> 150S	32	---	5	---	Footnote 24
<u>Natural Gas - 4911</u>										
1-01-006-01	Boilers > 100 Million Btu/hr except Tangential	1.9	---	5.7	<sup>21</sup> 0.6	See App. C	5.5	84	0.0005	Million Cubic Feet Burned
1-01-006-02	Boilers < 100 Million Btu/hr except Tangential	1.9	---	5.7	<sup>21</sup> 0.6	100	5.5	84	0.0005	Million Cubic Feet Burned
1-01-006-04	Tangentially Fired Units	1.9	---	5.7	<sup>21</sup> 0.6	170	5.5	24	0.0005	Million Cubic Feet Burned
<u>Process Gas - 4911</u>										
1-01-007-01	Boilers > 100 Million Btu/hr	3	3	---	950S	280	5.5	84	---	Million Cubic Feet Burned
1-01-007-02	Boilers < 100 Million Btu/hr	3	3	---	950S	100	6	84	---	Million Cubic Feet Burned
<u>Coke - 4911</u>										
1-01-008-01	All Boiler Sizes	10A	7.9A	---	39S	21	0.07	0.6	---	Tons Burned
<u>Wood/Bark Waste - 4911</u>										
1-01-009-01	Bark-fired Boiler	47	17	---	---	---	---	---	0.0029	Footnote 25
1-01-009-02	Wood/Bark Fired Boiler	7.2	6.5	---	---	---	---	---	---	Tons Burned
1-01-009-03	Wood-fired Boiler	8.8	---	---	---	---	---	---	---	Tons Burned
1-01-009-10	Fuel cell/Dutch oven boilers	---	---	---	0.075	0.38	---	6.6	---	Tons Burned
1-01-009-11	Stoker boilers	---	---	---	0.075	1.5	---	13.6	---	Tons Burned
1-01-009-12	Fluidized bed combustion boilers	---	---	---	0.075	2	---	1.4	---	Tons Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Liquified Petroleum Gas (LPG) - 4911</u>										
1-01-010-01	Butane	0.6	0.6	---	<sup>26</sup> 0.095s	21	0.26	3.6	---	1000 Gallons Burned
1-01-010-02	Propane	0.6	0.6	---	<sup>26</sup> 0.095s	19	0.25	3.2	---	1000 Gallons Burned
1-01-010-03	Butane/Propane Mixture: Specify Percent Butane in Comments	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>Bagasse - 4911</u>										
1-01-011-01	All Boiler Sizes	15.6	---	---	---	1.2	---	---	---	Tons Burned
<u>Solid Waste - 4911</u>										
1-01-012-01	Specify Waste Material in Comments	---	---	---	---	---	---	<sup>27</sup> 0.0165	0.265	Footnote 28
1-01-012-02	Refuse Derived Fuel	80	---	---	1.7	5	---	3.6	---	Tons Burned
<u>Liquid Waste - 4911</u>										
1-01-013-01	Specify Waste Material in Comments	---	---	---	---	---	1	---	---	1000 Gallons Burned
1-01-013-02	Waste Oil	61A	51A	---	147S	19	1	5	2.2	1000 Gallons Burned
<u>Geothermal Power Plants - 4961</u>										
1-01-015-01	Geothermal Power Plant: Off-gas Ejectors	---	---	---	---	---	---	---	---	Megawatt-Hour Produced
1-01-015-02	Geothermal Power Plant: Cooling Tower Exhaust	---	---	---	---	---	---	---	---	Megawatt-Hour Produced
<u>EXTERNAL COMBUSTION BOILERS -Industrial</u>										
<u>Anthracite Coal - 1000-3999</u>										
1-02-001-01	Pulverized Coal	10A	2.3A	---	39S	18	0.07	0.6	0.0089	Tons Burned
1-02-001-04	Traveling Grate (Overfeed) Stoker	0.8A	4.8	0.08A	39S	9	0.07	0.6	0.0089	Tons Burned
1-02-001-07	Hand-fired	10	5.2	---	39S	3	10	90	0.0089	Tons Burned
1-02-001-17	Fluidized Bed Boiler Burning Anthracite-Culm Fuel	---	---	---	<sup>21</sup> 2.9	1.8	---	0.3	---	Tons Burned
<u>Bituminous Coal - 1000-3999</u>										
1-02-002-01	Pulverized Coal: Wet Bottom	7A	2.6A	---	38S	31	---	0.5	0.000507	Footnote 12
1-02-002-02	Pulverized Coal: Dry Bottom	10A	2.3A	---	38S	See App. C	---	0.5	---	Tons Burned
1-02-002-03	Cyclone Furnace	2A	0.26A	---	38S	33	---	0.5	0.000507	Footnote 12
1-02-002-04	Spreader Stoker	66	13.2	---	38S	11	---	5	0.000507	Footnote 12
1-02-002-05	Overfeed Stoker	16	6	---	38S	7.5	---	6	0.000507	Footnote 12
1-02-002-06	Underfeed Stoker	15	---	---	31S	9.5	---	11	0.000507	Footnote 12
1-02-002-10	Overfeed Stoker	16	---	---	39S	7.5	0.07	6	0.0133	Tons Burned
1-02-002-12	Pulverized Coal: Dry Bottom (Tangential)	10A	2.3A	---	38S	See App. C	---	0.5	---	Tons Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Bituminous Coal - 1000-3999</i></u>										
1-02-002-13	Wet Slurry	---	---	---	---	---	---	---	---	Tons Burned
1-02-002-17	Atmospheric Fluidized Bed Combustion: Bubbling Bed	17	12.4	---	Footnote 13	15.2	---	18	---	Tons Burned
1-02-002-18	Atmospheric Fluidized Bed Combustion: Circulating Bed	17	12.4	---	Footnote 13	5	---	18	---	Tons Burned
1-02-002-19	Cogeneration	10A	2.3A	---	39S	15	0.07	0.6	---	Tons Burned
<u><i>Subbituminous Coal - 1000-3999</i></u>										
1-02-002-21	Pulverized Coal: Wet Bottom	7A	2.6A	---	35S	24	---	0.5	0.000507	Footnote 14
1-02-002-22	Pulverized Coal: Dry Bottom	10A	2.3A	---	35S	See App. C	---	0.5	0.000507	Footnote 14
1-02-002-23	Cyclone Furnace	2A	0.26A	---	35S	17	---	0.5	0.000507	Footnote 14
1-02-002-24	Spreader Stoker	66	13.2	---	35S	8.8	---	5	0.000507	Footnote 14
1-02-002-25	Traveling Grate (Overfeed) Stoker	16	6	---	35S	7.5	---	6	0.000507	Footnote 14
1-02-002-26	Pulverized Coal: Dry Bottom Tangential	10A	---	---	35S	See App. C	---	0.5	---	Tons Burned
1-02-002-29	Cogeneration	10A	2.3A	---	35S	14.4	0.06	0.6	---	Tons Burned
<u><i>Lignite - 1000-3999</i></u>										
1-02-003-00	Pulverized Coal: Wet Bottom	---	---	---	---	---	---	---	---	Tons Burned
1-02-003-01	Pulverized Coal: Dry Bottom, Wall Fired	---	---	---	30S	---	0.07	---	---	Tons Burned
1-02-003-02	Pulverized Coal: Dry Bottom, Tangential Fired	---	---	---	30S	---	0.07	0.6	---	Tons Burned
1-02-003-03	Cyclone Furnace	6.7A	0.87A	---	30S	---	0.07	0.6	---	Tons Burned
1-02-003-04	Traveling Grate (Overfeed) Stoker	---	1.07A	0.04	30S	6	0.07	6	---	Footnote 18
1-02-003-06	Spreader Stoker	---	---	0.04	30S	---	0.07	5	---	Footnote 18
1-02-003-07	Cogeneration	6.5A	2.3A	---	30S	7.3	0.07	0.6	---	Tons Burned
<u><i>Residual Oil - 1000-3999</i></u>										
1-02-004-01	Grade 6 Oil	<sup>20</sup> 9.19S + 3.22	<sup>22</sup> 7.17A	1.5	<sup>21</sup> 157S	47	---	5	---	1000 Gallons Burned
1-02-004-02	10-100 Million Btu/hr	<sup>22</sup> 8.34A	<sup>22</sup> 7.17A	---	<sup>21</sup> 157S	55	---	5	---	1000 Gallons Burned
1-02-004-03	< 10 Million Btu/hr	<sup>22</sup> 8.34A	<sup>22</sup> 7.17A	---	<sup>21</sup> 157S	55	---	5	---	1000 Gallons Burned
1-02-004-04	Grade 5 Oil	10	8.6	---	<sup>21</sup> 157S	47	---	5	---	1000 Gallons Burned
1-02-004-05	Cogeneration	<sup>20</sup> 9.19S + 3.22	<sup>20</sup> 7.9S + 2.77	---	158.6S	55	0.28	5	---	1000 Gallons Burned
<u><i>Distillate Oil - 1000-3999</i></u>										
1-02-005-01	Grades 1 and 2 Oil	2	1	1.3	<sup>21</sup> 142S	24	---	5	0.000009	Footnote 23
1-02-005-02	10-100 Million Btu/hr	2	1	---	<sup>21</sup> 142S	20	---	5	---	1000 Gallons Burned
1-02-005-03	< 10 Million Btu/hr	2	1	---	<sup>21</sup> 142S	20	---	5	---	1000 Gallons Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Distillate Oil - 1000-3999</u>										
1-02-005-04	Grade 4 Oil	7	6	---	<sup>21</sup> 150S	47	---	5	---	Footnote 24
1-02-005-05	Cogeneration	2	1	---	143.6S	20	0.2	5	---	1000 Gallons Burned
<u>Natural Gas - 1000-3999</u>										
1-02-006-01	> 100 Million Btu/hr	1.9	---	5.7	<sup>21</sup> 0.6	See App. C	5.5	84	0.0005	Million Cubic Feet Burned
1-02-006-02	10-100 Million Btu/hr	1.9	---	5.7	<sup>21</sup> 0.6	100	5.5	84	0.0005	Million Cubic Feet Burned
1-02-006-03	< 10 Million Btu/hr	1.9	---	5.7	0.6	100	5.5	84	---	Million Cubic Feet Burned
1-02-006-04	Cogeneration	1.9	---	5.7	<sup>21</sup> 0.6	170	5.5	24	---	Million Cubic Feet Burned
<u>Process Gas - 1000-3999</u>										
1-02-007-01	Petroleum Refinery Gas	3	3	---	950S	140	2.8	35	---	Million Cubic Feet Burned
1-02-007-04	Blast Furnace Gas	2.9	2.9	---	950S	23	---	13.7	---	Million Cubic Feet Burned
1-02-007-07	Coke Oven Gas	6.2	4.35	---	680S	80	1.2	18.4	---	Million Cubic Feet Burned
1-02-007-10	Cogeneration	---	---	---	---	---	2.8	---	---	Million Cubic Feet Burned
1-02-007-99	Other: Specify in Comments	---	---	---	---	---	---	---	0.00000666	Million Btus Input
<u>Coke - 1000-3999</u>										
1-02-008-02	All Boiler Sizes	7A	5.5A	---	39S	14	0.07	0.6	---	Tons Burned
1-02-008-04	Cogeneration	7A	5.5A	---	39S	14	0.07	0.6	---	Tons Burned
<u>Wood/Bark Waste - 1000-3999</u>										
1-02-009-01	Bark-fired Boiler (> 50,000 Lb Steam)	47	17	---	---	---	---	---	0.0029	Footnote 25
1-02-009-02	Wood/Bark-fired Boiler (> 50,000 Lb Steam)	7.2	6.5	---	---	---	---	---	---	Tons Burned
1-02-009-03	Wood-fired Boiler (> 50,000 Lb Steam)	8.8	---	---	---	---	---	---	---	Tons Burned
1-02-009-04	Bark-fired Boiler (< 50,000 Lb Steam)	47	17	---	---	---	---	---	0.0029	Footnote 25
1-02-009-05	Wood/Bark-fired Boiler (< 50,000 Lb Steam)	7.2	6.5	---	---	---	---	---	---	Tons Burned
1-02-009-06	Wood-fired Boiler (< 50,000 Lb Steam)	8.8	---	---	---	---	---	---	---	Tons Burned
1-02-009-07	Wood Cogeneration	---	---	---	---	---	---	---	---	Tons Burned
1-02-009-10	Fuel cell/Dutch oven boilers	---	---	---	0.075	0.38	---	6.6	---	Tons Burned
1-02-009-11	Stoker boilers	---	---	---	0.075	1.5	---	13.6	---	Tons Burned
1-02-009-12	Fluidized bed combustion boiler	---	---	---	0.075	2	---	1.4	---	Tons Burned
<u>Liquified Petroleum Gas (LPG) - 1000-3999</u>										
1-02-010-01	Butane	0.6	0.6	---	<sup>21, 26</sup> 0.09s	21	---	3.6	---	1000 Gallons Burned
1-02-010-02	Propane	0.6	0.6	---	<sup>21, 26</sup> 0.1s	19	---	3.2	---	1000 Gallons Burned



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Liquefied Petroleum Gas (LPG) - 1000-3999</i></u>										
1-02-010-03	Butane/Propane Mixture: Specify Percent Butane in Comments	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u><i>Bagasse - 1000-3999</i></u>										
1-02-011-01	All Boiler Sizes	15.6	---	---	---	1.2	---	---	---	Tons Burned
<u><i>Solid Waste - 1000-3999</i></u>										
1-02-012-01	Specify Waste Material in Comments	---	---	---	1.6	5.9	2	---	---	Tons Burned
1-02-012-02	Refuse Derived Fuel	80	44	---	1.7	5	---	3.6	0.13	Tons Burned
<u><i>Liquid Waste - 1000-3999</i></u>										
1-02-013-01	Specify Waste Material in Comments	---	---	---	28	23	1	---	---	1000 Gallons Burned
1-02-013-02	Waste Oil	61A	51A	---	147S	19	---	5	2.2	1000 Gallons Burned
<u><i>CO Boiler - 1000-3999</i></u>										
1-02-014-01	Natural Gas	13.7	13.7	---	0.6	140	2.8	35	---	Million Cubic Feet Burned
1-02-014-02	Process Gas	13.7	13.7	---	950S	140	2.8	35	---	Footnote 29
1-02-014-03	Distillate Oil	2	1	---	143.6S	20	0.2	5	---	1000 Gallons Burned
1-02-014-04	Residual Oil	<sup>20</sup> 9.19S + 3.22	<sup>20</sup> 7.9S + 2.77	---	158.6S	55	0.28	5	---	1000 Gallons Burned
<u><i>Methanol - 2861, 2869</i></u>										
1-02-016-01	Industrial Boiler	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u><i>Gasoline - 2512, 2865, 2911, 3021, 3331, 3761, 3764, 9711</i></u>										
1-02-017-01	Industrial Boiler	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u><i>EXTERNAL COMBUSTION BOILERS -Commercial/Institutional</i></u>										
<u><i>Anthracite Coal - 4000-4899, 4920-9999</i></u>										
1-03-001-01	Pulverized Coal	10A	2.3A	---	39S	18	0.07	0.6	0.0089	Tons Burned
1-03-001-02	Traveling Grate (Overfeed) Stoker	0.8A	4.8	0.08A	39S	9	0.07	0.6	0.0089	Tons Burned
1-03-001-03	Hand-fired	10	5.2	---	39S	3	10	90	0.0089	Tons Burned
<u><i>Bituminous Coal - 4000-4899, 4920-9999</i></u>										
1-03-002-03	Cyclone Furnace (Bituminous Coal)	2A	0.26A	---	38S	33	---	0.5	0.000507	Footnote 12
1-03-002-05	Pulverized Coal: Wet Bottom	7A	2.6A	---	38S	31	---	0.5	0.000507	Footnote 12
1-03-002-06	Pulverized Coal: Dry Bottom	10A	2.3A	---	38S	See App. C	---	0.5	0.000507	Footnote 12
1-03-002-07	Overfeed Stoker	16	6	---	38S	7.5	---	6	0.000507	Footnote 12

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Bituminous Coal - 4000-4899, 4920-9999</i></u>										
1-03-002-08	Underfeed Stoker	15	6.2	---	31S	9.5	---	11	---	Tons Burned
1-03-002-09	Spreader Stoker	66	13.2	---	38S	11	---	5	0.000507	Footnote 12
1-03-002-11	Overfeed Stoker	16	---	---	39S	7.5	0.07	6	---	Tons Burned
1-03-002-14	Hand-fired	15	---	---	31S	9.1	---	275	---	Tons Burned
1-03-002-16	Pulverized Coal: Dry Bottom (Tangential)	10A	2.3A	---	38S	See App. C	---	0.5	---	Tons Burned
1-03-002-17	Atmospheric Fluidized Bed Combustion: Bubbling Bed	17	12.4	---	Footnote 13	15.2	---	18	---	Tons Burned
1-03-002-18	Atmospheric Fluidized Bed Combustion: Circulating Bed	17	12.4	---	Footnote 13	5	---	18	---	Tons Burned
<u><i>Subbituminous Coal - 4000-4899, 4920-9999</i></u>										
1-03-002-21	Pulverized Coal: Wet Bottom	7A	2.6A	---	35S	24	---	0.5	0.000507	Footnote 14
1-03-002-22	Pulverized Coal: Dry Bottom	10A	2.3A	---	35S	See App. C	---	0.5	0.000507	Footnote 14
1-03-002-23	Cyclone Furnace	2A	0.26A	---	35S	17	---	0.5	0.000507	Footnote 14
1-03-002-24	Spreader Stoker	66	13.2	---	35S	8.8	---	5	0.000507	Footnote 14
1-03-002-25	Traveling Grate (Overfeed) Stoker	16	6	---	35S	7.5	---	6	0.000507	Footnote 14
1-03-002-26	Pulverized Coal: Dry Bottom Tangential	10A	2.3A	---	35S	See App. C	---	0.5	---	Tons Burned
<u><i>Lignite - 4000-4899, 4920-9999</i></u>										
1-03-003-00	Pulverized Coal: Wet Bottom	---	---	---	---	---	---	---	---	Tons Burned
1-03-003-05	Pulverized Coal: Dry Bottom, Wall Fired	---	---	---	30S	---	0.07	---	---	Tons Burned
1-03-003-06	Pulverized Coal: Dry Bottom, Tangential Fired	---	---	---	30S	---	0.07	0.6	---	Tons Burned
1-03-003-07	Traveling Grate (Overfeed) Stoker	---	1.07A	0.04	30S	6	0.07	6	---	Footnote 18
1-03-003-09	Spreader Stoker	---	---	0.04	30S	---	0.07	5	---	Footnote 18
<u><i>Residual Oil - 4000-4899, 4920-9999</i></u>										
1-03-004-01	Grade 6 Oil	<sup>20</sup> 9.19S + 3.22	<sup>22</sup> 5.17A	1.5	<sup>21</sup> 157S	47	---	5	---	1000 Gallons Burned
1-03-004-02	10-100 Million Btu/hr	10	<sup>22</sup> 5.17A	---	<sup>21</sup> 157S	55	---	5	---	1000 Gallons Burned
1-03-004-03	< 10 Million Btu/hr	10	<sup>22</sup> 5.17A	---	<sup>21</sup> 157S	55	---	5	---	1000 Gallons Burned
1-03-004-04	Grade 5 Oil	<sup>20</sup> 9.19S + 3.22	6.2	---	<sup>21</sup> 157S	55	---	5	---	1000 Gallons Burned
<u><i>Distillate Oil - 4000-4899, 4920-9999</i></u>										
1-03-005-01	Grades 1 and 2 Oil	2	1.08	1.3	<sup>21</sup> 142S	24	---	5	0.000009	Footnote 23
1-03-005-02	10-100 Million Btu/hr	2	1.08	---	<sup>21</sup> 142S	20	---	5	---	1000 Gallons Burned
1-03-005-03	< 10 Million Btu/hr	2	1.08	---	<sup>21</sup> 142S	20	---	5	---	1000 Gallons Burned
1-03-005-04	Grade 4 Oil	7	1.08	---	<sup>21</sup> 150S	20	---	5	---	1000 Gallons Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Natural Gas - 4000-4899, 4920-9999</i></u>										
1-03-006-01	> 100 Million Btu/hr	1.9	---	5.7	<sup>21</sup> 0.6	See App. C	5.5	84	0.0005	Million Cubic Feet Burned
1-03-006-02	10-100 Million Btu/hr	1.9	---	5.7	<sup>21</sup> 0.6	100	5.5	84	0.0005	Million Cubic Feet Burned
1-03-006-03	< 10 Million Btu/hr	1.9	---	5.7	<sup>21</sup> 0.6	100	5.5	84	0.0005	Million Cubic Feet Burned
<u><i>Process Gas - 4000-4899, 4920-9999</i></u>										
1-03-007-01	POTW Digester Gas-fired Boiler	---	---	---	4.5	---	3	---	---	Million Cubic Feet Burned
1-03-007-99	Other Not Classified	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
<u><i>Landfill Gas - 4000-4899, 4920-9999</i></u>										
1-03-008-11	Landfill Gas	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
<u><i>Wood/Bark Waste - 4000-4899, 4920-9999</i></u>										
1-03-009-01	Bark-fired Boiler	47	17	---	---	---	---	---	0.0029	Footnote 25
1-03-009-02	Wood/Bark-fired Boiler	7.2	6.5	---	---	---	---	---	---	Tons Burned
1-03-009-03	Wood-fired Boiler	8.8	---	---	---	---	---	---	---	Tons Burned
1-03-009-10	Fuel cell/Dutch oven boilers	---	---	---	0.075	0.38	---	6.6	---	Tons Burned
1-03-009-11	Stoker boilers	---	---	---	0.075	1.5	---	13.6	---	Tons Burned
1-03-009-12	Fluidized bed combustion boilers	---	---	---	0.075	2	---	1.4	---	Tons Burned
<u><i>Liquified Petroleum Gas (LPG) - 4000-4899, 4920-9999</i></u>										
1-03-010-01	Butane	0.5	0.5	---	<sup>21, 26</sup> 0.09s	15	---	2.1	---	1000 Gallons Burned
1-03-010-02	Propane	0.4	0.4	---	<sup>21, 26</sup> 0.1s	14	---	1.9	---	1000 Gallons Burned
1-03-010-03	Butane/Propane Mixture: Specify Percent Butane in Comments	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u><i>Solid Waste - 4000-4899, 4920-9999</i></u>										
1-03-012-01	Specify Waste Material in Comments	---	---	---	1.6	5.9	2	---	---	Tons Burned
1-03-012-02	Refuse Derived Fuel	80	44	---	1.7	5	---	3.6	0.13	Tons Burned
<u><i>Liquid Waste - 4000-4899, 4920-9999</i></u>										
1-03-013-01	Specify Waste Material in Comments	---	---	---	---	---	1	---	---	1000 Gallons Burned
1-03-013-02	Waste Oil	64A	51A	---	147S	19	---	5	2.2	1000 Gallons Burned
1-03-013-03	Sewage Grease Skimmings	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u><i>EXTERNAL COMBUSTION BOILERS -Space Heaters</i></u>										
<u><i>Industrial - 1000-3999</i></u>										
1-05-001-02	Coal	---	---	---	39S	3	---	---	---	Tons Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Industrial - 1000-3999</i></u>										
1-05-001-05	Distillate Oil	---	2.46	---	143.6S	---	---	---	---	1000 Gallons Burned
1-05-001-06	Natural Gas	3	3	---	0.6	100	5.3	20	---	Million Cubic Feet Burned
1-05-001-10	Liquified Petroleum Gas (LPG)	0.6	0.6	---	<sup>26</sup> 0.095s	20	---	3.4	---	1000 Gallons Burned
1-05-001-13	Waste Oil: Air Atomized Burner	66A	57A	---	107S	16	---	2.1	2	1000 Gallons Burned
1-05-001-14	Waste Oil: Vaporizing Burner	2.8A	---	---	100S	11	---	1.7	0.0164	1000 Gallons Burned
<u><i>Commercial/Institutional - 4000-4899, 4920-9999</i></u>										
1-05-002-02	Coal	---	---	---	39S	3	---	---	---	Tons Burned
1-05-002-05	Distillate Oil	---	2.46	---	143.6S	---	0.7	---	---	1000 Gallons Burned
1-05-002-06	Natural Gas	3	3	---	0.6	100	5.3	20	---	Million Cubic Feet Burned
1-05-002-09	Wood	8.8	---	---	0.075	1.5	---	13.6	---	Tons Burned
1-05-002-10	Liquified Petroleum Gas (LPG)	0.45	0.45	---	<sup>26</sup> 0.095s	14.5	---	2	---	1000 Gallons Burned
1-05-002-13	Waste Oil: Air Atomized Burner	66A	57A	---	107S	16	---	2.1	2	1000 Gallons Burned
1-05-002-14	Waste Oil: Vaporizing Burner	2.8A	---	---	100S	11	---	1.7	0.0164	1000 Gallons Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
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## **INTERNAL COMBUSTION ENGINES**

### **INTERNAL COMBUSTION ENGINES -Electric Generation**

#### **Distillate Oil (Diesel) - 4911**

2-01-001-01	Turbine	---	---	---	<sup>21, 30</sup> 1.01S	0.88	0.00041	0.0033	0.000014	Million Btus Input
2-01-001-02	Reciprocating	42.5	42.5	---	39.7	604	---	130	---	1000 Gallons Burned
2-01-001-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-01-001-06	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-01-001-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-01-001-08	Turbine: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-01-001-09	Turbine: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned

#### **Natural Gas - 4911**

2-01-002-01	Turbine	---	---	---	<sup>21, 31</sup> 0.94S	0.32	0.0021	0.082	---	Million Btus Input
2-01-002-02	Reciprocating	10	10	---	0.6	2840	116	399	---	Million Cubic Feet Burned
2-01-002-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-01-002-06	Reciprocating: Evaporative Losses (Fuel Delivery System)	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-01-002-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-01-002-08	Turbine: Evaporative Losses (Fuel Delivery System)	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-01-002-09	Turbine: Exhaust	---	---	---	---	---	---	---	---	Million Cubic Feet Burned

#### **Process Gas - 4911**

2-01-007-02	Reciprocating	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-01-007-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-01-007-06	Reciprocating: Evaporative Losses (Fuel Delivery System)	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-01-007-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	Million Cubic Feet Burned

#### **Landfill Gas - 4911**

2-01-008-01	Turbine	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-01-008-02	Reciprocating	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-01-008-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-01-008-06	Reciprocating: Evaporative Losses (Fuel Delivery System)	---	---	---	---	---	---	---	---	Million Cubic Feet Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Landfill Gas - 4911</u>										
2-01-008-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-01-008-08	Turbine: Evaporative Losses (Fuel Delivery System)	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-01-008-09	Turbine: Exhaust	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
<u>Kerosene/Naphtha (Jet Fuel) - 4911</u>										
2-01-009-01	Turbine	---	---	---	<sup>21, 32</sup> 1.018	0.88	---	0.0033	---	Million Btus Burned
2-01-009-02	Reciprocating	0.31	0.31	---	0.29	4.41	---	0.95	---	Million Btus Input
2-01-009-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-01-009-06	Reciprocating: Evaporative Losses (Fuel Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-01-009-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-01-009-08	Turbine: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-01-009-09	Turbine: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>Geysers/Geothermal - 4911</u>										
2-01-010-01	Steam Turbine	---	---	---	---	---	---	---	---	Tons Produced
2-01-010-10	Well Drilling: Steam Emissions	---	---	---	---	---	---	---	---	Tons Produced
2-01-010-20	Well Pad Fugitives: Blowdown	---	---	---	---	---	---	---	---	Tons Produced
2-01-010-30	Pipeline Fugitives: Blowdown	---	---	---	---	---	---	---	---	Tons Produced
2-01-010-31	Pipeline Fugitives: Vents/Leaks	---	---	---	---	---	---	---	---	Tons Produced
<u>Liquid Waste - 4900</u>										
2-01-013-02	Waste Oil - Turbine	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>Equipment Leaks - 4922</u>										
2-01-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Wastewater, Aggregate - 4900</u>										
2-01-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
2-01-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Wastewater, Points of Generation - 4900</u>										
2-01-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Flares - 4911</u>										
2-01-900-99	Heavy Water	---	---	---	---	---	---	---	---	1000 Gallons Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<b><i>INTERNAL COMBUSTION ENGINES -Industrial</i></b>										
<b><i>Distillate Oil (Diesel) - 1000-3999</i></b>										
2-02-001-01	Turbine	---	---	---	<sup>21, 30</sup> 1.01S	0.88	0.00041	0.0033	0.000014	Million Btus Input
2-02-001-02	Reciprocating	42.5	42.5	---	39.7	604	---	130	---	1000 Gallons Burned
2-02-001-03	Turbine: Cogeneration	---	---	---	<sup>21, 30</sup> 1.01S	0.88	0.00041	0.0033	0.000014	Million Btus Input
2-02-001-04	Reciprocating: Cogeneration	42.5	42.5	---	39.7	604	---	130	---	1000 Gallons Burned
2-02-001-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-001-06	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-001-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-001-08	Turbine: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-001-09	Turbine: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
<b><i>Natural Gas - 1000-3999</i></b>										
2-02-002-01	Turbine	---	---	---	<sup>21, 31</sup> 0.94S	0.32	0.0021	0.082	---	Million Btus Input
2-02-002-02	Reciprocating	10	10	---	0.6	2840	116	399	---	Million Cubic Feet Burned
2-02-002-03	Turbine: Cogeneration	---	---	---	<sup>21, 31</sup> 0.94S	0.32	0.0021	0.082	---	Million Btus Input
2-02-002-04	Reciprocating: Cogeneration	10	10	---	0.6	2840	116	399	---	Million Cubic Feet Burned
2-02-002-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-02-002-06	Reciprocating: Evaporative Losses (Fuel Delivery System)	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-02-002-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-02-002-08	Turbine: Evaporative Losses (Fuel Delivery System)	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-02-002-09	Turbine: Exhaust	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-02-002-52	2-cycle Lean Burn	---	0.0384	0.00991	<sup>21</sup> 0.000588	See App. C	0.12	See App. C	---	Million Btus Input
2-02-002-53	4-cycle Rich Burn	---	0.0095	0.00991	<sup>21</sup> 0.000588	See App. C	0.0296	See App. C	---	Million Btus Input
2-02-002-54	4-cycle Lean Burn	---	0.0000771	0.00991	<sup>21</sup> 0.000588	See App. C	0.118	See App. C	---	Million Btus Input
2-02-002-55	2-cycle Clean Burn	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-02-002-56	4-cycle Clean Burn	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
<b><i>Gasoline - 1000-3999</i></b>										
2-02-003-01	Reciprocating	12.6	12.6	---	10.6	205	---	7900	---	1000 Gallons Burned
2-02-003-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	1000 Gallons Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Gasoline - 1000-3999</u>										
2-02-003-06	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-003-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>Large Bore Engine - 1000-3999</u>										
2-02-004-01	Diesel	13.7	6.8	1.05	138S	438	13.7	116	---	1000 Gallons Burned
2-02-004-02	Dual Fuel (Oil/Gas)	2.2	2	---	Footnote 33	18	1.4	7.5	---	1000 Horsepower-Hours Output
2-02-004-03	Cogeneration: Dual Fuel	220	200	---	70	2170	140	553	---	100,000 Horsepower-Hours Output
2-02-004-05	Crankcase Blowby	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-004-06	Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-004-07	Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>Residual/Crude Oil - 1000-3999</u>										
2-02-005-01	Reciprocating	42.5	42.5	---	155S	604	---	130	---	1000 Gallons Burned
2-02-005-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-005-06	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-005-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>Process Gas - 2911</u>										
2-02-007-01	Turbine	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-02-007-02	Reciprocating Engine	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-02-007-05	Refinery Gas: Turbine	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-02-007-06	Refinery Gas: Reciprocating Engine	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-02-007-10	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-02-007-11	Reciprocating: Evaporative Losses (Fuel Delivery System)	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-02-007-12	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-02-007-13	Turbine: Evaporative Losses (Fuel Delivery System)	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-02-007-14	Turbine: Exhaust	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
<u>Kerosene/Naphtha (Jet Fuel) - 1000-3999</u>										
2-02-009-01	Turbine	---	---	---	<sup>21</sup> 1.01S	0.88	---	0.0033	---	Million Btus Burned
2-02-009-02	Reciprocating	0.31	0.31	---	0.29	4.41	---	0.95	---	Million Btus Input
2-02-009-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	1000 Gallons Burned



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Kerosene/Naphtha (Jet Fuel) - 1000-3999</i></u>										
2-02-009-06	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-009-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-009-08	Turbine: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-009-09	Turbine: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u><i>Liquified Petroleum Gas (LPG) - 1000-3999</i></u>										
2-02-010-01	Propane: Reciprocating	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-010-02	Butane: Reciprocating	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-010-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-010-06	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-010-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-010-08	Turbine: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-010-09	Turbine: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-010-11	Turbine	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-010-12	Reciprocating Engine	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-010-13	Turbine: Cogeneration	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-010-14	Reciprocating Engine: Cogeneration	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u><i>Methanol - 2861, 2869</i></u>										
2-02-016-01	Turbine	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-016-02	Reciprocating Engine	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-016-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-016-06	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-016-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-016-08	Turbine: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-016-09	Turbine: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u><i>Gasoline - 2911, 3339, 3761, 4923, 9711</i></u>										
2-02-017-01	Turbine	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-017-02	Reciprocating Engine	---	---	---	---	---	---	---	---	1000 Gallons Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Gasoline - 2911, 3339, 3761, 4923, 9711</u>										
2-02-017-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-017-06	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-017-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-017-08	Turbine: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-02-017-09	Turbine: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>Equipment Leaks - 2911, 3339, 3761, 4923, 9711</u>										
2-02-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Wastewater, Aggregate - 2911, 3339, 3761, 4923, 9711</u>										
2-02-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
2-02-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Wastewater, Points of Generation - 2911, 3339, 3761, 4923, 9711</u>										
2-02-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>INTERNAL COMBUSTION ENGINES -Commercial/Institutional</u>										
<u>Distillate Oil (Diesel) - 4000-4899, 4920-9999</u>										
2-03-001-01	Reciprocating	42.5	42.5	---	39.7	604	---	130	---	1000 Gallons Burned
2-03-001-02	Turbine	---	---	---	<sup>21, 30</sup> 1.01S	0.88	0.00041	0.0033	0.000014	Million Btus Input
2-03-001-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-03-001-06	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-03-001-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-03-001-08	Turbine: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-03-001-09	Turbine: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>Natural Gas - 4000-4899, 4920-9999</u>										
2-03-002-01	Reciprocating	10	10	---	0.6	2840	116	399	---	Million Cubic Feet Burned
2-03-002-02	Turbine	---	---	---	<sup>21, 31</sup> 0.94S	0.32	0.0021	0.082	---	Million Btus Input
2-03-002-03	Turbine: Cogeneration	---	---	---	<sup>21, 31</sup> 0.94S	0.32	0.0021	0.082	---	Million Btus Input
2-03-002-04	Cogeneration	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-03-002-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	Million Cubic Feet Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Natural Gas - 4000-4899, 4920-9999</u>										
2-03-002-06	Reciprocating: Evaporative Losses (Fuel Delivery System)	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-03-002-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-03-002-08	Turbine: Evaporative Losses (Fuel Delivery System)	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-03-002-09	Turbine: Exhaust	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
<u>Gasoline - 4000-4899, 4920-9999</u>										
2-03-003-01	Reciprocating	12.6	12.6	---	10.6	205	---	7900	---	1000 Gallons Burned
2-03-003-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-03-003-06	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-03-003-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>Digester Gas - 4952, 9511, 4941</u>										
2-03-007-01	Turbine	---	0.012	---	<sup>21</sup> 0.0065	0.16	0.0058	0.017	< 0.0000034	Million Btus Input
2-03-007-02	Reciprocating: POTW Digester Gas	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-03-007-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-03-007-06	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-03-007-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-03-007-08	Turbine: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-03-007-09	Turbine: Exhaust	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
<u>Landfill Gas - 4920, 4925, 4953, 4959</u>										
2-03-008-01	Turbine	---	0.023	---	<sup>21</sup> 0.045	0.14	0.013	0.44	---	Million Btus Input
2-03-008-02	Reciprocating	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-03-008-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-03-008-06	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-03-008-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-03-008-08	Turbine: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-03-008-09	Turbine: Exhaust	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
<u>Kerosene/Naphtha (Jet Fuel) - 4500, 4600</u>										
2-03-009-01	Turbine: JP-4	---	---	---	---	---	---	---	---	1000 Gallons Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Kerosene/Naphtha (Jet Fuel) - 4500, 4600</i></u>										
2-03-009-08	Turbine: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-03-009-09	Turbine: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u><i>Liquified Petroleum Gas (LPG) - 4000-4899, 4920-9999</i></u>										
2-03-010-01	Propane: Reciprocating	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-03-010-02	Butane: Reciprocating	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-03-010-05	Reciprocating: Crankcase Blowby	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-03-010-06	Reciprocating: Evaporative Losses (Fuel Storage and Delivery System)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-03-010-07	Reciprocating: Exhaust	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u><i>Equipment Leaks - 07, 10, 1600, 1700, 4400, 4500, 4600, 4900, 8060</i></u>										
2-03-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u><i>Wastewater, Aggregate - 0700, 1000, 1600, 1700, 4400, 4500, 4600, 4900</i></u>										
2-03-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
2-03-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u><i>Wastewater, Points of Generation - 0700, 1000, 1600, 1700, 4400, 4500, 4600, 4900</i></u>										
2-03-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u><i>INTERNAL COMBUSTION ENGINES -Engine Testing</i></u>										
<u><i>Aircraft Engine Testing - 3500-3599, 3700-3799</i></u>										
2-04-001-01	Turbojet	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-04-001-02	Turboshaft	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-04-001-10	Jet A Fuel	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-04-001-11	JP-5 Fuel	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-04-001-12	JP-4 Fuel	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-04-001-99	Other Not Classified	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u><i>Rocket Engine Testing - 3500-3599, 3700-3799</i></u>										
2-04-002-01	Rocket Motor: Solid Propellant	---	---	---	---	---	---	---	---	Tons Consumed
2-04-002-02	Liquid Propellant	---	---	---	---	---	---	---	---	Tons Consumed
2-04-002-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Turbine - 3500-3599, 3700-3799</i></u>										
2-04-003-01	Natural Gas	14	14	---	0.6	300	6.9	120	---	Million Cubic Feet Burned
2-04-003-02	Diesel/Kerosene	---	---	---	140S	97.7	---	6.72	---	1000 Gallons Burned
2-04-003-03	Distillate Oil	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-04-003-04	Landfill Gas	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-04-003-05	Kerosene/Naphtha	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-04-003-99	Other Not Classified	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u><i>Reciprocating Engine - 3500-3599, 3700-3799</i></u>										
2-04-004-01	Gasoline	6.47	6.2	---	5.31	102	148	3940	---	1000 Gallons Burned
2-04-004-02	Diesel/Kerosene	42.5	42.5	---	39.7	604	---	130	---	1000 Gallons Burned
2-04-004-03	Distillate Oil	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-04-004-04	Process Gas	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-04-004-05	Landfill Gas	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-04-004-06	Kerosene/Naphtha (Jet Fuel)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-04-004-07	Dual Fuel (Gas/Oil)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-04-004-08	Residual Oil/Crude Oil	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-04-004-09	Liquified Petroleum Gas (LPG)	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-04-004-99	Other Not Classified	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u><i>Equipment Leaks - 3761, 3764</i></u>										
2-04-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u><i>Wastewater, Aggregate - 3761, 3764</i></u>										
2-04-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
2-04-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u><i>Wastewater, Points of Generation - 3761, 3764</i></u>										
2-04-825-01	Water Deluge Solid Propellant Engine Test Unit	---	---	---	---	---	---	---	---	1000 Gallons Throughput
2-04-825-02	Water Deluge Liquid Propellant Engine Test Unit	---	---	---	---	---	---	---	---	1000 Gallons Throughput
2-04-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u><i>INTERNAL COMBUSTION ENGINES -Off-highway 2-stroke Gasoline Engines</i></u>										
<u><i>Industrial Equipment - 3519</i></u>										
2-60-003-20	Industrial Fork Lift: Gasoline Engine (2-stroke)	---	---	---	---	---	---	---	---	1000 Gallons Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>INTERNAL COMBUSTION ENGINES -Off-highway 4-stroke Gasoline Engines</u>										
<u>Industrial Equipment - 2911, 3339, 3761, 4923, 9711</u>										
2-65-003-20	Industrial Fork Lift: Gasoline Engine (4-stroke)	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>INTERNAL COMBUSTION ENGINES -Off-highway Diesel Engines</u>										
<u>Industrial Equipment - 3721</u>										
2-70-003-20	Industrial Fork Lift: Diesel	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>INTERNAL COMBUSTION ENGINES -Off-highway LPG-fueled Engines</u>										
<u>Industrial Equipment - 3621</u>										
2-73-003-20	Industrial Fork Lift: Liquified Petroleum Gas (LPG)	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>INTERNAL COMBUSTION ENGINES -Fixed Wing Aircraft L &amp; TO Exhaust</u>										
<u>Military - 3721, 9711, 9711</u>										
2-75-010-01	Piston Engine: Aviation Gas	---	---	---	---	---	---	---	---	Each Occurred
2-75-010-14	Jet Engine: JP-4	---	---	---	---	---	---	---	---	Each Occurred
2-75-010-15	Jet Engine: JP-5	---	---	---	---	---	---	---	---	Each Occurred
<u>Commercial - 3721</u>										
2-75-020-01	Piston Engine: Aviation Gas	---	---	---	---	---	---	---	---	Each Occurred
2-75-020-11	Jet Engine: Jet A	---	---	---	---	---	---	---	---	Each Occurred
<u>Civil - 5092</u>										
2-75-050-01	Piston Engine: Aviation Gas	---	---	---	---	---	---	---	---	Each Occurred
2-75-050-11	Jet Engine: Jet A	---	---	---	---	---	---	---	---	Each Occurred
<u>INTERNAL COMBUSTION ENGINES -Rotary Wing Aircraft L &amp; TO Exhaust</u>										
<u>Military - 9711</u>										
2-76-010-01	Piston Engine: Aviation Gas	---	---	---	---	---	---	---	---	Each Occurred
2-76-010-14	Jet Engine: JP-4	---	---	---	---	---	---	---	---	Each Occurred
2-76-010-15	Jet Engine: JP-5	---	---	---	---	---	---	---	---	Each Occurred
<u>Commercial - 2911, 3339, 3761, 4923, 9711</u>										
2-76-020-01	Piston Engine: Aviation Gas	---	---	---	---	---	---	---	---	Each Occurred
2-76-020-11	Jet Engine: Jet A	---	---	---	---	---	---	---	---	Each Occurred

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Civil - 2911, 3339, 3761, 4923, 9711</u>										
2-76-050-01	Piston Engine: Aviation Gas	---	---	---	---	---	---	---	---	Each Occurred
2-76-050-11	Jet Engine: Jet A	---	---	---	---	---	---	---	---	Each Occurred
<u>INTERNAL COMBUSTION ENGINES -Diesel Marine Vessels</u>										
<u>Commercial - 1311</u>										
2-80-002-11	Crew Boats: Main Engine Exhaust: Idling	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-80-002-12	Crew Boats: Main Engine Exhaust: Maneuvering	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-80-002-13	Crew Boats: Auxiliary Generator Exhaust: Hotelling	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-80-002-16	Supply Boats: Main Engine Exhaust: Idling	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-80-002-17	Supply Boats: Main Engine Exhaust: Maneuvering	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-80-002-18	Supply Boats: Auxiliary Generator Exhaust: Hotelling	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>INTERNAL COMBUSTION ENGINES -Fugitive Emissions</u>										
<u>Other Not Classified - 1000-9999</u>										
2-88-888-01	Specify in Comments	---	---	---	---	---	---	---	---	1000 Gallons Burned
2-88-888-02	Specify in Comments	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
2-88-888-03	Specify in Comments	---	---	---	---	---	---	---	---	1000 Horsepower-Hours Output

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<b><u>INDUSTRIAL PROCESSES</u></b>										
<i><u>INDUSTRIAL PROCESSES -Chemical Manufacturing</u></i>										
<i><u>Adipic Acid - 2869</u></i>										
3-01-001-01	General	0.9	0.037	---	---	---	42.7	115	---	Tons Produced
3-01-001-02	Raw Material Storage	---	---	---	---	---	2.2	---	---	Tons Produced
3-01-001-03	Cyclohexane Oxidation	---	---	---	---	1.4	0.55	0.49	---	Tons Produced
3-01-001-04	Nitric Acid Reaction	---	---	---	---	1.6	0.014	0.28	---	Tons Produced
3-01-001-05	Adipic Acid Refining	0.1	0.004	---	---	0.6	0.5	---	---	Tons Produced
3-01-001-06	Drying, Loading, and Storage	0.8	0.032	---	---	---	0.1	---	---	Tons Produced
3-01-001-07	Absorber	---	---	---	---	94.8	0.4	---	---	Tons Produced
3-01-001-08	Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-01-001-09	Cooler	---	---	---	---	---	---	---	---	Tons Produced
3-01-001-10	Loading And Storage	---	---	---	---	---	---	---	---	Tons Produced
3-01-001-80	Fugitive Emissions: General	---	---	---	---	---	61800	---	---	Each-Year Operating
3-01-001-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Ammonia Production - 2873</u></i>										
3-01-003-05	Feedstock Desulfurization	---	---	---	0.019	---	7.2	13.8	---	Tons Produced
3-01-003-06	Primary Reformer: Natural Gas Fired	0.144	0.144	---	0.0048	5.4	0.012	0.136	---	Tons Produced
3-01-003-07	Primary Reformer: Oil Fired	0.9	0.86	---	2.6	5.4	0.38	0.24	---	Tons Produced
3-01-003-08	Carbon Dioxide Regenerator	---	---	---	---	---	1.04	2	---	Tons Produced
3-01-003-09	Condensate Stripper	---	---	---	---	---	1.2	---	---	Tons Produced
3-01-003-10	Storage and Loading Tanks	---	---	---	---	---	---	---	---	Tons Stored
3-01-003-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Carbon Black Production - 2895</u></i>										
3-01-005-01	Channel Process	---	---	---	---	---	---	---	---	Tons Produced
3-01-005-02	Thermal Process	---	---	---	---	---	---	---	---	Tons Produced
3-01-005-03	Gas Furnace Process: Main Process Vent	---	3.2	---	---	---	---	---	---	Tons Produced
3-01-005-04	Oil Furnace Process: Main Process Vent	6.53	6.53	---	---	0.56	100	2800	---	Tons Produced
3-01-005-06	Transport Air Vent	0.58	0.58	---	---	---	---	---	---	Tons Produced
3-01-005-07	Pellet Dryer	0.45	0.24	---	<sup>27</sup> 0.52	0.73	0.4	---	---	Tons Produced
3-01-005-08	Bagging/Loading	0.06	0.06	---	---	---	---	---	---	Tons Produced



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Carbon Black Production - 2895</u>										
3-01-005-09	Furnace Process: Fugitive Emissions	0.2	0.2	---	---	---	---	---	---	Tons Produced
3-01-005-10	Main Process Vent with CO Boiler and Incinerator	2.07	---	---	35.2	9.3	1.98	1.75	---	Tons Produced
3-01-005-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Charcoal Manufacturing - 2861</u>										
3-01-006-01	General	---	---	---	---	---	---	---	---	Tons Produced
3-01-006-03	Batch Kiln	---	---	---	---	24	270	290	---	Tons Produced
3-01-006-04	Continuous Kiln	---	---	---	---	24	270	290	---	Tons Produced
3-01-006-05	Briquetting	---	---	---	---	---	---	---	---	Tons Produced
3-01-006-06	Raw Material Handling	---	---	---	---	---	---	---	---	Tons Processed
3-01-006-07	Crushing	---	---	---	---	---	---	---	---	Tons Processed
3-01-006-08	Handling and Storage	---	---	---	---	---	---	---	---	Tons Processed
3-01-006-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Chlorine - 2812, 2869</u>										
3-01-007-01	Carbon Reactivation	---	---	---	---	---	---	---	---	Tons Generated
3-01-007-02	Carbon Reactivation/Impregnation Kiln	---	---	---	---	---	---	---	---	Tons Produced
3-01-007-04	Carbon Reactivation/Heating Ovens	---	---	---	---	---	---	---	---	Tons Produced
3-01-007-05	Carbon Reactivation/Fugitives	---	---	---	---	---	---	---	---	Tons Produced
3-01-007-06	Carbon Reactivation/Afterburner	---	---	---	---	---	---	---	---	Tons Produced
3-01-007-07	Carbon Reactivation/Multiple Hearth Furnace	---	---	---	---	---	---	---	---	Tons Generated
3-01-007-08	Carbon Reactivation/Indirect Furnace	---	---	---	---	---	---	---	---	Tons Generated
3-01-007-09	Carbon Reactivation/Product Handling (Mesh, Prss)	---	---	---	---	---	---	---	---	Tons Handled
3-01-007-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Chloro-alkali Production - 2812</u>										
3-01-008-01	Liquefaction (Diaphragm Cell Process)	---	---	---	---	---	---	---	---	100 Tons Liquefied
3-01-008-02	Liquefaction (Mercury Cell Process)	---	---	---	---	---	---	---	---	100 Tons Liquefied
3-01-008-03	Chlorine Loading: Tank Car Vent	---	---	---	---	---	---	---	---	100 Tons Liquefied
3-01-008-04	Chlorine Loading: Storage Car Vent	---	---	---	---	---	---	---	---	100 Tons Liquefied
3-01-008-05	Air Blowing of Mercury Cell Brine	---	---	---	---	---	---	---	---	100 Tons Liquefied
3-01-008-99	Other Not Classified	---	---	---	---	---	---	---	---	100 Tons Liquefied

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Cleaning Chemicals - 2841, 2842</i></u>										
3-01-009-01	Spray Drying: Soaps and Detergents	90	---	---	---	---	0.05	---	---	Tons Produced
3-01-009-02	Specialty Cleaners	---	---	---	---	---	---	---	---	Tons Produced
3-01-009-05	Alkaline Saponification	---	---	---	---	---	---	---	---	Tons Processed
3-01-009-06	Direct Saponification	---	---	---	---	---	---	---	---	Tons Processed
3-01-009-07	Blending And Mixing	---	---	---	---	---	---	---	---	Tons Processed
3-01-009-08	Soap Packaging	---	---	---	---	---	---	---	---	Tons Processed
3-01-009-09	Detergent Slurry Preparation	---	---	---	---	---	---	---	---	Tons Processed
3-01-009-10	Detergent Granule Handling	---	---	---	---	---	---	---	---	Tons Processed
3-01-009-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Explosives (Trinitrotoluene) - 2892</i></u>										
3-01-010-05	Nitric/Sulfuric Acid Mixing	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-10	Process Vents: Batch Process	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-11	Batch Process: Nitration Reactors Fume Recovery	---	---	---	---	25	---	---	---	Tons Produced
3-01-010-12	Batch Process: Nitration Reactors Acid Recovery	---	---	---	---	55	---	---	---	Tons Produced
3-01-010-13	Batch Process: Nitric Acid Concentrators	---	---	---	---	37	---	---	---	Tons Produced
3-01-010-14	Batch Process: Sulfuric Acid Concentrators	---	---	---	14	40	---	---	---	Tons Produced
3-01-010-15	Batch Process: Red Water Incinerator	25	23.5	---	2	26	1.1	---	---	Tons Produced
3-01-010-21	Continuous Process: Nitration Reactor Fume Recover (Use 3-01-010-51)	---	---	---	---	8	---	---	---	Tons Produced
3-01-010-22	Continuous Process: Nitration Reactor Acid Recover (Use 3-01-010-52)	---	---	---	---	3	---	---	---	Tons Produced
3-01-010-23	Continuous Process: Red Water Incinerator (Use 3-01-010-53)	0.25	0.24	---	0.24	7	1.1	---	---	Tons Produced
3-01-010-25	Batch Process: Spent Acid Recovery: Denitrating Tower	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-26	Batch Process: Spent Acid Recovery: Sulfuric Acid Regenerator	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-27	Batch Process: Spent Acid Recovery: Bleacher	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-28	Batch Process: Spent Acid Recovery: Reflux Columns	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-30	Open Burning: Waste	180	142	---	---	150	1.1	56	---	Tons Burned
3-01-010-33	Batch Process: Nitric Acid Concentration: Distillation Tower	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-34	Batch Process: Nitric Acid Concentration: Bleacher	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-35	Batch Process: Nitric Acid Concentration: Condenser	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Explosives (Trinitrotoluene) - 2892</u>										
3-01-010-36	Batch Process: Nitric Acid Concentration: Absorber Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-37	Batch Process: Nitric Acid Concentration: Dehydrating Unit	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-40	Batch Process: Purification	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-45	Batch Process: Finishing: Melt Tank	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-46	Batch Process: Finishing: Dryers	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-47	Batch Process: Finishing: Flaker Drum	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-50	Process Vents: Continuous Process	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-51	Continuous Process: Nitration Reactor Fume Recovery	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-52	Continuous Process: Spent Acid Recovery	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-53	Continuous Process: Red Water Incineration	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-54	Continuous Process: Nitric Acid Concentrators	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-55	Continuous Process: Sulfuric Acid Concentrators	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-61	Continuous Process: Spent Acid Recovery: Denitrating Tower	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-62	Continuous Process: Spent Acid Recovery: Sulfuric Acid Regenerator	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-63	Continuous Process: Spent Acid Recovery: Bleacher	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-64	Continuous Process: Spent Acid Recovery: Reflux Columns	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-73	Continuous Process: Nitric Acid Concentration: Distillation Tower	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-74	Continuous Process: Nitric Acid Concentration: Bleacher	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-75	Continuous Process: Nitric Acid Concentration: Condenser	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-76	Continuous Process: Nitric Acid Concentration: Absorber Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-77	Continuous Process: Nitric Acid Concentration: Dehydrating Unit	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-80	Continuous Process: Purification	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-85	Continuous Process: Finishing: Melt Tank	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-86	Continuous Process: Finishing: Dryers	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-87	Continuous Process: Finishing: Flaker Drum	---	---	---	---	---	---	---	---	Tons Produced
3-01-010-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Hydrochloric Acid - 2819</i></u>										
3-01-011-01	By-product Process	---	---	---	---	---	---	---	---	Tons Produced
3-01-011-98	Handling and Storage (99.9% Removal)	---	---	---	---	---	---	---	---	1000 Gallons Handled
3-01-011-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Hydrofluoric Acid - 2819</i></u>										
3-01-012-02	Rotary Kiln: Acid Reactor	---	---	---	2.7	0.07	---	---	---	Tons Produced
3-01-012-03	Fluorspar Grinding/Drying	75	38.9	---	---	0.145	---	---	---	Tons Handled
3-01-012-04	Fluorspar Handling Silos	60	30.6	---	---	---	---	---	---	Tons Handled
3-01-012-05	Fluorspar Transfer	6	3.1	---	---	---	---	---	---	Tons Handled
3-01-012-06	Tail Gas Vent	---	---	---	45	---	---	---	---	Tons Produced
3-01-012-07	Fluorspar Drying Kiln: Fuel Combustion	---	---	---	---	---	---	---	---	Tons Handled
3-01-012-08	Rotary Kiln: Fuel Combustion	---	---	---	---	---	---	---	---	Tons Handled
3-01-012-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Nitric Acid - 2873</i></u>										
3-01-013-01	Absorber Tail Gas (Pre-1970 Facilities)	---	---	---	---	43	---	---	---	Tons Produced
3-01-013-02	Absorber Tail Gas (Post-1970 Facilities)	---	---	---	---	See App. C	---	---	---	Tons Produced
3-01-013-03	Nitric Acid Concentrators (Pre-1970)	---	---	---	---	10	---	---	---	Tons Produced
3-01-013-04	Nitric Acid Concentrators (Post-1970)	---	---	---	---	10	---	---	---	Tons Produced
3-01-013-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Paint Manufacture - 2851</i></u>										
3-01-014-01	General Mixing and Handling	20	---	---	---	---	30	---	---	Tons Produced
3-01-014-02	Pigment Handling	20	17	---	---	---	---	---	---	Tons Processed
3-01-014-03	Solvent Loss: General	---	---	---	---	---	---	---	---	Tons Lost
3-01-014-04	Raw Material Storage	---	---	---	---	---	---	---	---	1000 Gallons Stored
3-01-014-15	Premix/Preassembly	---	---	---	---	---	---	---	---	Tons Produced
3-01-014-16	Premix/Preassembly: Mix Tanks and Agitators	---	---	---	---	---	---	---	---	Tons Produced
3-01-014-17	Premix/Preassembly: Drums	---	---	---	---	---	---	---	---	Tons Produced
3-01-014-18	Premix/Preassembly: Material Loading	---	---	---	---	---	---	---	---	Tons Produced
3-01-014-30	Pigment Grinding/Milling	---	---	---	---	---	---	---	---	Tons Processed
3-01-014-31	Pigment Grinding/Milling: Roller Mills	---	---	---	---	---	---	---	---	Tons Processed
3-01-014-32	Pigment Grinding/Milling: Ball and Pebble Mills	---	---	---	---	---	---	---	---	Tons Processed
3-01-014-33	Pigment Grinding/Milling: Attritors	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Paint Manufacture - 2851</u></i>										
3-01-014-34	Pigment Grinding/Milling: Sand Mills	---	---	---	---	---	---	---	---	Tons Processed
3-01-014-35	Pigment Grinding/Milling: Bead Mills	---	---	---	---	---	---	---	---	Tons Processed
3-01-014-36	Pigment Grinding/Milling: Shot Mills	---	---	---	---	---	---	---	---	Tons Processed
3-01-014-37	Pigment Grinding/Milling: Stone Mills	---	---	---	---	---	---	---	---	Tons Processed
3-01-014-38	Pigment Grinding/Milling: Colloid Mills	---	---	---	---	---	---	---	---	Tons Processed
3-01-014-39	Pigment Grinding/Milling: Kady Mills	---	---	---	---	---	---	---	---	Tons Processed
3-01-014-40	Pigment Grinding/Milling: Impingement Mills	---	---	---	---	---	---	---	---	Tons Processed
3-01-014-41	Pigment Grinding/Milling: Horizontal Media Mills	---	---	---	---	---	---	---	---	Tons Processed
3-01-014-50	Product Finishing	---	---	---	---	---	---	---	---	Tons Produced
3-01-014-51	Product Finishing, Tinting: Mix Tank and Disperser	---	---	---	---	---	---	---	---	Tons Produced
3-01-014-52	Product Finishing, Tinting: Fixed Blend Tank	---	---	---	---	---	---	---	---	Tons Produced
3-01-014-53	Product Finishing, Thinning: Mix Tank and Disperser	---	---	---	---	---	---	---	---	Tons Produced
3-01-014-54	Product Finishing, Thinning: Fixed Blend Tank	---	---	---	---	---	---	---	---	Tons Produced
3-01-014-60	Product Filling	---	---	---	---	---	---	---	---	Tons Produced
3-01-014-61	Product Filling: Scale System	---	---	---	---	---	---	---	---	Tons Produced
3-01-014-62	Product Filling: Product Filtering	---	---	---	---	---	---	---	---	Tons Produced
3-01-014-63	Product Filling: Filling Operations	---	---	---	---	---	---	---	---	Tons Produced
3-01-014-70	Equipment Cleaning	---	---	---	---	---	---	---	---	Tons Produced
3-01-014-71	Equipment Cleaning: Hand Wipe	---	---	---	---	---	---	---	---	Tons Produced
3-01-014-72	Equipment Cleaning: Tanks, Vessels, etc.	---	---	---	---	---	---	---	---	Tons Produced
3-01-014-98	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
3-01-014-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Varnish Manufacturing - 2851</u></i>										
3-01-015-01	Bodying Oil	---	---	---	---	---	40	---	---	Tons Produced
3-01-015-02	Oleoresinous	---	---	---	---	---	150	---	---	Tons Produced
3-01-015-03	Alkyd	---	---	---	---	---	160	---	---	Tons Produced
3-01-015-05	Acrylic	---	---	---	---	---	20	---	---	Tons Produced
3-01-015-10	Oil Storage	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-015-15	Kettle Loading	---	---	---	---	---	---	---	---	Tons Produced
3-01-015-20	Varnish Cooking	---	---	---	---	---	---	---	---	Tons Produced
3-01-015-21	Varnish Cooking: Open Kettle	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Varnish Manufacturing - 2851</u></i>										
3-01-015-22	Varnish Cooking: Closed Kettle	---	---	---	---	---	---	---	---	Tons Produced
3-01-015-30	Varnish Thinning	---	---	---	---	---	---	---	---	Tons Produced
3-01-015-40	Clarification	---	---	---	---	---	---	---	---	Tons Produced
3-01-015-41	Clarification: Strainer	---	---	---	---	---	---	---	---	Tons Produced
3-01-015-42	Clarification: Centrifuge	---	---	---	---	---	---	---	---	Tons Produced
3-01-015-43	Clarification: Filter Press	---	---	---	---	---	---	---	---	Tons Produced
3-01-015-50	End Product Transfer	---	---	---	---	---	---	---	---	Tons Produced
3-01-015-60	End Product Storage	---	---	---	---	---	---	---	---	Tons Produced
3-01-015-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Phosphoric Acid: Wet Process - 2874</u></i>										
3-01-016-01	Reactor	---	---	---	---	---	---	---	---	Tons Handled
3-01-016-02	Gypsum Pond	---	---	---	---	---	---	---	---	Tons Handled
3-01-016-03	Condenser	---	---	---	---	---	---	---	---	Tons Handled
3-01-016-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Phosphoric Acid: Thermal Process - 2874</u></i>										
3-01-017-02	Absorber: General	---	---	---	---	---	---	---	---	Tons Burned
3-01-017-03	Absorber with Packed Tower	2.14	2.14	---	---	---	---	---	---	Tons Produced
3-01-017-04	Absorber with Venturi Scrubber	2.53	2.53	---	---	---	---	---	---	Tons Produced
3-01-017-05	Absorber with Glass Mist Eliminator	0.69	0.69	---	---	---	---	---	---	Tons Produced
3-01-017-06	Absorber with Wire Mist Eliminator	5.46	5.46	---	---	---	---	---	---	Tons Produced
3-01-017-07	Absorber with High-pressure Mist Eliminator	0.11	0.11	---	---	---	---	---	---	Tons Produced
3-01-017-08	Absorber with ESP	1.66	1.66	---	---	---	---	---	---	Tons Produced
3-01-017-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Plastics Production - 2821</u></i>										
3-01-018-01	Polyvinyl Chlorides and Copolymers (Use 6-46-3X0-XX)	35	23	---	0.025	200	17	---	---	Tons Produced
3-01-018-02	Polypropylene and Copolymers	3	2	---	---	131	0.7	---	---	Tons Produced
3-01-018-03	Ethylene-Propylene Copolymers	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-05	Phenolic Resins	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-07	General: Polyethylene (High Density)	---	0.66	---	---	---	---	---	---	Tons Produced
3-01-018-08	Monomer and Solvent Storage	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-09	Extruder	---	---	---	---	---	11	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Plastics Production - 2821</i>										
3-01-018-10	Conveying	---	---	---	---	---	0.46	---	---	Tons Produced
3-01-018-11	Storage	0.8	---	---	---	---	0.01	---	---	Tons Produced
3-01-018-12	General: Polyethylene (Low Density)	---	0.66	---	---	---	---	---	---	Tons Produced
3-01-018-13	Recovery and Purification System	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-14	Extruder	---	---	---	---	---	66	---	---	Tons Produced
3-01-018-15	Pellet Silo	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-16	Transferring/Handling/Loading/Packing	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-17	General	---	---	---	---	---	See App. C	---	---	Tons Produced
3-01-018-18	Reactor	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-19	Solvent Recovery	---	---	---	---	---	3.2	---	---	Tons Produced
3-01-018-20	Polymer Drying	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-21	Extruding/Pelletizing/Conveying/Storage	---	---	---	---	---	0.3	---	---	Tons Produced
3-01-018-22	Acrylic Resins	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-27	Polyamide Resins	---	---	---	---	1	---	---	---	Tons Produced
3-01-018-32	Urea-Formaldehyde Resins	---	---	---	---	---	14.7	---	---	Tons Produced
3-01-018-37	Polyester Resins	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-38	Reactor Kettle (Use 6-45-200-11 or 6-45-210-11)	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-39	Resin Thinning Tank (Use 6-45-200-21 or 6-45-210-21)	---	---	---	---	---	---	---	---	Tons Used
3-01-018-40	Resin Storage Tank (Use 6-45-200-23 or 6-45-210-23)	---	---	---	---	---	---	---	---	1000 Gallon-Years Stored
3-01-018-42	Melamine Resins	---	---	---	---	---	50	---	---	Tons Produced
3-01-018-47	Epoxy Resins	---	---	---	---	---	5.1	---	---	Tons Produced
3-01-018-49	Acrylonitrile-Butadiene-Styrene (ABS) Resin	---	---	---	---	---	60	---	---	Tons Produced
3-01-018-52	Polyfluorocarbons	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-60	Recovery System (Polyethylene)	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-61	Purification System (Polyethylene)	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-63	Extruder	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-64	Pellet Silo/Storage	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-65	Transferring/Conveying	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-66	Packing/Shipping	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-70	Reactor (Polyether Resins)	---	---	---	---	---	50	---	---	Tons Produced
3-01-018-71	Blowing Agent: Freon (Polyether Resins)	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Plastics Production - 2821</u></i>										
3-01-018-72	Miscellaneous (Polyether Resins)	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-80	Reactor (Polyurethane)	---	---	---	---	---	52	---	---	Tons Produced
3-01-018-81	Blowing Agent: Freon (Polyurethane)	---	---	---	---	---	---	---	---	Tons Used
3-01-018-82	Blowing Agent: Methylene Chloride (Polyurethane)	---	---	---	---	---	---	---	---	Tons Used
3-01-018-83	Transferring/Conveying/Storage (Polyurethane)	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-84	Packing/Shipping (Polyurethane)	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-85	Other Not Classified (Polyurethane)	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-90	Catalyst Preparation	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-91	Reactor Vents	---	---	---	---	---	---	---	---	Tons Produced
3-01-018-92	Separation Processes	---	---	---	---	---	2	---	---	Tons Produced
3-01-018-93	Raw Material Storage	---	---	---	---	---	---	---	---	Tons Processed
3-01-018-94	Solvent Storage	---	---	---	---	---	---	---	---	Tons Stored
3-01-018-99	Others Not Specified	See App. C	---	---	---	---	See App. C	---	---	Tons Produced
<i><u>Phthalic Anhydride - 2865</u></i>										
3-01-019-01	o-Xylene Oxidation: Main Process Stream	138	130	---	94	---	---	301	---	Tons Produced
3-01-019-02	o-Xylene Oxidation: Pre-Treatment	13	12.2	---	---	---	---	---	---	Tons Produced
3-01-019-04	o-Xylene Oxidation: Distillation	89	83.7	---	---	---	2.4	---	---	Tons Produced
3-01-019-05	Naphthalene Oxidation: Main Process Stream	56	52.6	---	---	---	---	100	---	Tons Produced
3-01-019-06	Naphthalene Oxidation: Pre-Treatment	5	4.7	---	---	---	---	---	---	Tons Produced
3-01-019-07	Naphthalene Oxidation: Distillation	38	---	---	---	---	10	---	---	Tons Produced
3-01-019-08	Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-01-019-09	Flaking and Bagging	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Printing Ink Manufacture - 2893</u></i>										
3-01-020-01	Vehicle Cooking: General	---	---	---	---	---	120	---	---	Tons Produced
3-01-020-02	Vehicle Cooking: Oils	---	---	---	---	---	40	---	---	Tons Produced
3-01-020-03	Vehicle Cooking: Oleoresin	---	---	---	---	---	150	---	---	Tons Produced
3-01-020-04	Vehicle Cooking: Alkyds	---	---	---	---	---	160	---	---	Tons Produced
3-01-020-05	Pigment Mixing	2	1.7	---	---	---	6.2	---	---	Tons Produced
3-01-020-15	Premix/Preassembly	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-17	Premix/Preassembly: Drums	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-18	Premix/Preassembly: Material Loading	---	---	---	---	---	---	---	---	Tons Produced



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Printing Ink Manufacture - 2893</u></i>										
3-01-020-30	Pigment Grinding/Milling	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-31	Pigment Grinding/Milling: Roller Mills	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-32	Pigment Grinding/Milling: Ball and Pebble Mills	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-33	Pigment Grinding/Milling: Attritors	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-34	Pigment Grinding/Milling: Sand Mills	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-35	Pigment Grinding/Milling: Bead Mills	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-36	Pigment Grinding/Milling: Shot Mills	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-37	Pigment Grinding/Milling: Stone Mills	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-38	Pigment Grinding/Milling: Colloid Mills	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-39	Pigment Grinding/Milling: Kady Mills	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-40	Pigment Grinding/Milling: Impingement Mills	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-41	Pigment Grinding/Milling: Horizontal Media Mills	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-50	Product Finishing	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-51	Product Finishing, Tinting: Mix Tank and Disperser	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-52	Product Finishing, Tinting: Fixed Blend Tank	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-53	Product Finishing, Thinning: Mix Tank and Disperser	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-54	Product Finishing, Thinning: Fixed Blend Tank	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-60	Product Filling	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-61	Product Filling: Scale System	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-62	Product Filling: Product Filtering	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-63	Product Filling: Filling Operations	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-70	Equipment Cleaning	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-71	Equipment Cleaning: Hand Wipe	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-72	Equipment Cleaning: Tanks, Vessels, etc.	---	---	---	---	---	---	---	---	Tons Produced
3-01-020-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Sodium Carbonate - 2812</u></i>										
3-01-021-01	Solvay Process: NH3 Recovery	---	---	---	---	---	---	---	---	Tons Produced
3-01-021-02	Solvay Process: Handling	50	10.5	---	---	---	---	---	---	Tons Produced
3-01-021-03	Trona Crushing/Screening	---	---	---	---	---	---	---	---	Tons Processed
3-01-021-04	Monohydrate Process: Rotary Ore Calciner: Gas-fired	368	24.7	---	---	---	---	---	---	Tons Processed
3-01-021-05	Monohydrate Process: Rotary Ore Calciner: Coal-fired	390	37.1	---	0.01	1.4	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Sodium Carbonate - 2812</i></u>										
3-01-021-06	Rotary Soda Ash Dryers	84	17.6	---	---	---	---	---	---	Tons Produced
3-01-021-07	Fluid-bed Soda Ash Dryers/Coolers	146	19	---	---	---	---	---	---	Tons Produced
3-01-021-08	Dissolver	---	---	---	---	---	---	---	---	Tons Produced
3-01-021-10	Trona Calcining	---	---	---	---	---	---	---	---	Tons Produced
3-01-021-11	Trona Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-01-021-12	Rotary Pre-dryer	3.1	5.2	---	---	---	---	---	---	Tons Fed
3-01-021-13	Bleacher: Gas-fired	311	7.8	---	---	---	---	---	---	Tons Fed
3-01-021-14	Rotary Dryer: Steam Tube	67	14	---	---	---	---	---	---	Tons Produced
3-01-021-20	Brine Evaporation	---	---	---	---	---	---	---	---	Tons Produced
3-01-021-21	Ore Crushing and Screening	---	---	---	---	---	---	---	---	Tons Processed
3-01-021-22	Soda Ash Storage: Loading and Unloading	---	---	---	---	---	---	---	---	Tons Processed
3-01-021-23	Ore Mining	---	---	---	---	---	---	---	---	Tons Produced
3-01-021-24	Ore Transfer	---	---	---	---	---	---	---	---	Tons Produced
3-01-021-25	Sesquicarbonate Process: Rotary Calciner	---	---	---	---	---	---	---	---	Tons Produced
3-01-021-26	Sesquicarbonate Process: Fluid-bed Calciner	---	---	---	---	---	---	---	---	Tons Produced
3-01-021-27	Soda Ash Screening	---	---	---	---	---	---	---	---	Tons Produced
3-01-021-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Sulfuric Acid (Chamber Process) - 2819</i></u>										
3-01-022-01	General	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Sulfuric Acid (Contact Process) - 2819</i></u>										
3-01-023-01	Absorber/@ 99.9% Conversion	---	---	---	1.4	0.004	---	---	---	Tons Produced
3-01-023-04	Absorber/@ 99.5% Conversion	---	---	---	7	0.004	---	---	---	Tons Produced
3-01-023-06	Absorber/@ 99.0% Conversion	---	---	---	14	0.004	---	---	---	Tons Produced
3-01-023-08	Absorber/@ 98.0% Conversion	---	---	---	27	0.004	---	---	---	Tons Produced
3-01-023-10	Absorber/@ 97.0% Conversion	---	---	---	40	0.004	---	---	---	Tons Produced
3-01-023-12	Absorber/@ 96.0% Conversion	---	---	---	55	0.004	---	---	---	Tons Produced
3-01-023-14	Absorber/@ 95.0% Conversion	---	---	---	70	0.004	---	---	---	Tons Produced
3-01-023-16	Absorber/@ 94.0% Conversion	---	---	---	82	0.004	---	---	---	Tons Produced
3-01-023-18	Absorber/@ 93.0% Conversion	---	---	---	96	0.004	---	---	---	Tons Produced
3-01-023-19	Concentrator	---	---	---	---	---	---	---	---	Tons Produced
3-01-023-20	Tank Car and Truck Unloading	---	---	---	0.1	---	---	---	---	Tons Loaded

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Sulfuric Acid (Contact Process) - 2819</u></i>										
3-01-023-21	Storage Tank Vent	---	---	---	0.1	---	---	---	---	Tons Stored
3-01-023-22	Process Equipment Leaks	---	---	---	---	---	---	---	---	Tons Produced
3-01-023-23	Sulfur Melting and Filtering	---	---	---	---	---	---	---	---	Tons Processed
3-01-023-24	Oleum Tower	---	---	---	---	---	---	---	---	Tons Processed
3-01-023-25	Gas Cleaning and Cooling	---	---	---	---	---	---	---	---	Tons Processed
3-01-023-30	Combustion Chamber	---	---	---	---	---	---	---	---	Tons Processed
3-01-023-31	Drying Tower	---	---	---	---	---	---	---	---	Tons Processed
3-01-023-32	Convertor	---	---	---	---	---	---	---	---	Tons Processed
3-01-023-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Synthetic Organic Fiber Manufacturing - 2824</u></i>										
3-01-024-01	Nylon #6: Staple (Uncontrolled)	---	0.01	---	---	---	4.3	---	---	Tons Produced
3-01-024-02	Polyesters: Staple	0.06	33.3	---	---	---	See App. C	---	---	Tons Produced
3-01-024-03	Polyester: Yarn	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-04	Nylon #6: Yarn	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-05	Polyfluorocarbons (e.g., Teflon)	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-06	Nylon#66: Controlled	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-07	Nylon #66: Uncontrolled	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-08	Acrylic: Copolymer (Inorganic)	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-09	Acrylic: Controlled	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-10	Acrylic: Uncontrolled	---	---	---	---	---	See App. C	---	---	Tons Produced
3-01-024-11	Modacrylic: Dry Spun	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-12	Acrylic and Modacrylic: Wet Spun	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-13	Acrylic: Homopolymer (Inorganic): Wet Spun	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-14	Polyolefin: Melt Spun	---	0.01	---	---	---	74.2	---	---	Tons Produced
3-01-024-15	Vinyls (e.g., Saran)	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-16	Aramid	---	---	---	---	---	4.3	---	---	Tons Produced
3-01-024-17	Spandex: Dry Spun (Use 6-49-300-XX)	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-18	Spandex: Reaction Spun (Use 6-49-310-XX)	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-19	Vinyon: Dry Spun	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-21	Dope Preparation (Use 6-49-300-11 or 6-49-310-11 for Spandex)	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-22	Filtration (Use 6-49-300-12 or 6-49-310-12 for Spandex)	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Synthetic Organic Fiber Manufacturing - 2824</i></u>										
3-01-024-23	Fiber Extrusion (Use 6-49-300-21 of 6-49-310-21 for Spandex)	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-24	Washing/Drying/Finishing (Use 6-49-300-30 or 6-49-310-30 for Spandex)	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-25	Fiber Storage (Use 6-49-300-45 or 6-49-310-45 for Spandex)	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-26	Equipment Cleanup (Use 6-49-300-50 or 6-49-310-50 for Spandex)	---	---	---	---	---	---	---	---	Tons Produced
3-01-024-27	Solvent Storage (Use 4-07-004-01 thru 4-07-999-98 for Spandex)	---	---	---	---	---	---	---	---	Tons Stored
3-01-024-28	Leaching	---	---	---	---	---	---	---	---	Tons Processed
3-01-024-29	Mixing	---	---	---	---	---	---	---	---	Tons Processed
3-01-024-31	Heat Treating Furnace: Carbonization	---	---	---	---	---	---	---	---	Tons Processed
3-01-024-32	Curing Oven: Carbonization	---	---	---	---	---	---	---	---	Tons Processed
3-01-024-34	Fiber Laminate Process	---	---	---	---	---	---	---	---	Tons Processed
3-01-024-35	Fiber Handling and Storage	---	---	---	---	---	---	---	---	Tons Processed
3-01-024-99	Other Not Classified	See App. C	---	---	---	---	See App. C	---	---	Tons Produced
<u><i>Cellulosic Fiber Production - 2823</i></u>										
3-01-025-01	Viscose (e.g., Rayon) (Use 6-49-200-XX)	---	---	---	---	---	---	---	---	Tons Produced
3-01-025-05	Cellulose Acetate: Filer Tow	---	---	---	---	---	290	---	---	Tons Produced
3-01-025-06	Cellulose Acetate and Triacetitic, Filament Yarn	---	---	---	---	---	---	---	---	Tons Produced
3-01-025-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Synthetic Rubber (Manufacturing Only) - 2822</i></u>										
3-01-026-01	General	---	---	---	---	---	5.2	---	---	Tons Produced
3-01-026-02	Butyl (Isobutylene)	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-08	Acrylonitrile	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-09	Dryers	---	---	---	---	---	5.02	---	---	Tons Produced
3-01-026-10	Blowdown Tank	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-11	Steam Stripper	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-12	Pre-storage Tank	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-13	Monomer Recovery: Absorber Vent	---	---	---	---	---	0.52	---	---	Tons Produced
3-01-026-14	Blending Tanks	---	---	---	---	---	0.84	---	---	Tons Produced
3-01-026-15	Isoprene	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Synthetic Rubber (Manufacturing Only) - 2822</i></u>										
3-01-026-16	Latex: Monomer Removal	---	---	---	---	---	16.9	---	---	Tons Produced
3-01-026-17	Latex: Blending Tank	---	---	---	---	---	0.2	---	---	Tons Produced
3-01-026-18	Uninhibited Monomer Storage	---	---	---	---	---	---	---	---	Gallons Stored
3-01-026-19	Inhibited Monomer Storage	---	---	---	---	---	---	---	---	Gallons Stored
3-01-026-20	Monomer Inhibitor Removal	---	---	---	---	---	---	---	---	Gallons Processed
3-01-026-21	Emulsion Crumb Process: Polymerization	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-22	Emulsion Crumb Process: Monomer Recovery: Uncontrolled	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-23	Emulsion Crumb Process: Styrene Recovery	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-24	Emulsion Crumb Process: Crumb Screens	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-25	Chloroprene	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-26	Emulsion Crumb Process: Crumb Bailing and Weighing	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-27	Emulsion Crumb Process: Crumb Storage	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-28	Emulsion Crumb Process: Rotary Press	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-30	Silicone Rubber	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-41	Emulsion Latex Process: Polymerization	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-42	Emulsion Latex Process: Styrene Condenser	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-43	Emulsion Latex Process: Latex Screen Filters	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-44	Emulsion Latex Process: Latex Packaging	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-45	Emulsion Latex Process: Latex Loading	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-46	Emulsion Latex Process: Latex Product Storage	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-50	Fugitive Emissions: Monomer Unloading	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-51	Fugitive Emissions: Soap Solution Storage	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-52	Fugitive Emissions: Activated Catalyst Storage	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-53	Fugitive Emissions: Modifier Storage	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-54	Fugitive Emissions: Stabilizer Storage	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-55	Fugitive Emissions: Antioxidant Storage	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-56	Fugitive Emissions: Carbon Black Storage	---	---	---	---	---	---	---	---	Tons Produced
3-01-026-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Ammonium Nitrate Production - 2873</i></u>										
3-01-027-01	Prilling Tower: Neutralizer	---	---	---	---	---	---	---	---	Tons Produced
3-01-027-04	Neutralizer	0.09 - 8.6	4.35	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Ammonium Nitrate Production - 2873</i></u>										
3-01-027-05	Granulator	0.4	---	---	---	---	---	---	---	Tons Produced
3-01-027-06	Dryers and Coolers	7	---	---	---	---	---	---	---	Tons Produced
3-01-027-07	Rotary Drum Granulator	392	78	---	---	---	---	---	---	Tons Produced
3-01-027-08	Pan Granulator	2.68	0.05	---	---	---	---	---	---	Tons Produced
3-01-027-09	Bulk Loading (General)	< 0.02	0.02	---	---	---	---	---	---	Tons Produced
3-01-027-10	Bagging of Product	0.19	0.16	---	---	---	---	---	---	Tons Produced
3-01-027-11	Neutralizer: High Density	4.35	4.35	---	---	---	---	---	---	Tons Produced
3-01-027-12	Prilling Tower: High Density	3.18	3	---	---	---	---	---	---	Tons Produced
3-01-027-13	High Density Dryers and Coolers (scb)	0.1	---	---	---	---	---	---	---	Tons Produced
3-01-027-14	Prilling Cooler: High Density	1.6	0.01	---	---	---	---	---	---	Tons Produced
3-01-027-17	Evaporator/Concentrator: High Density	0.52	0.49	---	---	---	---	---	---	Tons Produced
3-01-027-18	Coating: High Density	< 4	3.4	---	---	---	---	---	---	Tons Produced
3-01-027-20	Solids Screening	---	---	---	---	---	---	---	---	Tons Produced
3-01-027-21	Neutralizer: Low Density	4.35	4.35	---	---	---	---	---	---	Tons Produced
3-01-027-22	Prilling Tower: Low Density	0.92	0.8	---	---	---	---	---	---	Tons Produced
3-01-027-23	Low Density Dryers and Coolers (scb)	0.08	---	---	---	---	---	---	---	Tons Produced
3-01-027-24	Prilling Cooler: Low Density	51.6	0.2	---	---	---	---	---	---	Tons Produced
3-01-027-25	Prilling Dryer: Low Density	114	0.2	---	---	---	---	---	---	Tons Produced
3-01-027-27	Evaporator/Concentrator: Low Density	0.52	0.49	---	---	---	---	---	---	Tons Produced
3-01-027-28	Coating: Low Density	4	3.4	---	---	---	---	---	---	Tons Produced
3-01-027-29	Rotary Drum Granulator Coolers	16.2	0.5	---	---	---	---	---	---	Tons Produced
3-01-027-30	Pan Granulator Coolers	36.6	0.5	---	---	---	---	---	---	Tons Produced
<u><i>Normal Superphosphates - 2874</i></u>										
3-01-028-01	Grinding/Drying	---	4.6	---	---	---	---	---	---	Tons Produced
3-01-028-03	Rock Unloading	0.56	0.29	---	---	---	---	---	---	Tons Produced
3-01-028-04	Rock Feeder System	0.11	0.06	---	---	---	---	---	---	Tons Produced
3-01-028-05	Mixer/Den	0.52	0.27	---	---	---	---	---	---	Tons Produced
3-01-028-06	Curing/Building	7.2	6.1	---	---	---	---	---	---	Tons Produced
3-01-028-07	Bagging/Handling	---	---	---	---	---	---	---	---	Tons Produced
3-01-028-20	Mixing	---	---	---	---	---	---	---	---	Tons Produced
3-01-028-21	Den	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Normal Superphosphates - 2874</u>										
3-01-028-22	Curing	---	---	---	---	---	---	---	---	Tons Produced
3-01-028-23	Ammoniator/Granulator	---	---	---	---	---	---	---	---	Tons Granulated
3-01-028-24	Dryer	---	---	---	---	---	---	---	---	Tons Granulated
3-01-028-25	Cooler	---	---	---	---	---	---	---	---	Tons Granulated
3-01-028-26	Pulverizer: Granular Phosphate	---	---	---	---	---	---	---	---	Tons Granulated
<u>Triple Superphosphate - 2874</u>										
3-01-029-03	Rock Unloading	0.14	0.07	---	---	---	---	---	---	Tons Produced
3-01-029-04	Rock Feeder System	0.03	0.02	---	---	---	---	---	---	Tons Produced
3-01-029-05	Run of Pile: Mixer/Den/Curing	0.03	0.02	---	---	---	---	---	---	Tons Produced
3-01-029-06	Granulator: Reactor/Dryer	0.1	0.05	---	---	---	---	---	---	Tons Produced
3-01-029-07	Granulator: Curing	0.2	0.1	---	---	---	---	---	---	Tons Produced
3-01-029-08	Bagging/Handling	---	---	---	---	---	---	---	---	Tons Produced
3-01-029-09	Mechanical Cutting	---	---	---	---	---	---	---	---	Tons Produced
3-01-029-10	Crushing and Screening	---	---	---	---	---	---	---	---	Tons Produced
3-01-029-20	Mixing	---	---	---	---	---	---	---	---	Tons Produced
3-01-029-21	Den	---	---	---	---	---	---	---	---	Tons Produced
3-01-029-22	Curing	---	---	---	---	---	---	---	---	Tons Produced
3-01-029-23	Ammoniator/Granulator	---	---	---	---	---	---	---	---	Tons Granulated
3-01-029-24	Dryer	---	---	---	---	---	---	---	---	Tons Granulated
3-01-029-25	Cooler	---	---	---	---	---	---	---	---	Tons Granulated
<u>Ammonium Phosphates - 2874</u>										
3-01-030-00	Entire Plant	---	---	---	---	---	---	---	---	
3-01-030-01	Dryers and Coolers	1.5	1.3	---	3.1	1.7	0.03	---	---	Tons Produced
3-01-030-02	Ammoniator/Granulator	1.52	1.3	---	0.3	---	---	---	---	Tons Produced
3-01-030-03	Screening/Transfer	0.06	---	---	---	---	---	---	---	Tons Produced
3-01-030-04	Bagging/Handling	---	---	---	---	---	---	---	---	Tons Produced
3-01-030-20	Mixing	---	---	---	---	---	---	---	---	Tons Produced
3-01-030-21	Den	---	---	---	---	---	---	---	---	Tons Produced
3-01-030-22	Curing	---	---	---	---	---	---	---	---	Tons Produced
3-01-030-23	Ammoniator/Granulator	---	---	---	---	---	---	---	---	Tons Granulated
3-01-030-24	Dryer	---	---	---	---	---	---	---	---	Tons Granulated

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Ammonium Phosphates - 2874</i></u>										
3-01-030-25	Cooler	---	---	---	---	---	---	---	---	Tons Granulated
3-01-030-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Terephthalic Acid/Dimethyl Terephthalate - 2869</i></u>										
3-01-031-01	HNO <sub>3</sub> - Para-xylene: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-031-02	Reactor Vent	---	---	---	---	---	30	34	---	Tons Produced
3-01-031-03	Crystallization, Separation, and Drying Vent	---	---	---	---	---	3.8	---	---	Tons Produced
3-01-031-04	Distillation and Recovery Vent	---	---	---	---	---	2.2	---	---	Tons Produced
3-01-031-05	Product Transfer Vent	---	---	---	---	---	3.6	4	---	Tons Produced
3-01-031-06	Gas/Liquid Separator	---	---	---	---	---	---	---	---	Tons Produced
3-01-031-07	High Pressure Absorber	---	---	---	---	---	---	---	---	Tons Produced
3-01-031-08	Solid/Liquid Separator	---	---	---	---	---	---	---	---	Tons Produced
3-01-031-09	Residue Still	---	---	---	---	---	---	---	---	Tons Produced
3-01-031-10	C-TPA Purification	---	---	---	---	---	---	---	---	Tons Produced
3-01-031-80	Fugitive Emissions	---	---	---	---	---	294400	---	---	Each-Year Operating
3-01-031-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Elemental Sulfur Production - 2819</i></u>										
3-01-032-01	Mod. Claus: 2 Stage w/o Control (92-95% Removal)	---	---	---	280	0.35	3	---	---	Tons Produced
3-01-032-02	Mod. Claus: 3 Stage w/o Control (95-96% Removal)	---	---	---	189	0.1	9.1	---	---	Tons Produced
3-01-032-03	Mod. Claus: 4 Stage w/o Control (96-97% Removal)	---	---	---	145	0.1	---	---	---	Tons Produced
3-01-032-04	Sulfur Removal Process (99.9% Removal)	---	---	---	---	0.1	0.05	---	---	Tons Produced
3-01-032-05	Sulfur Storage	---	---	---	---	---	---	---	---	Tons Stored
3-01-032-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Pesticides - 2879</i></u>										
3-01-033-01	Malathion	---	---	---	---	---	0.01	---	---	Gallons Produced
3-01-033-11	General	---	---	---	---	---	---	---	---	Gallons Stored
3-01-033-12	General	---	---	---	---	---	---	---	---	Pounds Stored
3-01-033-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Aniline/Ethanolamines - 2869</i></u>										
3-01-034-02	General: Aniline	---	---	---	---	---	0.2	---	---	Tons Produced
3-01-034-03	Reactor Cycle Purge Vent	---	---	---	---	---	---	---	---	Tons Produced



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Aniline/Ethanolamines - 2869</u></i>										
3-01-034-04	Dehydration Column Vent	---	---	---	---	---	---	---	---	Tons Produced
3-01-034-05	Purification Column Vent	---	---	---	---	---	---	---	---	Tons Produced
3-01-034-06	Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-034-10	General: Ethanolamines	---	---	---	---	---	---	---	---	Tons Produced
3-01-034-11	Ammonia Scrubber Vent	---	---	---	---	---	---	---	---	Tons Produced
3-01-034-12	Vacuum Distillation: Jet Vent	---	---	---	---	---	---	---	---	Tons Produced
3-01-034-14	Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-034-15	Ethylenediamine	---	---	---	---	---	---	---	---	Tons Produced
3-01-034-20	Hexamethylenediamine	---	---	---	---	---	---	---	---	Tons Produced
3-01-034-25	Hexamethylenetetramine	---	---	---	---	---	---	---	---	Tons Produced
3-01-034-30	Melamine	---	---	---	---	---	---	---	---	Tons Produced
3-01-034-35	Methylamines	---	---	---	---	---	---	---	---	Tons Produced
3-01-034-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Inorganic Pigments - 2816</u></i>										
3-01-035-01	TiO <sub>2</sub> Sulfate Process: Calciner	---	27.6	---	---	---	---	---	---	Tons Produced
3-01-035-02	TiO <sub>2</sub> Sulfate Process: Digester	---	---	---	3.6	---	---	---	---	Tons Produced
3-01-035-03	TiO <sub>2</sub> Chloride Process: Reactor	---	---	---	---	---	---	---	---	Tons Produced
3-01-035-06	Lead Oxide: Barton Pot	0.43 - 0.85	0.64	---	---	---	---	---	0.44	Tons Produced
3-01-035-07	Lead Oxide: Calciner	14.27	15	---	---	---	---	---	14	Tons Produced
3-01-035-10	Red Lead	1	1	---	---	---	---	---	0.9	Tons Produced
3-01-035-15	White Lead	---	0.69	---	---	---	---	---	0.55	Tons Produced
3-01-035-20	Lead Chromate	---	0.2	---	---	---	---	---	0.13	Tons Produced
3-01-035-50	Ore Grinding	---	---	---	---	---	---	---	---	Tons Produced
3-01-035-51	Ore Dryer	---	6.9	---	---	---	---	---	---	Tons Produced
3-01-035-52	Pigment Milling	---	---	---	---	---	---	---	---	Tons Produced
3-01-035-53	Pigment Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-01-035-54	Conveying/Storage/Packing	---	---	---	---	---	---	---	---	Tons Produced
3-01-035-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Sodium Bicarbonate - 2812</u></i>										
3-01-038-01	General	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Hydrogen Cyanide - 2819</u>										
3-01-039-01	Air Heater: General	---	---	---	---	---	14	---	---	Tons Produced
3-01-039-02	Ammonia Absorber	---	---	---	---	---	---	---	---	Tons Produced
3-01-039-03	HCN Absorber	---	---	---	---	---	---	---	---	Tons Produced
<u>Urea Production - 2873</u>										
3-01-040-01	General: Specify in Comments	---	---	---	---	---	---	---	---	Tons Produced
3-01-040-02	Solution Concentration (Controlled)	0.021	0.011	---	---	---	---	---	---	Tons Produced
3-01-040-03	Prilling	3.8	3.57	---	---	---	---	---	---	Tons Produced
3-01-040-04	Drum Granulation	241	4.82	---	---	---	0.009	---	---	Tons Produced
3-01-040-05	Coating	4	3.4	---	---	---	---	---	---	Tons Produced
3-01-040-06	Bagging	0.19	0.16	---	---	---	---	---	---	Tons Produced
3-01-040-07	Bulk Loading	0.02	0.017	---	---	---	---	---	---	Tons Produced
3-01-040-08	Non-fluidized Bed Prilling (Agricultural Grade)	3.8	3.4	---	---	---	---	---	---	Tons Produced
3-01-040-09	Non-fluidized Bed Prilling (Feed Grade)	3.6	3.1	---	---	---	---	---	---	Tons Produced
3-01-040-10	Fluidized Bed Prilling (Agricultural Grade)	6.2	3.7	---	---	---	0.02	---	---	Tons Produced
3-01-040-11	Fluidized Bed Prilling (Feed Grade)	3.6	0.86	---	---	---	0.004	---	---	Tons Produced
3-01-040-12	Rotary Drum Cooler	7.78	5.4	---	---	---	---	---	---	Tons Produced
3-01-040-13	Solids Screening	---	---	---	---	---	---	---	---	Tons Produced
3-01-040-14	Pan Granulation	---	---	---	---	---	---	---	---	Tons Produced
3-01-040-20	Solution Synthesis	---	---	---	---	---	---	---	---	Tons Produced
<u>Nitrocellulose - 2892</u>										
3-01-041-01	Nitration Reactor	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-02	Sulfuric Acid Concentrators	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-03	Boiling Tubs	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-04	Nitric Acid Concentrators	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-05	Nitric/Sulfuric Acid Mixing	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-06	Batch Process: Purification Beaters	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-07	Batch Process: Purification Poacher	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-08	Batch Process: Purification Blender	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-09	Batch Process: Purification Wringer	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-10	Raw Cellulose Purification	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-20	Batch Process: Spent Acid Recovery	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Nitrocellulose - 2892</i>										
3-01-041-21	Batch Process: Spent Acid Recovery: Denitrating Tower	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-22	Batch Process: Spent Acid Recovery: Sulfuric Acid Regenerator	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-23	Batch Process: Spent Acid Recovery: Bleacher	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-24	Batch Process: Spent Acid Recovery: Reflux Columns	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-30	Batch Process: Nitric Acid Concentration	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-31	Batch Process: Nitric Acid Concentration: Distillation Tower	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-32	Batch Process: Nitric Acid Concentration: Bleacher	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-33	Batch Process: Nitric Acid Concentration: Condenser	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-34	Batch Process: Nitric Acid Concentration: Absorber Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-35	Batch Process: Nitric Acid Concentration: Dehydrating Unit	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-50	Continuous Process: Nitration Reactors	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-51	Continuous Process: Sulfuric Acid Concentrators	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-52	Continuous Process: Purification Boiling Tubs	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-53	Continuous Process: Nitric Acid Concentrators	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-54	Continuous Process: Purification Beaters	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-55	Continuous Process: Purification Poacher	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-56	Continuous Process: Purification Blender	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-57	Continuous Process: Purification Wringer	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-60	Continuous Process: Spent Acid Recovery	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-61	Continuous Process: Spent Acid Recovery: Denitrating Tower	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-62	Continuous Process: Spent Acid Recovery: Sulfuric Acid Regenerator	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-63	Continuous Process: Spent Acid Recovery: Bleacher	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-64	Continuous Process: Spent Acid Recovery: Reflux Columns	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-70	Continuous Process: Nitric Acid Concentration	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-71	Continuous Process: Nitric Acid Concentration: Distillation Tower	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-72	Continuous Process: Nitric Acid Concentration: Bleacher	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Nitrocellulose - 2892</u>										
3-01-041-73	Continuous Process: Nitric Acid Concentration: Condenser	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-74	Continuous Process: Nitric Acid Concentration: Absorber Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-75	Continuous Process: Nitric Acid Concentration: Dehydrating Unit	---	---	---	---	---	---	---	---	Tons Produced
3-01-041-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Lead Alkyl Manufacturing (Sodium/Lead Alloy Process) - 2869</u>										
3-01-042-01	Recovery Furnace	59.3	59.3	---	---	2.67	---	---	55	Tons Produced
3-01-042-02	Process Vents: Tetraethyl Lead	---	---	---	---	---	---	---	4	Tons Produced
3-01-042-03	Process Vents: Tetramethyl Lead	---	---	---	---	---	---	---	150	Tons Produced
3-01-042-04	Sludge Pits	---	1.9	---	---	---	---	---	1.2	Tons Produced
<u>Lead Alkyl Manufacturing (Electrolytic Process) - 2869</u>										
3-01-043-01	General	---	---	---	---	---	---	---	1	Tons Produced
<u>Organic Fertilizer - 2873</u>										
3-01-045-01	General: Mixing/Handling	---	---	---	---	---	---	---	---	Tons Processed
<u>Adhesives - 1311, 2491, 2653, 2679, 2821, 2824, 2843, 2851, 28</u>										
3-01-050-01	General/Compound Unknown	---	---	---	---	---	---	---	---	Tons Produced
<u>Animal Adhesives - 2834, 2899, 2890, 2891</u>										
3-01-051-01	Animal Adhesives	---	---	---	---	---	---	---	---	Tons Produced
3-01-051-05	Raw Materials Grinding	---	---	---	---	---	---	---	---	Tons Processed
3-01-051-08	Degreasing	---	---	---	---	---	---	---	---	Tons Produced
3-01-051-10	Lining/Plumping	---	---	---	---	---	---	---	---	Tons Produced
3-01-051-12	Washing	---	---	---	---	---	---	---	---	Tons Produced
3-01-051-14	Cooking	---	---	---	---	---	---	---	---	Tons Produced
3-01-051-16	Hot Water Extractions	---	---	---	---	---	---	---	---	Tons Produced
3-01-051-18	Filtering/Centrifuging	---	---	---	---	---	---	---	---	Tons Produced
3-01-051-20	Evaporation	---	---	---	---	---	---	---	---	Tons Produced
3-01-051-22	Chilling	---	---	---	---	---	---	---	---	Tons Produced
3-01-051-24	Drying	---	---	---	---	---	---	---	---	Tons Produced
3-01-051-30	End Product Finishing	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Casein - 2821, 2824, 2891, 3089</u>										
3-01-052-01	Casein Manufacture	---	---	---	---	---	---	---	---	Tons Produced
3-01-052-05	Precipitation	---	---	---	---	---	---	---	---	Tons Produced
3-01-052-10	Draining	---	---	---	---	---	---	---	---	Tons Produced
3-01-052-11	Draining: Batch Method	---	---	---	---	---	---	---	---	Tons Produced
3-01-052-12	Draining: Continuous Method	---	---	---	---	---	---	---	---	Tons Produced
3-01-052-15	Washing	---	---	---	---	---	---	---	---	Tons Produced
3-01-052-20	Dewatering	---	---	---	---	---	---	---	---	Tons Produced
3-01-052-21	Dewatering: Continuous Power Press	---	---	---	---	---	---	---	---	Tons Produced
3-01-052-22	Dewatering: Hand Press	---	---	---	---	---	---	---	---	Tons Produced
3-01-052-30	Grinding Curd	---	---	---	---	---	---	---	---	Tons Produced
3-01-052-35	Drying	---	---	---	---	---	---	---	---	Tons Produced
3-01-052-40	Grinding, Packaging, and Storing	---	---	---	---	---	---	---	---	Tons Produced
<u>Pharmaceutical Preparations - 2834</u>										
3-01-060-01	Vacuum Dryers	---	---	---	---	---	---	---	---	100 Pounds Produced
3-01-060-02	Reactors	---	---	---	---	---	---	---	---	100 Pounds Produced
3-01-060-03	Distillation Units	---	---	---	---	---	---	---	---	100 Pounds Produced
3-01-060-04	Filters	---	---	---	---	---	---	---	---	100 Pounds Produced
3-01-060-05	Extractors	---	---	---	---	---	---	---	---	100 Pounds Produced
3-01-060-06	Centrifuges	---	---	---	---	---	---	---	---	100 Pounds Produced
3-01-060-07	Crystallizers	---	---	---	---	---	---	---	---	100 Pounds Produced
3-01-060-08	Exhaust Systems	---	---	---	---	---	---	---	---	100 Pounds Produced
3-01-060-09	Air Dryers	---	---	---	---	---	---	---	---	100 Pounds Produced
3-01-060-10	Storage/Transfer	---	---	---	---	---	---	---	---	100 Pounds Produced
3-01-060-11	Coating Process	---	---	---	---	---	---	---	---	Tons Consumed
3-01-060-12	Granulation Process	---	---	---	---	---	---	---	---	Tons Consumed
3-01-060-13	Fermentation Tanks	---	---	---	---	---	---	---	---	100 Pounds Produced
3-01-060-21	Raw Material Unloading	---	---	---	---	---	---	---	---	Tons Processed
3-01-060-22	Miscellaneous Fugitives	---	---	---	---	---	---	---	---	Tons Processed
3-01-060-23	Miscellaneous Fugitives	---	---	---	---	---	---	---	---	Tons Processed
3-01-060-99	Other Not Classified	---	---	---	---	---	---	---	---	100 Pounds Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Inorganic Chemical Manufacturing (General) - 2812, 2813, 2816, 2819</u>										
3-01-070-01	Fugitive Leaks	---	---	---	---	---	---	---	---	Tons Produced
3-01-070-02	Storage/Transfer	---	---	---	---	---	---	---	---	Tons Produced
<u>Hydrogen - 2813</u>										
3-01-071-01	Reformers	---	---	---	---	---	---	---	---	Million Cubic Feet Processed
3-01-071-02	CO Converter	---	---	---	---	---	---	---	---	Million Cubic Feet Processed
3-01-071-03	Hydrogen Storage	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
<u>Acetone/Ketone Production - 2869</u>										
3-01-091-01	Acetone: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-091-05	Methyl Ethyl Ketone	---	---	---	---	---	2.4	---	---	Tons Produced
3-01-091-10	Methyl Isobutyl Ketone	---	---	---	---	---	---	---	---	Tons Produced
3-01-091-51	Acetone: Cumene Oxidation	---	---	---	---	---	---	---	---	Tons Produced
3-01-091-52	Acetone: CHP Concentrator	---	---	---	---	---	---	---	---	Tons Produced
3-01-091-53	Acetone: Light-ends Distillation Vent	---	---	---	---	---	---	---	---	Tons Produced
3-01-091-54	Acetone: Finishing Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-091-80	Acetone: Fugitive Emissions	---	---	---	---	---	452000	---	---	Each-Year Operating
3-01-091-99	Ketone: Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Maleic Anhydride - 2865</u>										
3-01-100-02	Product Recovery Absorber	---	---	---	---	---	174	---	---	Tons Produced
3-01-100-03	Vacuum System Vent	---	---	---	---	---	0.2	---	---	Tons Produced
3-01-100-04	Briquetting	---	---	---	---	---	2.5	---	---	Tons Produced
3-01-100-05	Secondary Sources: Dehydration Column, Vacuum System	---	---	---	---	---	0.2	---	---	Tons Produced
3-01-100-80	Fugitive Emissions	---	---	---	---	---	62300	---	---	Each-Year Operating
3-01-100-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Asbestos Chemical - 3999, 2819,</u>										
3-01-111-03	Brake Line/Grinding	---	---	---	---	---	---	---	---	Tons Produced
3-01-111-99	Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Elemental Phosphorous - 2819</u>										
3-01-112-01	Calciner	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Elemental Phosphorous - 2819</u>										
3-01-112-02	Furnace	---	---	---	---	---	---	---	---	Tons Processed
3-01-112-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Boric Acid - 2800</u>										
3-01-113-01	Dryer	---	0.58	---	---	---	---	---	---	Tons Dried
<u>Potassium Chloride - 2800</u>										
3-01-114-01	Dryer	---	2.68	---	---	---	---	---	---	Tons Produced
<u>Aluminum Sulfate Manufacturing - 2819</u>										
3-01-115-01	Bauxite Unloading	---	---	---	---	---	---	---	---	Tons Processed
3-01-115-02	Hammer Mill	---	---	---	---	---	---	---	---	Tons Processed
3-01-115-03	Bauxite Storage	---	---	---	---	---	---	---	---	Tons Processed
3-01-115-04	Elevator	---	---	---	---	---	---	---	---	Tons Processed
3-01-115-05	Conveyor	---	---	---	---	---	---	---	---	Tons Processed
3-01-115-06	Cooker	---	---	---	---	---	---	---	---	Tons Processed
3-01-115-07	Alums Storage	---	---	---	---	---	---	---	---	Tons Processed
3-01-115-08	H2SO4 Process Tank	---	---	---	---	---	---	---	---	Tons Processed
3-01-115-09	Alums Loading	---	---	---	---	---	---	---	---	Tons Processed
<u>Formaldahyde, Acrolein, Acetaldehyde, Butyraldehyde - 2869</u>										
3-01-120-01	Formaldehyde: Silver Catalyst	---	---	---	---	---	13	36	---	Tons Produced
3-01-120-02	Formaldehyde: Mixed Oxide Catalyst	---	---	---	---	---	16	---	---	Tons Produced
3-01-120-05	Formaldehyde: Absorber Vent	---	---	---	---	---	---	---	---	Tons Produced
3-01-120-06	Formaldehyde: Fractionator Vent	---	---	---	---	---	---	---	---	Tons Produced
3-01-120-07	Formaldehyde: Fugitive Emissions	---	---	---	---	---	35700	---	---	Each-Year Operating
3-01-120-11	Acetaldehyde from Ethylene	---	---	---	---	---	2.8	---	---	Tons Produced
3-01-120-12	Acetaldehyde from Ethanol	---	---	---	---	---	0.04	5.5	---	Tons Produced
3-01-120-13	Acetaldehyde: Off-air Absorber Vent	---	---	---	---	---	4.5	---	---	Tons Produced
3-01-120-14	Acetaldehyde: Off-gas Absorber Vent	---	---	---	---	---	5.6	---	---	Tons Produced
3-01-120-17	Acetaldehyde: Fugitive Emissions	---	---	---	---	---	165000	---	---	Each-Year Operating
3-01-120-21	Butyraldehyde: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-120-31	Acrolein: CO2 Stripping Tower	---	---	---	---	---	120	---	---	Tons Produced
3-01-120-32	Acrolein: Aqueous Acrolein Receiver	---	---	---	---	---	6	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Formaldahyde, Acrolein, Acetaldehyde, Butyraldehyde - 2869</u>										
3-01-120-33	Acrolein: Distillation System	---	---	---	---	---	15	---	---	Tons Produced
3-01-120-34	Acrolein: Refrigeration Unit	---	---	---	---	---	54	---	---	Tons Produced
3-01-120-37	Acrolein: Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-120-99	Acrolein: Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Organic Dyes/Pigments - 2865</u>										
3-01-121-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Chloroprene - 2869</u>										
3-01-124-01	General	---	---	---	---	---	11.17	---	---	Tons Produced
3-01-124-02	Butadiene Dryer	---	---	---	---	---	2.4	---	---	Tons Produced
3-01-124-03	Chlorination Reactor	---	---	---	---	---	0.47	---	---	Tons Produced
3-01-124-04	Dichlorobutene Still	---	---	---	---	---	7.8	---	---	Tons Produced
3-01-124-05	Isomerization and 3,4-DCB Recovery Vent	---	---	---	---	---	0.3	---	---	Tons Produced
3-01-124-06	Chloroprene Stripper	---	---	---	---	---	0.3	---	---	Tons Produced
3-01-124-07	Brine Stripper	---	---	---	---	---	0.3	---	---	Tons Produced
3-01-124-80	Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Chlorine Derivatives - 2869</u>										
3-01-125-01	Ethylene Dichloride via Oxychlorination	---	---	---	---	---	---	---	---	Tons Produced
3-01-125-02	Ethylene Dichloride via Direct Chlorination	---	---	---	---	---	---	---	---	Tons Produced
3-01-125-04	Ethylene Dichloride: Caustic Scrubber	---	---	---	---	---	---	---	---	Tons Produced
3-01-125-05	Ethylene Dichloride: Reactor Vessel	---	---	---	---	---	---	---	---	Tons Produced
3-01-125-06	Ethylene Dichloride: Distillation Unit	---	---	---	---	---	---	---	---	Tons Produced
3-01-125-09	Ethylene Dichloride: Fugitive Emissions	---	---	---	---	---	182000	---	---	Each-Year Operating
3-01-125-10	Chloromethanes: General	---	---	---	---	---	12.3	---	---	Tons Produced
3-01-125-11	Chloromethanes: Recycled Methane Inert-purge	---	---	---	---	---	4.2	---	---	Tons Produced
3-01-125-12	Chloromethanes: Drying Bed Regeneration Vent	---	---	---	---	---	0.1	---	---	Tons Produced
3-01-125-14	Chloromethanes: Fugitive Emissions	---	---	---	---	---	482000	---	---	Each-Year Operating
3-01-125-15	Ethyl Chloride: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-125-20	Perchloroethylene: General	---	---	---	---	---	2.7	---	---	Tons Produced
3-01-125-21	Perchloroethylene: Distillation Vent	---	---	---	---	---	0.8	---	---	Tons Produced
3-01-125-22	Perchloroethylene: Caustic Scrubber	---	---	---	---	---	---	---	---	Tons Produced
3-01-125-24	Perchloroethylene: Fugitive Emissions	---	---	---	---	---	365000	---	---	Each-Year Operating



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Chlorine Derivatives - 2869</i>										
3-01-125-25	Trichloroethane: General	---	---	---	---	---	5.2	---	---	Tons Produced
3-01-125-26	Trichloroethane: HCl Absorber Vent	---	---	---	---	---	0.2	---	---	Tons Produced
3-01-125-27	Trichloroethane: Drying Column Vent	---	---	---	---	---	---	---	---	Tons Produced
3-01-125-28	Trichloroethane: Distillation Column Vent	---	---	---	---	---	0.38	---	---	Tons Produced
3-01-125-29	Trichloroethane: Fugitive Emissions	---	---	---	---	---	77400	---	---	Each-Year Operating
3-01-125-30	Trichloroethylene: General	---	---	---	---	---	1.3	---	---	Tons Produced
3-01-125-31	Trichloroethylene: Distillation Unit	---	---	---	---	---	---	---	---	Tons Produced
3-01-125-32	Trichloroethylene: Neutralizer	---	---	---	---	---	---	---	---	Tons Produced
3-01-125-33	Trichloroethylene: Product Drying Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-125-34	Trichloroethylene: Fugitive Emissions	---	---	---	---	---	365000	---	---	Each-Year Operating
3-01-125-35	Chlorobenzenes: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-125-40	Vinyl Chloride: General	---	---	---	---	---	6.5	---	---	Tons Produced
3-01-125-41	Vinyl Chloride: Cracking Furnace	---	---	---	---	---	---	---	---	Tons Produced
3-01-125-42	Vinyl Chloride: HCl Recovery	0.2	---	---	---	---	0.2	---	---	Tons Produced
3-01-125-43	Vinyl Chloride: Light-ends Recovery	---	---	---	---	---	2	---	---	Tons Produced
3-01-125-44	Dichloroethane: Drying Column	---	---	---	---	---	1	---	---	Tons Produced
3-01-125-45	Vinyl Chloride Monomer: Drying Column	---	---	---	---	---	1	---	---	Tons Produced
3-01-125-46	Vinyl Chloride: Product Recovery Still	---	---	---	---	---	---	---	---	Tons Produced
3-01-125-47	Vinyl Chloride: Cracking Furnace Decoking	---	---	---	---	---	---	---	---	Tons Produced
3-01-125-50	Vinyl Chloride: Fugitive Emissions	---	---	---	---	---	274000	---	---	Each-Year Operating
3-01-125-51	Vinylidene Chloride: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-125-52	Vinylidene Chloride: Dehydrochlorination Reactor	---	---	---	---	---	12.4	---	---	Tons Produced
3-01-125-53	Vinylidene Chloride: Distillation Column Vent	---	---	---	---	---	1.4	---	---	Tons Produced
3-01-125-55	Vinylidene Chloride: Fugitive Emissions	---	---	---	---	---	19000	---	---	Each-Year Operating
3-01-125-56	Chloromethanes via MH & MCC Processes: Inert-gas Purge Vent	---	---	---	---	---	3	---	---	Tons Produced
3-01-125-57	Chloromethanes via MH & MCC Processes: Methylene Chloride Condenser	---	---	---	---	---	0.04	---	---	Tons Produced
3-01-125-58	Chloromethanes via MH & MCC Processes: Chloroform Condenser	---	---	---	---	---	0.01	---	---	Tons Produced
3-01-125-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Brominated Organics - 2869</i></u>										
3-01-126-99	Bromine Organics	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Fluorocarbons/Chlorofluorocarbons - 2869</i></u>										
3-01-127-01	General	---	---	---	---	---	14.5	---	---	Tons Produced
3-01-127-02	Distillation Column	---	---	---	---	---	12.7	---	---	Tons Produced
3-01-127-03	HCl Recovery Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-127-20	Chlorofluorocarbon 12/11	---	---	---	---	---	6.2	---	---	Tons Produced
3-01-127-30	Chlorofluorocarbon 23/22	---	---	---	---	---	38	---	---	Tons Produced
3-01-127-40	Chlorofluorocarbon 113/114	---	---	---	---	---	13.2	---	---	Tons Produced
3-01-127-80	Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
<u><i>Ammonium Sulfate (Use 3-01-210 for Caprolactum Production) - 2873</i></u>										
3-01-130-01	Caprolactum By-product Plants	---	---	---	---	---	---	---	---	Tons Produced
3-01-130-03	Process Vents	---	---	---	---	---	---	---	---	Tons Produced
3-01-130-04	Caprolactum By-product: Rotary Dryer	46	---	---	---	---	1.48	---	---	Tons Produced
3-01-130-05	Caprolactum By-product: Fluid Bed Dryer	218	21.8	---	---	---	1.48	---	---	Tons Produced
3-01-130-06	Caprolactum By-product: Crystallizer (Evaporator)	---	---	---	---	---	---	---	---	Tons Produced
3-01-130-07	Caprolactum By-product: Screening	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Organic Acid Manufacturing - 2869</i></u>										
3-01-132-01	Acetic Acid via Methanol	---	---	---	---	0.06	4	---	---	Tons Produced
3-01-132-05	Acetic Acid via Butane	---	---	---	---	0.08	14	27.1	---	Tons Produced
3-01-132-10	Acetic Acid via Acetaldehyde	---	---	---	---	---	22	---	---	Tons Produced
3-01-132-21	General: Acrylic Acid	---	---	---	---	---	240	---	---	Tons Produced
3-01-132-22	Quench Absorber	---	---	---	---	---	238.6	---	---	Tons Produced
3-01-132-23	Extraction Column	---	---	---	---	---	0.29	---	---	Tons Produced
3-01-132-24	Vacuum System	---	---	---	---	---	7.6	---	---	Tons Produced
3-01-132-27	Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-132-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Acetic Anhydride - 2869</i></u>										
3-01-133-01	General	---	---	---	---	---	5.5	9.9	---	Tons Produced
3-01-133-02	Reactor By-product Gas Vent	---	---	---	---	---	9	14	---	Tons Produced
3-01-133-03	Distillation Column Vent	---	---	---	---	---	1.4	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Acetic Anhydride - 2869</u>										
3-01-133-80	Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Esters Production - 2869</u>										
3-01-137-01	Ethyl Acrylate	---	---	---	---	---	---	---	---	Tons Produced
3-01-137-10	Butyl Acrylate	---	---	---	---	---	---	---	---	Tons Produced
3-01-137-99	Acrylates: Specify in Comments	---	---	---	---	---	---	---	---	Tons Produced
<u>Acetylene Production - 2813</u>										
3-01-140-01	Raw Material Handling	---	---	---	---	---	---	---	---	Tons Throughput
3-01-140-02	Grinding/Milling	---	---	---	---	---	---	---	---	Tons Throughput
3-01-140-03	Mixing	---	---	---	---	---	---	---	---	Tons Throughput
3-01-140-04	Waste Handling	---	---	---	---	13.5	9.3	---	---	Tons Throughput
3-01-140-05	General	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
<u>Bisphenol A - 2869</u>										
3-01-152-01	General	---	---	---	---	---	---	---	---	Tons Produced
<u>Butadiene - 2869</u>										
3-01-153-01	General	---	---	---	---	---	---	---	---	Tons Produced
3-01-153-10	Houdry Process: Total	---	---	---	---	---	23	---	---	Tons Produced
3-01-153-11	Houdry Process: Flue Gas Vent	---	---	---	---	---	0.1	---	---	Tons Produced
3-01-153-12	Houdry Process: Dehydrogenation Reactor	---	---	---	---	---	6.6	---	---	Tons Produced
3-01-153-20	n-Butene Process: Total	---	---	---	---	---	23.2	---	---	Tons Produced
3-01-153-21	n-Butene Process: Flue Gas Vent	---	---	---	---	---	0.1	---	---	Tons Produced
3-01-153-22	n-Butene Process: Hydrocarbon Absorber Column	---	---	---	---	---	10	---	---	Tons Produced
3-01-153-80	Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Cumene - 2865</u>										
3-01-156-01	General	---	---	---	---	---	1.1	---	---	Tons Produced
3-01-156-02	Aluminum Chloride Catalyst Process: Benzene Drying Column	---	---	---	---	---	0.04	---	---	Tons Produced
3-01-156-03	Aluminum Chloride Catalyst Process: Catalyst Mix Tank Scrubber Vent	---	---	---	---	---	0.3	---	---	Tons Produced
3-01-156-04	Aluminum Chloride Catalyst Process: Wash-Decant System Vent	---	---	---	---	---	0.02	---	---	Tons Produced
3-01-156-05	Aluminum Chloride Catalyst Process: Benzene Recovery	---	---	---	---	---	0.03	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Cumene - 2865</u>										
3-01-156-06	Aluminum Chloride Catalyst Process: Cumene Distillation Vent	---	---	---	---	---	0.06	---	---	Tons Produced
3-01-156-07	Aluminum Chloride Catalyst Process: DIPB Stripping Vent	---	---	---	---	---	0.002	---	---	Tons Produced
3-01-156-09	Solid Phosphoric Acid Catalyst Process: Cumene Distillation Sys. Vent	---	---	---	---	---	0.06	---	---	Tons Produced
3-01-156-80	Fugitive Emissions	---	---	---	---	---	149000	---	---	Each-Year Operating
<u>Cyclohexane - 2865</u>										
3-01-157-01	General	---	---	---	---	---	---	---	---	Tons Produced
3-01-157-02	Blowdown Tank Discharge	---	---	---	---	---	0.006	---	---	Tons Produced
3-01-157-03	Pumps/Valves/Compressors	---	---	---	---	---	1.5	---	---	Tons Produced
3-01-157-04	Catalyst Replacement	---	---	---	---	---	---	---	---	Tons Removed
3-01-157-80	Fugitive Emissions	---	---	---	---	---	240000	---	---	Each-Year Operating
<u>Cyclohexanone/Cyclohexanol - 2869</u>										
3-01-158-01	General	---	---	---	---	---	44.4	---	---	Tons Produced
3-01-158-02	High Pressure Scrubber Vent	---	---	---	---	---	33.8	85.2	---	Tons Produced
3-01-158-03	Low Pressure Scrubber Vent	---	---	---	---	---	5.3	19.4	---	Tons Produced
3-01-158-21	Hydrogenation Reactor Vent	---	---	---	---	---	3	---	---	Tons Produced
3-01-158-22	Distillation Vent	---	---	---	---	---	0.12	---	---	Tons Produced
3-01-158-80	Fugitive Emissions	---	---	---	---	---	378000	---	---	Each-Year Operating
<u>Vinyl Acetate - 2869</u>										
3-01-167-01	General	---	---	---	---	---	---	---	---	Tons Produced
3-01-167-02	Inert-gas Purge Vent	---	---	---	---	---	8.8	---	---	Tons Produced
3-01-167-03	CO2 Purge Vent	---	---	---	---	---	0.6	---	---	Tons Produced
3-01-167-04	Inhibitor Mix Tank Discharge	---	---	---	---	---	5.6	---	---	Tons Produced
3-01-167-80	Fugitive Emissions	---	---	---	---	---	360000	---	---	Each-Year Operating
3-01-167-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Ethyl Benzene - 2865</u>										
3-01-169-01	General	---	---	---	---	---	---	---	---	Tons Produced
3-01-169-02	Alkylation Reactor Vent	---	---	---	---	---	---	---	---	Tons Produced
3-01-169-03	Benzene Drying	---	---	---	---	---	---	---	---	Tons Produced
3-01-169-04	Benzene Recovery/Recycle	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Ethyl Benzene - 2865</u>										
3-01-169-05	Ethylbenzene Recovery	---	---	---	---	---	---	---	---	Tons Produced
3-01-169-06	Polyethylbenzene Recovery	---	---	---	---	---	---	---	---	Tons Produced
3-01-169-80	Fugitive Emissions	---	---	---	---	---	328000	---	---	Each-Year Operating
<u>Ethylene Oxide - 2869</u>										
3-01-174-01	General	---	---	---	---	---	---	---	---	Tons Produced
3-01-174-02	Air Oxidation Process Reactor: Main Vent	---	---	---	---	---	2	---	---	Tons Produced
3-01-174-10	Oxygen Oxidation Process Reactor: CO2 Purge Vent	---	---	---	---	---	1.5	---	---	Tons Produced
3-01-174-11	Oxygen Oxidation Process Reactor: Argon Purge Vent	---	---	---	---	---	0.004	---	---	Tons Produced
3-01-174-21	Stripper Purge Vent	---	---	---	---	---	0.2	---	---	Tons Produced
3-01-174-80	Fugitive Emissions	---	---	---	---	---	168000	---	---	Each-Year Operating
<u>Glycerin (Glycerol) - 2869</u>										
3-01-176-01	General	---	---	---	---	---	131.6	---	---	Tons Produced
3-01-176-10	Chlorination Process: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-176-11	CO2 Absorber	---	---	---	---	---	0.8	---	---	Tons Produced
3-01-176-12	Evaporator	---	---	---	---	---	0.2	---	---	Tons Produced
3-01-176-13	Concentrator	---	---	---	---	---	0.2	---	---	Tons Produced
3-01-176-14	Stripping Column	---	---	---	---	---	0.2	---	---	Tons Produced
3-01-176-15	Light-ends Stripping Column	---	---	---	---	---	0.2	---	---	Tons Produced
3-01-176-16	Solvent Stripping Column	---	---	---	---	---	0.04	---	---	Tons Produced
3-01-176-17	Product Distillation Column	---	---	---	---	---	0.2	---	---	Tons Produced
3-01-176-18	Cooling Tower	---	---	---	---	---	5.6	---	---	Tons Produced
3-01-176-30	Oxidation Process: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-176-31	Light-ends Stripper	---	---	---	---	---	30	---	---	Tons Produced
3-01-176-32	Concentrator	---	---	---	---	---	0.3	---	---	Tons Produced
3-01-176-33	Glycerin Flasher Column	---	---	---	---	---	0.3	---	---	Tons Produced
3-01-176-34	Product Distillation Column	---	---	---	---	---	0.3	---	---	Tons Produced
3-01-176-80	Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Toluene Diisocyanate - 2865</u>										
3-01-181-01	General	---	---	---	---	---	19.3	---	---	Tons Produced
3-01-181-02	Sulfuric Acid Concentrator	---	---	---	---	---	10	---	---	Tons Produced
3-01-181-03	Nitration Reactor	---	---	---	---	---	0.05	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Toluene Diisocyanate - 2865</i></u>										
3-01-181-04	Catalyst Filtration	---	---	---	---	---	0.001	---	---	Tons Produced
3-01-181-05	TDA Vacuum Distillation Vent	---	---	---	---	---	0.007	---	---	Tons Produced
3-01-181-06	Dichlorobenzene Solvent Recovery	---	---	---	---	---	3	---	---	Tons Produced
3-01-181-07	TDI Flash Distillation	---	---	---	---	---	3	---	---	Tons Produced
3-01-181-08	TDI Purification	---	---	---	---	---	3	---	---	Tons Produced
3-01-181-09	Residue Vacuum Distillation Unit	---	---	---	---	---	---	---	---	Tons Produced
3-01-181-10	HCl Absorber	---	---	---	---	---	---	---	---	Tons Produced
3-01-181-80	Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
<u><i>Methyl Methacrylate - 2869</i></u>										
3-01-190-01	General	---	---	---	---	---	---	---	---	Tons Produced
3-01-190-02	Acetone Cyanohydrin Reactor Off-gas	---	---	---	---	---	0.08	---	---	Tons Produced
3-01-190-03	Recovery Columns	---	---	---	---	---	2.3	---	---	Tons Produced
3-01-190-04	Acetone Evaporation Vacuum Vent	---	---	---	---	---	0.008	---	---	Tons Produced
3-01-190-10	Hydrolysis Reactor	---	---	---	---	---	13.2	---	---	Tons Produced
3-01-190-11	Distillation Unit	---	---	---	---	---	1.9	---	---	Tons Produced
3-01-190-12	MMA and Light-ends Distillation Unit	---	---	---	---	---	16.5	---	---	Tons Produced
3-01-190-13	Acid Distillation	---	---	---	---	---	1.1	---	---	Tons Produced
3-01-190-14	MMA Purification	---	---	---	---	---	15.8	---	---	Tons Produced
3-01-190-80	Fugitive Emissions	---	---	---	---	---	273000	---	---	Each-Year Operating
<u><i>Nitrobenzene - 2865</i></u>										
3-01-195-01	General	---	---	---	---	---	---	---	---	Tons Produced
3-01-195-02	Reactor and Separator Vent	---	---	---	---	---	1.9	---	---	Tons Produced
3-01-195-03	Acid Stripper Vent	---	---	---	---	---	0.34	---	---	Tons Produced
3-01-195-04	Washer and Neutralizer Vent	---	---	---	---	---	0.02	---	---	Tons Produced
3-01-195-05	Nitrobenzene Stripper Vent	---	---	---	---	---	0.34	---	---	Tons Produced
3-01-195-06	Waste Acid Storage	---	---	---	---	---	---	---	---	1000 Gallon-Years Stored
3-01-195-80	Fugitive Emissions	---	---	---	---	---	138000	---	---	Each-Year Operating
<u><i>Butylene, Ethylene, Propylene, Olefin Production - 2869</i></u>										
3-01-197-01	Ethylene: General	0.02	---	---	6	0.02	---	0.02	---	Tons Produced
3-01-197-05	Propylene: General	---	---	---	---	---	1	---	---	Tons Produced
3-01-197-06	Propylene: Reactor	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Butylene, Ethylene, Propylene, Olefin Production - 2869</i>										
3-01-197-07	Propylene: Drying Tower	---	---	---	---	---	---	---	---	Tons Produced
3-01-197-08	Propylene: Light-ends Stripper	---	---	---	---	---	---	---	---	Tons Produced
3-01-197-09	Propylene: Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-197-10	Butylene: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-197-41	Ethylene: Flue Gas Vent	---	---	---	---	---	---	---	---	Tons Produced
3-01-197-42	Ethylene: Pyrolysis Furnace Decoking	0.02	---	---	---	---	---	---	---	Tons Produced
3-01-197-43	Ethylene: Acid Gas Removal	---	---	---	6	---	0.02	---	---	Tons Produced
3-01-197-44	Ethylene: Catalyst Regeneration	---	---	---	---	---	---	---	---	Tons Produced
3-01-197-45	Ethylene: Compressor Lube Oil Vent	---	---	---	---	---	0.02	---	---	Tons Produced
3-01-197-49	Ethylene: Fugitive Emissions	---	---	---	---	---	695000	---	---	Each-Year Operating
3-01-197-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i>Phenol - 2865</i>										
3-01-202-01	General	---	---	---	---	---	15.4	---	---	Tons Produced
3-01-202-02	Cumene Oxidation	---	---	---	---	---	4.6	---	---	Tons Produced
3-01-202-03	CHP Concentrator	---	---	---	---	---	2.4	---	---	Tons Produced
3-01-202-04	Light-ends Distillation Vent	---	---	---	---	---	0.6	---	---	Tons Produced
3-01-202-05	Acetone Finishing	---	---	---	---	---	1.3	---	---	Tons Produced
3-01-202-06	Phenol Distillation Column	---	---	---	---	---	7.6	---	---	Tons Produced
3-01-202-10	Oxidate Wash/Separation	---	---	---	---	---	0.16	---	---	Tons Produced
3-01-202-11	CHP Cleavage Vent	---	---	---	---	---	0.95	---	---	Tons Produced
3-01-202-80	Fugitive Emissions	---	---	---	---	---	729000	---	---	Each-Year Operating
<i>Propylene Oxide - 2869</i>										
3-01-205-01	General	---	---	---	---	---	---	---	---	Tons Produced
3-01-205-02	Chlorohydration Process: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-205-03	Vent Gas Scrubber Vent	---	---	---	---	---	20.5	---	---	Tons Produced
3-01-205-04	Saponification Column Vent	---	---	---	---	---	0.09	---	---	Tons Produced
3-01-205-05	PO Stripping Column Vent	---	---	---	---	---	0.01	---	---	Tons Produced
3-01-205-06	Light-ends Stripping Column Vent	---	---	---	---	---	0.01	---	---	Tons Produced
3-01-205-07	PO Final Distillation Column Vent	---	---	---	---	---	0.01	---	---	Tons Produced
3-01-205-08	DCP Distillation Column Vent	---	---	---	---	---	0.0002	---	---	Tons Produced
3-01-205-09	DCIPE Distillation Column Vent	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Propylene Oxide - 2869</i>										
3-01-205-20	Isobutane Hydroperoxide Process: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-205-21	Oxidation Reactor Scrubber Vent	---	---	---	---	---	3.5	---	---	Tons Produced
3-01-205-22	TBA Stripping Column Vent	---	---	---	---	---	0.008	---	---	Tons Produced
3-01-205-23	Catalyst Mix Tank Vent	---	---	---	---	---	---	---	---	Tons Produced
3-01-205-24	PO Stripping Column Vent	---	---	---	---	---	0.04	---	---	Tons Produced
3-01-205-25	Crude TBA Recovery Column Vent	---	---	---	---	---	0.03	---	---	Tons Produced
3-01-205-26	TBA Wash-Decant System Vent	---	---	---	---	---	0.01	---	---	Tons Produced
3-01-205-27	Wastewater Stripping Column Vent	---	---	---	---	---	4.56	---	---	Tons Produced
3-01-205-28	Solvent Scrubber Vent	---	---	---	---	---	1.3	---	---	Tons Produced
3-01-205-29	Solvent Recovery Column Vent	---	---	---	---	---	0.0009	---	---	Tons Produced
3-01-205-30	Water Stripping Column Vent	---	---	---	---	---	0.003	---	---	Tons Produced
3-01-205-31	Propylene Glycol and Dipropylene Glycol Combined Vent	---	---	---	---	---	0.1	---	---	Tons Produced
3-01-205-32	Flue Gas Vent	---	---	---	---	---	0.08	---	---	Tons Produced
3-01-205-40	Ethylbenzene Hydroperoxide Process: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-205-41	Oxidation Reactor Scrubber Vent	---	---	---	---	---	3.2	---	---	Tons Produced
3-01-205-42	Falling Film Evaporator Vent	---	---	---	---	---	0.01	---	---	Tons Produced
3-01-205-43	Catalyst Mix Tank Vent	---	---	---	---	---	---	---	---	Tons Produced
3-01-205-44	Separation Column Vent	---	---	---	---	---	0.3	---	---	Tons Produced
3-01-205-45	Light-ends Stripping Column Vent	---	---	---	---	---	0.3	---	---	Tons Produced
3-01-205-46	Propylene Recovery Column Vent	---	---	---	---	---	0.3	---	---	Tons Produced
3-01-205-47	Product Wash-Decant System Vent	---	---	---	---	---	0.001	---	---	Tons Produced
3-01-205-48	Mixed Hydrocarbon Wash-Decant System Vent	---	---	---	---	---	0.003	---	---	Tons Produced
3-01-205-49	Ethyl Benzene Wash-Decant System Vent	---	---	---	---	---	0.003	---	---	Tons Produced
3-01-205-50	Ethyl Benzene Stripping Column Vent	---	---	---	---	---	0.003	---	---	Tons Produced
3-01-205-51	Light-hydrocarbon Stripping Column Vent	---	---	---	---	---	0.003	---	---	Tons Produced
3-01-205-52	MBA-AP Stripping Column Vent	---	---	---	---	---	0.02	---	---	Tons Produced
3-01-205-53	Dehydration Reactor System Vent	---	---	---	---	---	0.002	---	---	Tons Produced
3-01-205-54	Light-impurities Stripping Column Vent	---	---	---	---	---	2.5	---	---	Tons Produced
3-01-205-55	Styrene Finishing Column Vent	---	---	---	---	---	1.7	---	---	Tons Produced
3-01-205-80	Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Styrene - 2865</u>										
3-01-206-01	General	0.02	---	---	---	0.04	---	---	---	Tons Produced
3-01-206-02	Benzene Recycle	---	---	---	---	---	---	---	---	Tons Produced
3-01-206-03	Styrene Purification	---	---	---	---	---	---	---	---	Tons Produced
3-01-206-80	Fugitive Emissions	---	---	---	---	---	248000	---	---	Each-Year Operating
<u>Caprolactum (Use 3-01-130 for Ammonium Sulfate By-product Production) - 2869</u>										
3-01-210-01	General	---	---	---	---	---	11.9	---	---	Tons Produced
3-01-210-02	Cyclohexanone Purification Vent	---	---	---	---	---	6.2	---	---	Tons Produced
3-01-210-03	Dehydrogenation Reactor Vent	---	---	---	---	---	---	---	---	Tons Produced
3-01-210-04	Oleum Reactor	---	---	---	---	---	---	---	---	Tons Produced
3-01-210-05	Neutralization Reactor Vent	---	---	---	---	---	0.08	---	---	Tons Produced
3-01-210-06	Solvent Separation/Recovery	---	---	---	---	---	4	---	---	Tons Produced
3-01-210-07	Oximation Reactor/Separator	---	---	---	---	---	0.05	---	---	Tons Produced
3-01-210-08	Caprolactum Purification	---	---	---	---	---	0.3	---	---	Tons Produced
3-01-210-09	Ammonium Sulfate Drying (Use 3-01-130-04 or 3-01-130-05)	---	---	---	---	---	1.2	---	---	Tons Produced
3-01-210-10	AS:Cool/Screen/Storage(Use 301130-06&07,301870-25&26,301875-25&26)	---	---	---	---	---	0.1	---	---	Tons Produced
3-01-210-80	Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Linear Alkylbenzene - 2869</u>										
3-01-211-01	Olefin Process: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-211-02	Benzene Drying	---	---	---	---	---	---	---	---	Tons Produced
3-01-211-03	Hydrogen Fluoride Scrubber Vent	---	---	---	---	---	0.022	---	---	Tons Produced
3-01-211-04	Vacuum Refining	---	---	---	---	---	0.2	---	---	Tons Produced
3-01-211-21	Chlorination Process: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-211-22	Parafin Drying Column Vent	---	---	---	---	---	0.0056	---	---	Tons Produced
3-01-211-23	HCl Absorber Vent	---	---	---	---	---	0.5	---	---	Tons Produced
3-01-211-24	Atmospheric Wash-Decant Vent	---	---	---	---	---	0.025	---	---	Tons Produced
3-01-211-25	Benzene Stripping Column	---	---	---	---	---	0.0074	---	---	Tons Produced
3-01-211-80	Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Methanol/Alcohol Production - 2869</u>										
3-01-250-01	Methanol: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-250-02	Methanol: Purge Gas Vent	---	---	---	---	---	2.2	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Methanol/Alcohol Production - 2869</i></u>										
3-01-250-03	Methanol: Distillation Vent	---	---	---	---	---	0.8	---	---	Tons Produced
3-01-250-04	Methanol: Fugitive Emissions	---	---	---	---	---	573000	---	---	Each-Year Operating
3-01-250-05	Ethanol via Ethylene	---	---	---	---	---	---	---	---	Tons Produced
3-01-250-10	Ethanol by Fermentation	---	---	---	---	---	1.9	---	---	Tons Produced
3-01-250-15	Isopropanol	---	---	---	---	---	---	---	---	Tons Produced
3-01-250-20	Alcohols by Oxo Process	0.006	---	---	---	0.08	---	22.5	---	Tons Produced
3-01-250-25	Fatty Alcohols by Hydrogenation	---	---	---	---	---	---	---	---	Tons Produced
3-01-250-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Ethylene Glycol - 2869</i></u>										
3-01-251-01	General	---	---	---	---	---	10.3	---	---	Tons Produced
3-01-251-02	Evaporator Purge Vent	---	---	---	---	---	---	---	---	Tons Produced
3-01-251-03	Water Removal Steam: Jet Ejector	---	---	---	---	---	---	---	---	Tons Produced
3-01-251-04	Distillation Column Vent	---	---	---	---	---	---	---	---	Tons Produced
3-01-251-80	Fugitive Emissions	---	---	---	---	---	24000	---	---	Each-Year Operating
<u><i>Etherene Production - 2869</i></u>										
3-01-252-01	General	---	---	---	---	---	0.16	---	---	Tons Produced
<u><i>Glycol Ethers - 2869</i></u>										
3-01-253-01	General	---	---	---	---	---	---	---	---	Tons Produced
3-01-253-02	Vacuum System Vent	---	---	---	---	---	0.03	---	---	Tons Produced
3-01-253-05	Catalyst: Methanol Mix Tank	---	---	---	---	---	0.02	---	---	Tons Produced
3-01-253-06	Methanol Recovery Column Vent	---	---	---	---	---	0.3	---	---	Tons Produced
3-01-253-15	Catalyst: Ethanol Mix Tank	---	---	---	---	---	0.01	---	---	Tons Produced
3-01-253-16	Ethanol Recovery Column Vent	---	---	---	---	---	0.19	---	---	Tons Produced
3-01-253-25	Catalyst: Butanol Mix Tank	---	---	---	---	---	0.002	---	---	Tons Produced
3-01-253-26	Butanol Recovery Column Vent	---	---	---	---	---	0.03	---	---	Tons Produced
3-01-253-30	Secondary Emissions: Handling and Disposal of Process Waste Streams	---	---	---	---	---	0.06	---	---	Tons Produced
3-01-253-80	Fugitive Emissions	---	---	---	---	---	20100	---	---	Each-Year Operating
<u><i>Nitriles, Acrylonitrile, Adiponitrile Production - 2869</i></u>										
3-01-254-01	Acetonitrile	---	---	---	---	---	497	---	---	Tons Produced
3-01-254-05	General: Acrylonitrile	---	---	---	---	---	220	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Nitriles, Acrylonitrile, Adiponitrile Production - 2869</u>										
3-01-254-06	Absorber Vent: Normal	---	---	---	---	---	200	---	---	Tons Produced
3-01-254-07	Absorber Vent: Startup	---	---	---	---	---	0.5	---	---	Tons Produced
3-01-254-08	Recovery/Purification Column Vent	---	---	---	---	---	20	---	---	Tons Produced
3-01-254-09	Fugitive Emissions	---	---	---	---	---	223000	---	---	Each-Year Operating
3-01-254-10	Via Adipic Acid: General	3.6	---	---	---	0.3	---	---	---	Tons Produced
3-01-254-11	Ammonia Recovery Still	---	---	---	---	0.3	---	---	---	Tons Produced
3-01-254-12	Product Fractionator Vent	3.6	---	---	---	---	---	---	---	Tons Produced
3-01-254-13	Product Recovery Vent	---	---	---	---	---	---	---	---	Tons Produced
3-01-254-15	Via Butadiene: General	21.5	---	---	---	231.9	51.3	---	---	Tons Produced
3-01-254-16	Chlorination Reactor	---	---	---	---	---	35.8	---	---	Tons Produced
3-01-254-17	Cyanide Synthesis	---	---	---	---	75.8	---	---	---	Tons Produced
3-01-254-18	Cyanation/Isomerization	7.6	---	---	---	42.4	15.5	---	---	Tons Produced
3-01-254-20	Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-254-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Benzene/Toluene/Aromatics/Xylenes - 2869</u>										
3-01-258-01	Benzene: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-258-02	Benzene: Reactor	---	---	---	---	---	---	---	---	Tons Produced
3-01-258-03	Benzene: Distillation Unit	---	---	---	---	---	---	---	---	Tons Produced
3-01-258-05	Toluene: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-258-06	Toluene: Reactor	---	---	---	---	---	---	---	---	Tons Produced
3-01-258-07	Toluene: Distillation Unit	---	---	---	---	---	---	---	---	Tons Produced
3-01-258-10	p-Xylene: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-258-15	Xylenes: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-258-16	Xylenes: Reactor	---	---	---	---	---	---	---	---	Tons Produced
3-01-258-17	Xylenes: Distillation Unit	---	---	---	---	---	---	---	---	Tons Produced
3-01-258-80	Aromatics: Fugitive Emissions	---	---	---	---	---	379000	---	---	Each-Year Operating
3-01-258-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Chlorobenzene - 2869</u>										
3-01-301-01	Tail Gas Scrubber	---	---	---	---	---	1.2	---	---	Tons Produced
3-01-301-02	Benzene Drying: Distillation	---	---	---	---	---	---	---	---	Tons Produced
3-01-301-03	Benzene Recovery	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Chlorobenzene - 2869</i></u>										
3-01-301-04	Heavy-ends Processing	---	---	---	---	---	---	---	---	Tons Produced
3-01-301-05	MCB Distillation	---	---	---	---	---	---	---	---	Tons Produced
3-01-301-06	Vacuum System Vent	---	---	---	---	---	0.9	---	---	Tons Produced
3-01-301-07	DCB Crystallization	---	---	---	---	---	0.03	---	---	Tons Produced
3-01-301-08	DCB Crystal Handling/Loading	---	---	---	---	---	0.04	---	---	Tons Produced
3-01-301-10	Catalyst Incineration	---	---	---	---	---	---	---	---	Tons Burned
3-01-301-14	Secondary Emissions: Handling and Disposal of Wastewater	---	---	---	---	---	0.06	---	---	Tons Produced
3-01-301-15	Atmospheric Distillation Vents	---	---	---	---	---	0.8	---	---	Tons Produced
3-01-301-80	Fugitive Emissions	---	---	---	---	---	417000	---	---	Each-Year Operating
<u><i>Carbon Tetrachloride - 2869</i></u>										
3-01-302-01	General	---	---	---	---	---	---	---	---	Tons Produced
3-01-302-02	Distillation Vent	---	---	---	---	---	0.01	---	---	Tons Produced
3-01-302-03	Caustic Scrubber	---	---	---	---	---	0.3	---	---	Tons Produced
3-01-302-80	Fugitive Emissions	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Allyl Chloride - 2869</i></u>										
3-01-303-01	Chlorination Process: General	---	---	---	---	---	---	---	---	Tons Produced
3-01-303-02	HCl Absorber	---	---	---	---	---	0.3	---	---	Tons Produced
3-01-303-03	Light-ends Distillation	---	---	---	---	---	130	---	---	Tons Produced
3-01-303-04	Allyl Chloride Distillation Column	---	---	---	---	---	0.2	---	---	Tons Produced
3-01-303-05	DCP Distillation Column	---	---	---	---	---	2	---	---	Tons Produced
3-01-303-80	Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
<u><i>Allyl Alcohol - 2869</i></u>										
3-01-304-01	General	---	---	---	---	---	---	---	---	Tons Produced
3-01-304-02	Catalyst Preparation	---	---	---	---	---	450	---	---	Tons Produced
3-01-304-03	Filtration System	---	---	---	---	---	6.4	---	---	Tons Produced
3-01-304-04	Light-ends Stripper	---	---	---	---	---	22	---	---	Tons Produced
3-01-304-05	Distillation System Condenser	---	---	---	---	---	23	---	---	Tons Produced
3-01-304-80	Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
<u><i>Epichlorohydrin - 2869</i></u>										
3-01-305-01	General	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Epichlorohydrin - 2869</i></u>										
3-01-305-02	Epoxidation Reactor	---	---	---	---	---	---	---	---	Tons Produced
3-01-305-03	Azetropo Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-305-04	Light-ends Stripper	---	---	---	---	---	---	---	---	Tons Produced
3-01-305-05	Finishing Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-305-80	Fugitive Emissions	---	---	---	---	---	---	---	---	Each-Year Operating
<u><i>Nitroglycerin Production - 2800</i></u>										
3-01-401-01	Continuous Nitrator	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-02	Product Purification/Neutralization	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-03	Nitric Acid Recovery (Use more specific codes 3-01-410-10 thru -25)	---	---	---	---	---	---	---	---	Tons Recovered
3-01-401-05	Nitric/Sulfuric Acid Mixing	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-10	Continuous Process: Separation	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-20	Continuous Process: Spent Acid Recovery	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-21	Continuous Process: Spent Acid Recovery: Denitrating Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-22	Continuous Process: Spent Acid Recovery: Sulfuric Acid Regenerator	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-23	Continuous Process: Spent Acid Recovery: Sulfuric Acid Concentrator	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-24	Continuous Process: Spent Acid Recovery: Bleacher	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-25	Continuous Process: Spent Acid Recovery: Reflux Columns	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-30	Continuous Process: Nitric Acid Concentration	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-31	Continuous Process: Nitric Acid Concentration: Distillation Tower	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-32	Continuous Process: Nitric Acid Concentration: Bleacher	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-33	Continuous Process: Nitric Acid Concentration: Condenser	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-34	Continuous Process: Nitric Acid Concentration: Absorber Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-35	Continuous Process: Nitric Acid Concentration: Dehydrating Unit	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-36	Continuous Process: Nitric Acid Conc.: Nitric Acid Concentrators	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-50	Waste Disposal: Neutralization and Wash	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Nitroglycerin Production - 2800</u></i>										
3-01-401-51	Waste Disposal: Separation	---	---	---	---	---	---	---	---	Tons Produced
3-01-401-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Explosives Manufacture - Pentaerythritol Tetranitrate (PETN) - 2892</u></i>										
3-01-402-10	Process Vents: Batch Process	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-11	Batch Process: Nitration Reactors and Washers	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-14	Batch Process: Stabilization	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-17	Batch Process: Acetone Distillation and Recovery	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-20	Batch Process: Spent Acid Recovery	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-21	Batch Process: Spent Acid Recovery: Denitrating Tower	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-22	Batch Process: Spent Acid Recovery: Sulfuric Acid Regenerator	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-23	Batch Process: Spent Acid Recovery: Sulfuric Acid Concentrator	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-24	Batch Process: Spent Acid Recovery: Bleacher	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-25	Batch Process: Spent Acid Recovery: Reflux Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-30	Batch Process: Nitric Acid Concentration	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-31	Batch Process: Nitric Acid Concentration: Distillation Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-32	Batch Process: Nitric Acid Concentration: Bleacher	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-33	Batch Process: Nitric Acid Concentration: Condenser	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-34	Batch Process: Nitric Acid Concentration: Absorber Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-35	Batch Process: Nitric Acid Concentration: Dehydrating Unit	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-36	Batch Process: Nitric Acid Concentration: Nitric Acid Concentrators	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-50	Process Vents: Continuous Process	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-51	Continuous Process: Nitration Reactors and Washers	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-52	Continuous Process: Stabilization	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-53	Continuous Process: Acetone Distillation and Recovery	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-60	Continuous Process: Spent Acid Recovery	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-61	Continuous Process: Spent Acid Recovery: Denitrating Tower	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-62	Continuous Process: Spent Acid Recovery: Sulfuric Acid Regenerator	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Explosives Manufacture - Pentaerythritol Tetranitrate (PETN) - 2892</u>										
3-01-402-63	Continuous Process: Spent Acid Recovery: Sulfuric Acid Concentrator	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-64	Continuous Process: Spent Acid Recovery: Bleacher	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-65	Continuous Process: Spent Acid Recovery: Reflux Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-70	Continuous Process: Nitric Acid Concentration	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-71	Continuous Process: Nitric Acid Concentration: Distillation Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-72	Continuous Process: Nitric Acid Concentration: Bleacher	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-73	Continuous Process: Nitric Acid Concentration: Condenser	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-74	Continuous Process: Nitric Acid Concentration: Absorber Column	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-75	Continuous Process: Nitric Acid Concentration: Dehydrating Unit	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-76	Continuous Process: Nitric Acid Conc.: Nitric Acid Concentrators	---	---	---	---	---	---	---	---	Tons Produced
3-01-402-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Explosives Manufacture - RDX/HMX Production - 2892</u>										
3-01-403-06	Nitric Acid/Ammonium Nitrate Mixing	---	---	---	---	---	---	---	---	Tons Produced
3-01-403-07	Hexamine/Acetic Acid Mixing	---	---	---	---	---	---	---	---	Tons Produced
3-01-403-10	Process Vents: Batch Process	---	---	---	---	---	---	---	---	Tons Produced
3-01-403-11	Batch Process: Nitration Reactor	---	---	---	---	---	---	---	---	Tons Produced
3-01-403-12	Batch Process: Aging Tank	---	---	---	---	---	---	---	---	Tons Produced
3-01-403-13	Batch Process: Simmer Tank	---	---	---	---	---	---	---	---	Tons Produced
3-01-403-20	Batch Process: Refinement	---	---	---	---	---	---	---	---	Tons Produced
3-01-403-30	Batch Process: Blending	---	---	---	---	---	---	---	---	Tons Produced
3-01-403-40	Batch Process: Formulation	---	---	---	---	---	---	---	---	Tons Produced
3-01-403-50	Batch Process: Acetic Acid Recovery	---	---	---	---	---	---	---	---	Tons Produced
3-01-403-60	Batch Process: Acetone or Cyclohexanone Recovery	---	---	---	---	---	---	---	---	Tons Produced
3-01-403-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>General Processes - 2865, 2869</u>										
3-01-800-01	Fugitive Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-800-02	Pipeline Valves: Gas Stream	---	---	---	---	---	---	---	---	Each-Year Operating

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>General Processes - 2865, 2869</u>										
3-01-800-03	Pipeline Valves: Light Liquid/Gas Stream	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-800-04	Pipeline Valves: Heavy Liquid Stream	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-800-05	Pipeline Valves: Hydrogen Stream	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-800-06	Open-ended Valves: All Streams	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-800-07	Flanges: All Streams	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-800-08	Pump Seals: Light Liquid/Gas Stream	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-800-09	Pump Seals: Heavy Liquid Stream	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-800-10	Compressor Seals: Gas Stream	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-800-11	Compressor Seals: Heavy Liquid Stream	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-800-12	Drains: All Streams	---	---	---	---	---	---	---	---	Each-Year Operating
3-01-800-13	Vessel Relief Valves: All Streams	---	---	---	---	---	---	---	---	Each-Year Operating
<u>General Processes - 2865, 2869</u>										
3-01-810-01	Air Oxidation Units	---	---	---	---	---	---	---	---	Tons Produced
<u>Wastewater Treatment - 2865, 2869</u>										
3-01-820-01	Wastewater Stripper	---	---	---	---	---	---	---	---	Tons Produced
3-01-820-02	Wastewater Treatment	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-820-03	Wastewater Treatment	---	---	---	---	---	---	---	---	Tons Produced
3-01-820-04	Chemical Plant Wastewater System: Junction Box	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-820-05	Chemical Plant Wastewater System: Lift Station	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-820-06	Chemical Plant Wastewater System: Aerated Impoundment	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-820-07	Chemical Plant Wastewater System: Non-aerated Impoundment	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-820-08	Chemical Plant Wastewater System: Weir	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-820-09	Chemical Plant Wastewater System: Activated Sludge Impoundment	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-820-10	Chemical Plant Wastewater System: Clarifier	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-820-11	Chemical Plant Wastewater System: Open Trench	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Wastewater, Points of Generation - 2800</u>										
3-01-825-01	TNT: Waterwash of Crude TNT (Yellow Water)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-02	TNT: Sellite Treatment and Subsequent Washing of Crude TNT (Red H <sub>2</sub> O)	---	---	---	---	---	---	---	---	1000 Gallons Throughput



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Wastewater, Points of Generation - 2800</u></i>										
3-01-825-03	TNT: Nitration Fume Scrubber	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-04	TNT: Finishing Operation Fume Scrubber	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-10	NG: NG/Acid Separator Soda Wash	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-11	NG: Separator Following Soda Wash	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-12	NG: Separator Following Fresh Water Wash	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-13	NG: Emulsifier	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-14	NG: Refrigeration House	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-15	NG: Spent Acid Storage	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-16	NG: Air Compressor House	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-17	NG: Refrigeration House	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-30	NC: Nitric Acid Concentrators	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-31	NC: Nitration Reactor	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-32	NC: Purification Boiling Tubs	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-33	NC: Purification Beaters	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-34	NC: Purification Poacher	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-35	NC: Purification Blender	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-36	NC: Purification Wringer	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-50	PETN: Nitration Reactors	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-51	PETN: Spent Acid Recovery	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-52	PETN: Nitric Acid Concentrators	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-53	PETN: Stabilization	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-60	RDX/HMX: Nitration	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-61	RDX/HMX: Filter/Wash	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-62	RDX/HMX: Recrystallization	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-63	RDX/HMX: Dewatering	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>General Processes - 2865, 2869</u></i>										
3-01-830-01	Storage/Transfer	---	---	---	---	---	---	---	---	Tons Produced
<i><u>General Processes - 2865, 2869</u></i>										
3-01-840-01	Distillation Units	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Inorganic Chemical Storage (Fixed Roof Tanks) - 2800</i>										
3-01-870-01	Hydrochloric Acid: Breathing Loss (Use 3-01-870-33)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-02	Hydrochloric Acid: Working Loss (Use 3-01-870-34)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-870-03	Hydrofluoric Acid: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-04	Hydrofluoric Acid: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-870-05	Nitric Acid: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-06	Nitric Acid: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-870-07	Phosphoric Acid: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-08	Phosphoric Acid: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-870-09	Sulfuric Acid: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-10	Sulfuric Acid: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-870-11	Ammonium Nitrate: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-12	Ammonium Nitrate: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-870-13	Urea: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-14	Urea: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-870-15	Copper Sulfate: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-16	Copper Sulfate: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-870-17	Aqueous Ammonia: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-18	Aqueous Ammonia: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-870-19	Ammonium Bicarbonate: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-20	Ammonium Bicarbonate: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-870-21	Hydrazine Hydrate: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-22	Hydrazine Hydrate: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-870-23	Anhydrous Hydrazine: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-24	Anhydrous Hydrazine: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Inorganic Chemical Storage (Fixed Roof Tanks) - 2800</u></i>										
3-01-870-25	Ammonium Sulfate: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-26	Ammonium Sulfate: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-870-29	Fluosilicic Acid: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-30	Fluosilicic Acid: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-870-31	Chromic Acid: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-32	Chromic Acid: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-870-33	Hydrochloric Acid: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-34	Hydrochloric Acid: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-870-97	Specify Liquid: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-870-98	Specify Liquid: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Inorganic Chemical Storage (Floating Roof Tank) - 2800</u></i>										
3-01-875-01	Carbon Disulfide: Breathing Loss (Use 4-07-296-01)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-875-02	Carbon Disulfide: Withdrawal Loss (Use 4-07-296-02)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-875-03	Hydrofluoric Acid: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-875-04	Hydrofluoric Acid: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-875-05	Nitric Acid: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-875-06	Nitric Acid: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-875-07	Phosphoric Acid: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-875-08	Phosphoric Acid: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-875-09	Sulfuric Acid: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-875-10	Sulfuric Acid: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-875-11	Ammonium Nitrate: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-875-12	Ammonium Nitrate: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-875-13	Urea: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Inorganic Chemical Storage (Floating Roof Tank) - 2800</u></i>										
3-01-875-14	Urea: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-875-15	Copper Sulfate: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-875-16	Copper Sulfate: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-875-17	Liquid Ammonia: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-875-18	Liquid Ammonia: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-875-19	Ammonium Bicarbonate: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-875-20	Ammonium Bicarbonate: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-875-21	Hydrazine Hydrate: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-875-22	Hydrazine Hydrate: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-875-23	Anhydrous Hydrazine: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-875-24	Anhydrous Hydrazine: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-875-25	Ammonium Sulfate: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-875-26	Ammonium Sulfate: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-875-29	Fluosilicic Acid: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-875-30	Fluosilicic Acid: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-875-31	Chromic Acid: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-875-32	Chromic Acid: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-875-33	Hydrochloric Acid: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-875-34	Hydrochloric Acid: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-875-97	Specify Liquid: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-01-875-98	Specify Liquid: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Inorganic Chemical Storage (Pressure Tanks) - 2800</u></i>										
3-01-885-01	Ammonia: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-885-02	Carbon Monoxide: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-885-03	Chlorine: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Inorganic Chemical Storage (Pressure Tanks) - 2800</u></i>										
3-01-885-04	Hydrogen Cyanide: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-885-05	Sulfur Dioxide: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-885-06	Nitrogen: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-885-07	Carbon Dioxide: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-885-08	Hydrazine Hydrate: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-885-09	Anhydrous Hydrazine: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-885-10	Anhydrous Ammonia: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-885-11	Hydrogen Fluoride: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-885-12	Fluosilicic Acid: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-885-13	Hydrogen Chloride: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-885-14	Fluorine: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-01-885-99	Specify Gas: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fugitive Emissions - 2800</u></i>										
3-01-888-01	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-01-888-02	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-01-888-03	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-01-888-04	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-01-888-05	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
<i><u>Fuel Fired Equipment - 2800</u></i>										
3-01-900-01	Distillate Oil (No. 2): Process Heaters	---	---	---	143.6S	20	0.2	---	---	1000 Gallons Burned
3-01-900-02	Residual Oil: Process Heaters	---	---	---	158.6S	50	0.28	---	---	1000 Gallons Burned
3-01-900-03	Natural Gas: Process Heaters	---	---	---	0.6	140	2.8	---	---	Million Cubic Feet Burned
3-01-900-04	Process Gas: Process Heaters	---	---	---	---	140	2.8	---	---	Million Cubic Feet Burned
3-01-900-11	Distillate Oil (No. 2): Incinerators	---	---	---	---	---	0.4	---	---	1000 Gallons Burned
3-01-900-12	Residual Oil: Incinerators	---	---	---	---	---	0.56	---	---	1000 Gallons Burned
3-01-900-13	Natural Gas: Incinerators	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-01-900-14	Process Gas: Incinerators	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-01-900-21	Distillate Oil (No. 2): Flares	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-01-900-22	Residual Oil: Flares	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-01-900-23	Natural Gas: Flares	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
3-01-900-99	Specify in Comments Field	See App. C	---	---	50	0.068	3.7	See App. C	---	Footnote 34

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Other Not Classified - 2800</i>										
3-01-999-98	Specify in Comments Field	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-01-999-99	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
<i>INDUSTRIAL PROCESSES -Food and Agriculture</i>										
<i>Alfalfa Dehydration - 2048</i>										
3-02-001-01	General	---	---	---	---	---	---	---	---	Tons Produced
3-02-001-02	Primary Cyclone and Dryer (use -11 thru -14)	---	---	---	---	---	---	---	---	Tons Produced
3-02-001-03	Meal Collector Cyclone	---	---	---	---	---	---	---	---	Tons Produced
3-02-001-04	Pellet Cooler Cyclone	---	---	---	---	---	---	---	---	Tons Produced
3-02-001-07	Pellet Collector Cyclone	---	---	---	---	---	---	---	---	Tons Produced
3-02-001-11	Gas-fired, Triple-Pass Dryer Cyclone	4.8	---	1	---	---	---	---	---	Tons Produced
3-02-001-12	Coal-fired, Triple-Pass Dryer Cyclone	7.5	---	---	---	---	---	---	---	Tons Produced
3-02-001-15	Gas-fired, Single-Pass Dryer Cyclone	4.1	---	0.65	---	---	---	---	---	Tons Produced
3-02-001-17	Wood-fired, Single-Pass Dryer Cyclone	3.1	---	1.3	---	---	---	---	---	Tons Produced
3-02-001-20	Pellet Storage Bin Cyclone	---	---	---	---	---	---	---	---	Tons Produced
3-02-001-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i>Coffee Roasting - 2095</i>										
3-02-002-01	Direct Fired Roaster (use 302002-24 or -25)	---	---	---	---	---	---	---	---	Tons Processed
3-02-002-02	Indirect Fired Roaster (use 302002-20 or -21)	---	---	---	---	---	---	---	---	Tons Processed
3-02-002-03	Stoner/Cooler (use 302002-30)	---	---	---	---	---	---	---	---	Tons Processed
3-02-002-04	Green Coffee Bean Unloading	---	---	---	---	---	---	---	---	Tons Unloaded
3-02-002-06	Screening - Debris Removal from Green Coffee Beans	---	---	---	---	---	---	---	---	Tons Screened
3-02-002-08	Green Coffee Bean Storage and Handling	---	---	---	---	---	---	---	---	Tons Stored
3-02-002-10	Decaffeination : Solvent Extraction	---	---	---	---	---	---	---	---	Tons Processed
3-02-002-11	Decaffeination : Supercritical CO2 Extraction	---	---	---	---	---	---	---	---	Tons Processed
3-02-002-16	Steam or Hot Air Drying of Decaffeinated Green Coffee Beans	---	---	---	---	---	---	---	---	Tons Processed
3-02-002-20	Indirect-fired Batch Roaster -Natural Gas (incl combustion emiss)	<sup>27</sup> 0.12	---	---	---	---	0.86	---	---	Tons Fed
3-02-002-21	Indirect-fired Continuous Roaster -Natural Gas (incl combustion emiss)	0.66	---	<sup>27</sup> 0.1	---	---	1.4	1.5	---	Tons Fed
3-02-002-24	Direct-fired Batch Roaster - Natural Gas	---	---	---	---	---	---	---	---	Tons Fed
3-02-002-25	Direct-fired Continuous Roaster - Natural Gas	---	---	---	---	---	---	---	---	Tons Fed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Coffee Roasting - 2095</i>										
3-02-002-28	Cooling of Roasted Coffee Beans	---	---	---	---	---	---	---	---	Tons Fed to Roaster
3-02-002-30	De-stoning - Air Classification for Debris Removal	---	---	---	---	---	---	---	---	Tons Processed
3-02-002-34	Equilibration - Air Drying & Stabilization of Roasted Coffee Beans	---	---	---	---	---	---	---	---	Tons Produced
3-02-002-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i>Instant Coffee Products - 2095</i>										
3-02-003-01	Spray Drying (Instant Coffee) Ground Coffee after H2O Extraction	---	---	---	---	---	---	---	---	Tons Processed
3-02-003-06	Freeze Drying (Instant Coffee) Ground Coffee after H2O Extraction	---	---	---	---	---	---	---	---	Tons Produced
<i>Cotton Ginning - 724</i>										
3-02-004-01	Unloading Fan	5	0.75	---	---	---	---	---	---	Bales Processed
3-02-004-02	Seed Cotton Cleaning System (use SCCs 3-02-004-20, 21, & 22)	1	0.05	---	---	---	---	---	---	Bales Processed
3-02-004-03	Master Trash Fan (incl Stick&Burr Mach/Gin Stand/Extr'r Feed/Batt Cond)	3	0.03	---	---	---	---	---	---	Bales Processed
3-02-004-04	Miscellaneous (incl Lint Clr/Batt Cond/Trash, Overflo & Mote Fans)	3	0.23	---	---	---	---	---	---	Bales Processed
3-02-004-05	Extract Feeder Cleaners	---	---	---	---	---	---	---	---	Bales Processed
3-02-004-06	Saw Ginning	---	---	---	---	---	---	---	---	Bales Processed
3-02-004-07	Lint Cleaners	---	---	---	---	---	---	---	---	Bales Processed
3-02-004-08	Battery Condenser (incl Baling System)	---	---	---	---	---	---	---	---	Bales Processed
3-02-004-09	Stick and Green Leaf Extracting Cleaner (use SCCs 3-02-004-20, 21,	---	---	---	---	---	---	---	---	Bales Processed
3-02-004-10	General - Entire Process, Sum of Typical Equip Used	12	1	---	---	---	---	---	---	Bales Processed
3-02-004-11	Burr Machine Cleaner (use SCCs 3-02-004-20, 21, & 22)	---	---	---	---	---	---	---	---	Bales Processed
3-02-004-12	Stick Machine Cleaner (use SCCs 3-02-004-20, 21, & 22)	---	---	---	---	---	---	---	---	Bales Processed
3-02-004-15	Drying (use SCCs 3-02-004-20, 21, & 22)	---	---	---	---	---	---	---	---	Bales Processed
3-02-004-20	No. 1 Dryer and Cleaner	---	---	---	---	---	---	---	---	Bales Processed
3-02-004-21	No. 2 Dryer and Cleaner	---	---	---	---	---	---	---	---	Bales Processed
3-02-004-22	No. 3 Dryer and Cleaner	---	---	---	---	---	---	---	---	Bales Processed
3-02-004-25	Overflow Fan	---	---	---	---	---	---	---	---	Bales Processed
3-02-004-30	Cyclone Robber System	---	---	---	---	---	---	---	---	Bales Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Cotton Ginning - 724</u></i>										
3-02-004-35	Mote Fan	---	---	---	---	---	---	---	---	Bales Processed
3-02-004-36	Mote Trash Fan	---	---	---	---	---	---	---	---	Bales Processed
3-02-004-99	Not Classified	---	---	---	---	---	---	---	---	Bales Processed
<i><u>Feed and Grain Terminal Elevators - 5153, 4221, 4491</u></i>										
3-02-005-01	Shipping/Receiving	1	---	---	---	---	---	---	---	Tons Processed
3-02-005-02	Transfer/Convey	2	---	---	---	---	---	---	---	Tons Processed
3-02-005-03	Cleaning	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-04	Drying	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-05	Unloading (Receiving)	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-06	Loading (Shipping)	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-07	Removal from Bins (Tunnel Belt)	1.4	---	---	---	---	---	---	---	Tons Processed
3-02-005-08	Elevator Legs (Headhouse)	1.5	---	---	---	---	---	---	---	Tons Processed
3-02-005-09	Tripper (Gallery Belt)	1	---	---	---	---	---	---	---	Tons Processed
3-02-005-10	Removal from Bins (Tunnel Belt)	2.8	---	---	---	---	---	---	---	Tons Shipped or Received
3-02-005-11	Elevator Legs (Headhouse)	4.5	---	---	---	---	---	---	---	Tons Shipped or Received
3-02-005-12	Country Elevators: General	10.2	1.65	---	---	---	---	---	---	Tons Shipped or Received
3-02-005-13	Fumigation Tanks	---	---	---	---	---	---	---	---	Tons Treated
3-02-005-14	General	---	---	---	---	---	---	---	---	Tons Shipped or Received
3-02-005-15	Cleaning	---	---	---	---	---	---	---	---	Tons Shipped or Received
3-02-005-16	Loading	---	---	---	---	---	---	---	---	Tons Shipped or Received
3-02-005-17	Turning	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-18	Turning	---	---	---	---	---	---	---	---	Tons Shipped or Received
3-02-005-19	Tripper (Gallery)	---	---	---	---	---	---	---	---	Tons Shipped or Received
3-02-005-20	Batch Dryer	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-21	Cross-flow Dryer	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-22	Counter-flow Dryer	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-23	Batch Dryer	---	---	---	---	---	---	---	---	Tons Shipped or Received
3-02-005-24	Cross-flow Dryer	---	---	---	---	---	---	---	---	Tons Shipped or Received
3-02-005-25	Counter-flow Dryer	---	---	---	---	---	---	---	---	Tons Shipped or Received
3-02-005-26	General	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-27	Grain Drying - Column Dryer	0.22	0.055	---	---	---	---	---	---	Tons Processed



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Feed and Grain Terminal Elevators - 5153, 4221, 4491</u></i>										
3-02-005-28	Grain Drying - Rack Dryer	3	0.75	---	---	---	---	---	---	Tons Processed
3-02-005-30	Headhouse & Internal Handling (legs, belts, distributors, scale, etc.)	0.061	0.034	---	---	---	---	---	---	Tons Processed
3-02-005-31	Fugitive Emissions: General	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-32	Fugitive Emissions: Shipping/Receiving	---	---	---	---	---	---	---	---	Tons Shipped or Received
3-02-005-37	Grain Cleaning - Internal Vibrating	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-38	Grain Cleaning - Stationary Enclosed	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-40	Storage Bin Vents	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-50	Unloading (Receiving) from Trucks (unspecified type)	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-51	Unloading (Receiving) from Straight Trucks	0.18	0.059	---	---	---	---	---	---	Tons Processed
3-02-005-52	Unloading (Receiving) from Hopper Trucks	0.035	0.0078	---	---	---	---	---	---	Tons Processed
3-02-005-53	Unloading (Receiving) from Railcars	0.032	0.0078	---	---	---	---	---	---	Tons Processed
3-02-005-54	Unloading (Receiving) from Barges	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-55	Unloading (Receiving) from Ships	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-60	Unloading (Shipping) into Trucks (unspecified type)	0.086	0.029	---	---	---	---	---	---	Tons Processed
3-02-005-61	Loading (Shipping) into Straight Trucks	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-62	Loading (Shipping) into Hopper Trucks	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-63	Loading (Shipping) into Railcars	0.027	0.0022	---	---	---	---	---	---	Tons Processed
3-02-005-64	Loading (Shipping) into Barges	---	---	---	---	---	---	---	---	Tons Processed
3-02-005-65	Loading (Shipping) into Ships	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Feed and Grain Country Elevators - 5153, 4221, 4491</u></i>										
3-02-006-01	Shipping/Receiving	5	---	---	---	---	---	---	---	Tons Processed
3-02-006-02	Transfer/Convey	3	---	---	---	---	---	---	---	Tons Processed
3-02-006-03	Cleaning	3	0.45	---	---	---	---	---	---	Tons Processed
3-02-006-04	Drying	0.7	0.43	---	---	---	---	---	---	Tons Processed
3-02-006-05	Unloading (Receiving)	0.6	0.294	---	---	---	---	---	---	Tons Processed
3-02-006-06	Loading (Shipping)	0.3	0.05	---	---	---	---	---	---	Tons Processed
3-02-006-07	Removal from Bins (Tunnel Belt)	1	0.694	---	---	---	---	---	---	Tons Processed
3-02-006-08	Elevator Legs (Headhouse)	1.5	0.23	---	---	---	---	---	---	Tons Processed
3-02-006-09	Tripper (Gallery Belt)	1.7	0.26	---	---	---	---	---	---	Tons Shipped or Received
3-02-006-10	Removal from Bins (Tunnel Belt)	1	0.694	---	---	---	---	---	---	Tons Shipped or Received
3-02-006-11	Elevator Legs (Headhouse)	---	0.7	---	---	---	---	---	---	Tons Shipped or Received

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Feed and Grain Country Elevators - 5153, 4221, 4491</u></i>										
3-02-006-99	General	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Grain Millings - 2041</u></i>										
3-02-007-01	General	5	---	---	---	---	---	---	---	Tons Processed
3-02-007-02	General	7	---	---	---	---	---	---	---	Tons Processed
3-02-007-03	Barley Cleaning	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-04	Milo Cleaning	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-05	Barley Flour Mill	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-06	Barley: Receiving	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-07	Barley: Bulk Loading	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-08	Barley Malting: Grain Receiving	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-09	Barley Malting: Gas-fired Malt Kiln	0.19	0.17	0.088	---	---	---	---	---	Tons Processed
3-02-007-10	Milo: Receiving	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-11	Durum Milling: Grain Receiving	See App. C	See App. C	---	---	---	---	---	---	Tons Received
3-02-007-12	Durum Milling: Precleaning/Handling	---	---	---	---	---	---	---	---	Tons Received
3-02-007-13	Durum Milling: Cleaning House	---	---	---	---	---	---	---	---	Tons Received
3-02-007-14	Durum Milling: Millhouse	---	---	---	---	---	---	---	---	Tons Received
3-02-007-21	Rye: Grain Receiving	See App. C	See App. C	---	---	---	---	---	---	Tons Received
3-02-007-22	Rye: Precleaning/Handling	0.061	0.034	---	---	---	---	---	---	Tons Processed
3-02-007-23	Rye: Cleaning House	---	---	---	---	---	---	---	---	Tons Received
3-02-007-24	Rye: Millhouse	---	---	---	---	---	---	---	---	Tons Received
3-02-007-30	General	---	---	---	---	---	---	---	---	Tons Produced
3-02-007-31	Wheat: Grain Receiving	See App. C	See App. C	---	---	---	---	---	---	Tons Received
3-02-007-32	Wheat: Precleaning/Handling	0.061	0.034	---	---	---	---	---	---	Tons Processed
3-02-007-33	Wheat: Cleaning House	---	---	---	---	---	---	---	---	Tons Received
3-02-007-34	Wheat: Millhouse	70	35	---	---	---	---	---	---	Tons Processed
3-02-007-40	Dry Corn Milling: Silo Storage	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-41	Dry Corn Milling: Grain Receiving	See App. C	See App. C	---	---	---	---	---	---	Tons Received
3-02-007-42	Dry Corn Milling: Grain Drying	See App. C	See App. C	---	---	---	---	---	---	Tons Received
3-02-007-43	Dry Corn Milling: Precleaning/Handling	0.061	0.034	---	---	---	---	---	---	Tons Processed
3-02-007-44	Dry Corn Milling: Cleaning House	---	---	---	---	---	---	---	---	Tons Received
3-02-007-45	Dry Corn Milling: Degerming and Milling	---	---	---	---	---	---	---	---	Tons Received

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Grain Millings - 2041</i>										
3-02-007-46	Dry Corn Milling: Bulk Loading	---	---	---	---	---	---	---	---	Tons Received
3-02-007-47	Dry Corn Milling: Pneumatic Conveyor	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-48	Dry Corn Milling: Grinding	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-51	Wet Corn Milling: Grain Receiving	1	---	---	---	---	---	---	---	Tons Received
3-02-007-52	Wet Corn Milling: Grain Handling	0.87	---	---	---	---	---	---	---	Tons Received
3-02-007-53	Wet Corn Milling: Grain Cleaning	1.6	---	---	---	---	---	---	---	Tons Received
3-02-007-54	Wet Corn Milling: Dryers	0.48	0.29	---	---	---	---	---	---	Tons Received
3-02-007-55	Wet Corn Milling: Bulk Loading	---	---	---	---	---	---	---	---	Tons Received
3-02-007-56	Wet Corn Milling: Milling	---	---	---	---	---	---	---	---	Tons Received
3-02-007-57	Dry Corn Milling: Mixing Tank	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-58	Dry Corn Milling: Extruder	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-59	Dry Corn Milling: Kettle Cooker	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-60	Oat: General	See App. C	See App. C	---	---	---	---	---	---	Tons Received
3-02-007-61	Steeping: Grain Conditioning in Tanks Containing Dilute Sulfurous Acid	---	---	---	---	---	---	---	---	Tons Steeped
3-02-007-62	Evaporators: Concentrate Steepwater to 30-55 % Solids by Evaporation	---	---	---	---	---	---	---	---	Gallons Removed
3-02-007-63	Gluten Feed Drying: Direct-fired Dryer - Produces Corn Gluten Feed	---	---	---	---	---	---	---	---	Tons Produced
3-02-007-64	Gluten Feed Drying: Indirect-fired Dryer - Produces Corn Gluten Feed	---	---	---	---	---	---	---	---	Tons Produced
3-02-007-65	Degerminating Mills: Separates Germ from Starch and Gluten	---	---	---	---	---	---	---	---	Tons Fed
3-02-007-66	Germ Drying: Drying Germ from Degerminating Mills	---	---	---	---	---	---	---	---	Tons Produced
3-02-007-67	Fiber Drying: Drying Corn Hulls after Separation from Starch & Gluten	---	---	---	---	---	---	---	---	Tons Produced
3-02-007-68	Gluten Drying: Direct-fired Dryer - Produces Corn Gluten Meal	---	---	---	---	---	---	---	---	Tons Produced
3-02-007-69	Gluten Drying: Indirect-fired Dryer - Produces Corn Gluten Meal	---	---	---	---	---	---	---	---	Tons Produced
3-02-007-70	Dextrose Drying	---	---	---	---	---	---	---	---	Tons Produced
3-02-007-71	Rice: Grain Receiving	---	---	---	---	---	---	---	---	Tons Received
3-02-007-72	Rice: Precleaning/Handling	---	---	---	---	---	---	---	---	Tons Received
3-02-007-73	Rice: Drying	0.063	0.0312	---	---	---	---	---	---	Tons Processed
3-02-007-74	Rice: Cleaning/Millhouse	---	---	---	---	---	---	---	---	Tons Received

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Grain Millings - 2041</u></i>										
3-02-007-75	Rice: Paddy Cleaning	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-76	Rice: Mill House	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-77	Rice: Aspirator	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-78	Rice: Cleaning/Millhouse	---	---	---	---	---	---	---	---	Tons Received
3-02-007-81	Soybean: Grain Receiving	0.15	---	---	---	---	---	---	---	Tons Received
3-02-007-82	Soybean: Grain Handling	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-83	Soybean: Grain Cleaning	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-84	Soybean: Drying	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-85	Soybean: Cracking and Dehulling	3.3	---	---	---	---	---	---	---	Tons Received
3-02-007-86	Soybean: Hull Grinding	2	---	---	---	---	---	---	---	Tons Received
3-02-007-87	Soybean: Bean Conditioning	0.1	---	---	---	---	---	---	---	Tons Received
3-02-007-88	Soybean: Flaking	0.57	---	---	---	---	---	---	---	Tons Received
3-02-007-89	Soybean: Meal Dryer	1.5	---	---	---	---	---	---	---	Tons Received
3-02-007-90	Soybean: Meal Cooler	1.8	---	---	---	---	---	---	---	Tons Received
3-02-007-91	Soybean: Bulk Loading	0.27	---	---	---	---	---	---	---	Tons Received
3-02-007-92	Soybean: White Flake Cooler	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-93	Soybean: Meal Grinder/Sizing	---	---	---	---	---	---	---	---	Tons Processed
3-02-007-99	See Comments	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Feed Manufacture - 2082</u></i>										
3-02-008-01	General	3	---	---	---	---	---	---	---	Tons Processed
3-02-008-02	Grain Receiving	0.017	0.0025	---	---	---	---	---	---	Tons Received
3-02-008-03	Shipping	0.0033	0.0008	---	---	---	---	---	---	Tons Processed
3-02-008-04	Handling	5.5	---	---	---	---	---	---	---	Tons Received
3-02-008-05	Grinding	---	0.06	---	---	---	---	---	---	Tons Received
3-02-008-06	Pellet Coolers	---	0.1	---	---	---	---	---	---	Tons Received
3-02-008-07	Grain Cleaning	---	---	---	---	---	---	---	---	Tons Received
3-02-008-08	Milling	---	---	---	---	---	---	---	---	Tons Received
3-02-008-09	Mixing/Blending	---	---	---	---	---	---	---	---	Tons Received
3-02-008-10	Conveying	---	---	---	---	---	---	---	---	Tons Received
3-02-008-11	Scalping	---	---	---	---	---	---	---	---	Tons Received
3-02-008-12	Bulk Load-out	---	---	---	---	---	---	---	---	Tons Received

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Feed Manufacture - 2082</u></i>										
3-02-008-13	Shaking	---	---	---	---	---	---	---	---	Tons Received
3-02-008-14	Storage	---	---	---	---	---	---	---	---	Tons Processed
3-02-008-15	Grinding	---	---	---	---	---	---	---	---	Tons Processed
3-02-008-16	Pellet Cooler	---	---	---	---	---	---	---	---	Tons Processed
3-02-008-17	Grain Milling: Hammermill	---	---	---	---	---	---	---	---	Tons Processed
3-02-008-18	Grain Milling: Flaker	---	---	---	---	---	---	---	---	Tons Processed
3-02-008-19	Grain Milling: Grain Cracker	---	---	---	---	---	---	---	---	Tons Processed
3-02-008-21	Fugitive Emissions: General	---	---	---	---	---	---	---	---	Tons Processed
3-02-008-22	Fugitive Emissions: Shipping/Receiving	---	---	---	---	---	---	---	---	Tons Processed
3-02-008-23	Fugitive Emissions: Packing	---	---	---	---	---	---	---	---	Tons Processed
3-02-008-32	Citrate: Handling/Transferring	---	---	---	---	---	---	---	---	Tons Produced
3-02-008-33	Citrate: Grinding	---	---	---	---	---	---	---	---	Tons Produced
3-02-008-34	Citrate: Drying	---	---	---	---	---	---	---	---	Tons Produced
3-02-008-35	Citrate: Storage	---	---	---	---	---	---	---	---	Tons Produced
3-02-008-99	Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Beer Production - 2082</u></i>										
3-02-009-01	Grain Handling (see also 3-02-005-xx)	3	---	---	---	---	---	---	---	Tons Processed
3-02-009-02	Drying Spent Grains (use SCCs 3-02-009-30 & -31)	---	---	---	---	---	---	---	---	Tons Processed
3-02-009-03	Brew Kettle (use SCC 3-02-009-07)	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-02-009-04	Aging Tank: Secondary Fermentation	---	---	---	---	---	---	---	---	Barrel-Years Stored
3-02-009-05	Malt Kiln	0.045	0.027	---	---	---	---	---	---	Tons Dried
3-02-009-06	Malt Mill	---	---	---	---	---	---	---	---	Tons Processed
3-02-009-07	Brew Kettle	0.41	---	---	---	---	0.64	---	---	1000 Barrels Packaged
3-02-009-08	Aging Tank: Filling	---	---	---	---	---	0.57	---	---	1000 Barrels Packaged
3-02-009-10	Beer Bottling: Storage	---	---	---	---	---	---	---	---	Tons Processed
3-02-009-11	Fugitive Emissions: General	---	---	---	---	---	---	---	---	1000 Gallons Produced
3-02-009-12	Fugitive Emissions: General	---	---	---	---	---	---	---	---	Tons Processed
3-02-009-15	Milled Malt Hopper	---	---	---	---	---	---	---	---	Tons Throughput
3-02-009-20	Raw Material Storage	---	---	---	---	---	---	---	---	1000 Gallons Produced
3-02-009-21	Mash Tun	---	---	---	---	---	0.054	---	---	1000 Barrels Packaged
3-02-009-22	Cereal Cooker	---	---	---	---	---	0.0075	---	---	1000 Barrels Packaged

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Beer Production - 2082</u></i>										
3-02-009-23	Lauter Tun or Strainmaster	---	---	---	---	---	0.0055	---	---	1000 Barrels Packaged
3-02-009-24	Hot Wort Settling Tank	---	---	---	---	---	0.075	---	---	1000 Barrels Packaged
3-02-009-25	Wort Cooler	---	---	---	---	---	0.022	---	---	1000 Barrels Packaged
3-02-009-26	Trub Vessel	---	---	---	---	---	0.25	---	---	1000 Barrels Packaged
3-02-009-30	Brewers Grain Dryer: Natural Gas-fired	26	0.33	---	---	---	0.73	---	---	Tons Produced
3-02-009-31	Brewers Grain Dryer: Fuel Oil-fired	---	---	---	---	---	---	---	---	Tons Produced
3-02-009-32	Brewers Grain Dryer: Steam-heated	26	0.33	---	---	---	0.73	0.22	---	Tons Produced
3-02-009-35	Fermenter Venting: Closed Fermenter	---	---	---	---	---	2	---	---	1000 Barrels Packaged
3-02-009-37	Fermenter Venting: Open Fermenter	---	---	---	---	---	---	---	---	1000 Barrels Packaged
3-02-009-39	Activated Carbon Regeneration	---	---	---	---	---	0.035	---	---	1000 Barrels Packaged
3-02-009-40	Brewers Yeast Disposal	---	---	---	---	---	---	---	---	1000 Barrels Packaged
3-02-009-41	Yeast Propagation	---	---	---	---	---	---	---	---	1000 Barrels Packaged
3-02-009-51	Can Filling Line	---	---	---	---	---	14	---	---	1000 Barrels Canned
3-02-009-52	Sterilized Can Filling Line	---	---	---	---	---	35	---	---	1000 Barrels Canned
3-02-009-53	Bottle Filling Line	---	---	---	---	---	17	---	---	1000 Barrels Bottled
3-02-009-54	Sterilized Bottle Filling Line	---	---	---	---	---	40	---	---	1000 Barrels Bottled
3-02-009-55	Keg Filling Line	---	---	---	---	---	0.69	---	---	1000 Barrels Kegged
3-02-009-60	Bottle Soaker and Cleaner	---	---	---	---	---	0.2	---	---	1000 Cases Washed
3-02-009-61	Bottle Crusher	---	---	---	---	---	0.48	---	---	Each Crushed
3-02-009-62	Can Crusher with Pneumatic Conveyor	---	---	---	---	---	0.088	---	---	Gallons Recovered
3-02-009-63	Beer Sump	---	---	---	---	---	---	---	---	1000 Barrels Packaged
3-02-009-64	Waste Beer Recovery	---	---	---	---	---	---	---	---	1000 Barrels Packaged
3-02-009-65	Waste Beer Storage Tanks	---	---	---	---	---	---	---	---	1000 Barrels Packaged
3-02-009-66	Ethanol Removal from Waste Beer	---	---	---	---	---	---	---	---	1000 Barrels Packaged
3-02-009-67	Ethanol Recovery from Waste Beer	---	---	---	---	---	---	---	---	1000 Barrels Packaged
3-02-009-98	Other Not Classified	---	---	---	---	---	---	---	---	Gallons Produced
3-02-009-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Distilled Spirits - 2085</u></i>										
3-02-010-01	Grain Handling (see 3-02-006-05)	3	---	---	---	---	---	---	---	Tons Processed
3-02-010-02	Dryer House Operations	5	---	---	---	---	---	---	---	Tons Processed
3-02-010-03	Aging (see 3-02-010-17)	---	---	---	---	---	10	---	---	Barrels (50 Gallon) Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Distilled Spirits - 2085</u></i>										
3-02-010-04	Fermentation Tank (see 3-02-010-14)	---	---	---	---	---	---	---	---	1000 Gallons Produced
3-02-010-05	Malt Milling	---	---	---	---	---	---	---	---	Tons Processed
3-02-010-06	Malt Drying	---	---	---	---	---	---	---	---	Tons Dried
3-02-010-10	Whiskey Bottling: Storage (see 3-02-010-18)	---	---	---	---	---	---	---	---	1000 Gallons Produced
3-02-010-11	Fugitive Emissions: General	---	---	---	---	---	---	---	---	1000 Gallons Produced
3-02-010-12	Fugitive Emissions: General	---	---	---	---	---	---	---	---	Tons Processed
3-02-010-13	Whiskey: Grain Mashing	---	---	---	---	---	---	---	---	Tons Processed
3-02-010-14	Whiskey: Fermentation Tank	---	---	---	---	---	---	---	---	1000 Bushels Input
3-02-010-15	Whiskey: Distillation	---	---	---	---	---	---	---	---	1000 Gallons Produced
3-02-010-17	Whiskey: Aging - Evaporation Loss	---	---	---	---	---	---	---	---	Barrel-Years (53 Gal) Aged
3-02-010-18	Whiskey: Blending/Bottling	---	---	---	---	---	---	---	---	1000 Gallons Produced
3-02-010-20	Raw Material Storage	---	---	---	---	---	---	---	---	Tons Processed
3-02-010-99	Other Not Classified	---	---	---	---	---	---	---	---	Gallons Produced
<i><u>Wines, Brandy, and Brandy Spirits - 2084</u></i>										
3-02-011-01	Grape Crushing/Treatment: White Wines	---	---	---	---	---	---	---	---	1000 Gallons Produced
3-02-011-02	Grape Crushing/Treatment: Red Wine	---	---	---	---	---	---	---	---	1000 Gallons Produced
3-02-011-03	Aging	---	---	---	---	---	---	---	---	Barrel-Years Stored
3-02-011-04	Fermentation Tank	---	---	---	---	---	---	---	---	1000 Gallons Produced
3-02-011-05	Wine Fermentation - White Wine	---	---	---	---	---	1.8	---	---	1000 Gallons Produced
3-02-011-06	Wine Fermentation - Red Wine	---	---	---	---	---	4.6	---	---	1000 Gallons Produced
3-02-011-10	Wine Bottling: Storage	---	---	---	---	---	---	---	---	1000 Gallons Produced
3-02-011-11	Fugitive Emissions: Pomace Screening - Red Wine	---	---	---	---	---	0.5	---	---	1000 Gallons Produced
3-02-011-12	Fugitive Emissions: Pomace Press - Red Wine	---	---	---	---	---	0.02	---	---	1000 Gallons Produced
3-02-011-20	Raw Material Storage	---	---	---	---	---	---	---	---	Tons Processed
3-02-011-21	Wine Bottling - White Wine	---	---	---	---	---	0.1	---	---	1000 Gallons Bottled
3-02-011-99	Other Not Classified	---	---	---	---	---	---	---	---	Gallons Produced
<i><u>Fish Processing - 2077, 2091</u></i>										
3-02-012-01	Cookers: Fresh Fish Scrap	---	---	---	---	---	0.03	---	---	Tons Produced
3-02-012-02	Cookers: Stale Fish Scrap	---	---	---	---	---	3.5	---	---	Tons Produced
3-02-012-03	Dryers	0.1	---	---	---	---	---	---	---	Tons Processed
3-02-012-04	Canning Cookers	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Fish Processing - 2077, 2091</i></u>										
3-02-012-05	Steam Tube Dryer	5	1.05	---	---	---	---	---	---	Tons Processed
3-02-012-06	Direct Fired Dryer	8	1.68	---	---	---	---	---	---	Tons Processed
3-02-012-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Meat Smokehouses - 2012, 2013</i></u>										
3-02-013-01	Combined Operations	---	---	---	---	---	---	---	---	Tons Smoked
3-02-013-02	Batch Smokehouses: Smoking Cycle	23	23	30	---	---	44	---	---	Tons Used
3-02-013-03	Batch Smokehouses: Cooking Cycle	---	---	---	---	---	---	---	---	1000 Pounds Produced
3-02-013-04	Continuous Smokehouse: Smoke Zone	66	66	75	---	---	17	---	---	Tons Used
3-02-013-05	Continuous Smokehouse: Heat Zone	---	---	---	---	---	---	---	---	1000 Pounds Produced
3-02-013-11	Meat Charbroiler	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Starch Manufacturing - 2036</i></u>										
3-02-014-01	Combined Operations	8	---	---	---	120.8	252.1	---	---	Tons Produced
3-02-014-02	Steeping (Acidification)	---	---	---	---	---	---	---	---	Tons Processed
3-02-014-03	Grinding	---	---	---	---	---	---	---	---	Tons Processed
3-02-014-04	Screening	---	---	---	---	---	---	---	---	Tons Produced
3-02-014-05	Centrifuging	---	---	---	---	---	---	---	---	Tons Processed
3-02-014-06	Starch Filtering	---	---	---	---	---	---	---	---	Tons Processed
3-02-014-07	Starch Storage Bin	---	---	---	---	---	---	---	---	Tons Stored
3-02-014-08	Starch Bulk Loadout	---	---	---	---	---	---	---	---	Tons Loaded
3-02-014-10	Modified Starch Drying: Flash Dryers	---	---	---	---	---	---	---	---	Tons Produced
3-02-014-11	Modified Starch Drying: Spray Dryers	---	---	---	---	---	---	---	---	Tons Produced
3-02-014-12	Unmodified Starch Drying: Flash Dryers	---	---	---	---	---	---	---	---	Tons Produced
3-02-014-13	Unmodified Starch Drying: Spray Dryers	---	---	---	---	---	---	---	---	Tons Produced
3-02-014-21	Fugitive Emissions: General	---	---	---	---	---	---	---	---	Tons Processed
3-02-014-22	Fugitive Emissions: Starch Packaging	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Sugar Cane Refining - 2061, 2062</i></u>										
3-02-015-01	General	---	---	---	---	---	---	---	---	Tons Produced
3-02-015-03	Evaporators	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-02-015-05	Clarifier	---	---	---	---	---	---	---	---	1000 Gallons Produced
3-02-015-07	Vacuum Pans	---	---	---	---	---	---	---	---	Tons Produced
3-02-015-10	Cane Sugar Dryer	---	---	---	---	---	---	---	---	Tons Produced



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Sugar Cane Refining - 2061, 2062</i></u>										
3-02-015-12	Bulk Sugar Storage	---	---	---	---	---	---	---	---	Tons Produced
3-02-015-14	Bulk Sugar Loadout	---	---	---	---	---	---	---	---	Tons Loaded
3-02-015-20	Clarification (Phosphatation)	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-02-015-21	Clarification (Carbonation)	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-02-015-25	Adsorbent Regeneration	---	---	---	---	---	---	---	---	Tons Conveyed
3-02-015-26	Adsorbent Conveyor Transfer	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-02-015-30	Evaporator	---	---	---	---	---	---	---	---	Tons Produced
3-02-015-32	Vacuum Pans	---	---	---	---	---	---	---	---	Tons Produced
3-02-015-35	Sugar Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-02-015-36	Sugar Cooler	---	---	---	---	---	---	---	---	Tons Produced
3-02-015-37	Sugar Granulator (Dryer & Cooler)	---	---	---	---	---	---	---	---	Tons Produced
3-02-015-40	Screen	---	---	---	---	---	---	---	---	Tons Produced
3-02-015-42	Sugar Storage and Packaging	---	---	---	---	---	---	---	---	Tons Produced
3-02-015-44	Bulk Loadout	---	---	---	---	---	---	---	---	Tons Loaded
3-02-015-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Sugar Beet Processing - 2063</i></u>										
3-02-016-01	Pulp Dryer : Coal-fired	4.4	---	---	0.41	0.06	0.2	---	---	Footnote 35
3-02-016-05	Pulp Dryer : Oil-fired	---	---	---	---	---	---	---	---	Tons Fed
3-02-016-08	Pulp Dryer : Natural Gas-fired	---	---	---	---	---	---	---	---	Tons Fed
3-02-016-12	Dried Pulp Pelletizer	---	---	---	---	---	---	---	---	Tons Produced
3-02-016-16	Dried Pulp Pellet Cooler	---	---	---	---	---	---	---	---	Tons Produced
3-02-016-21	First Carbonation Tank	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-02-016-22	Second Carbonation Tank	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-02-016-31	Sulfur Stove Contacting Tower	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-02-016-41	First Effect Evaporator Vent	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-02-016-51	Sugar Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-02-016-55	Sugar Cooler	---	---	---	---	---	---	---	---	Tons Produced
3-02-016-58	Sugar Granulator (Dryer & Cooler)	---	---	---	---	---	---	---	---	Tons Produced
3-02-016-61	Sugar Conveying and Sacking	---	---	---	---	---	---	---	---	Tons Produced
3-02-016-82	Lime Crusher	---	---	---	---	---	---	---	---	Tons Crushed
3-02-016-84	Lime Kiln : Coal-fired	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Sugar Beet Processing - 2063</i></u>										
3-02-016-86	Lime Kiln : Natural Gas-fired	---	---	---	---	---	---	---	---	Tons Processed
3-02-016-88	Lime Slaker	---	---	---	---	---	---	---	---	Tons Processed
3-02-016-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Peanut Processing - 2076, 2079, 2099</i></u>										
3-02-017-01	Loading/Unloading	---	---	---	---	---	---	---	---	Tons Processed
3-02-017-02	Cleaning	---	---	---	---	---	---	---	---	Tons Processed
3-02-017-03	Shelling	---	---	---	---	---	---	---	---	Tons Processed
3-02-017-04	Milling	---	---	---	---	---	---	---	---	Tons Processed
3-02-017-05	Dryer	---	---	---	---	---	---	---	---	Tons Processed
3-02-017-11	Unloading of Almonds to Receiving Pit	0.06	---	---	---	---	---	---	---	Tons Processed
3-02-017-12	Precleaning of Orchard Debris from Almonds	---	---	---	---	---	---	---	---	Tons Processed
3-02-017-13	Hull Removal and Separation from In-shell Almonds	---	---	---	---	---	---	---	---	Tons Processed
3-02-017-14	Hulling and Shelling of Almonds (Huller/Sheller)	---	---	---	---	---	---	---	---	Tons Processed
3-02-017-15	Classifier Screen Deck to Remove Shell from Meats	---	---	---	---	---	---	---	---	Tons Processed
3-02-017-16	Air Leg to Separate Shells from Meats	0.51	---	---	---	---	---	---	---	Tons Processed
3-02-017-17	Almond Roaster: Direct-fired Rotating Drum	---	---	---	---	---	---	---	---	Tons Produced
3-02-017-99	Other Not Classified	---	---	---	---	0.065	---	---	---	Tons Processed
<u><i>Candy Manufacturing - 2064, 2066</i></u>										
3-02-018-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Vegetable Oil Processing - 2046, 2074, 2076, 2079</i></u>										
3-02-019-01	Corn Oil: General	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-02	Cottonseed Oil: General	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-03	Soybean Oil: General	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-04	Peanut Oil: General	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-05	General	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-06	Corn Oil: General	---	---	---	---	---	18.7	---	---	Tons Produced
3-02-019-07	Cottonseed Oil: General	---	---	---	---	---	17.5	---	---	Tons Produced
3-02-019-08	Soybean Oil: General (use 3-02-019-98)	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-09	Peanut Oil: General	---	---	---	---	---	20.7	---	---	Tons Produced
3-02-019-11	Oil Extraction	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-12	Meal Preparation	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Vegetable Oil Processing - 2046, 2074, 2076, 2079</i>										
3-02-019-13	Oil Refining	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-14	Fugitive Leaks	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-15	Solvent Storage (Use 4-07-016-15 & -16 or 4-07-176-03 & -04)	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-16	Oil Extraction	---	---	---	---	---	16.77	---	---	Tons Produced
3-02-019-17	Meal Preparation	---	---	---	---	---	1.1	---	---	Tons Produced
3-02-019-18	Oil Refining	---	---	---	---	---	0.46	---	---	Tons Produced
3-02-019-19	Fugitive Leaks	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-20	Solvent Storage (Use 4-07-016-15 & -16 or 4-07-176-03 & -04 if possible)	---	---	---	---	---	---	---	---	Tons Processed
3-02-019-21	Solvent Work Tank	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-02-019-23	Aspiration Exhaust Vent: Startup and Shutdown	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-25	Oil Extraction Rotary Cell Extractor	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-26	Oil Extraction Vertically Arranged Basket Type Extractor	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-27	Oil Extraction Continuous, Shallowbed, Rectangular Loop, No Baskets	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-30	Meal Preparation: Desolventizer/Toaster	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-31	Meal Preparation: Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-32	Meal Preparation: Cooler	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-33	Meal Preparation: Pneumatic Conveyor	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-35	Meal Preparation: Screening and Grinding	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-39	Meal Storage Tanks	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-41	Oil Refining: Miscellaneous Holding Tank	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-42	Oil Refining: Evaporator(s)	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-45	Oil Refining: Oil Stripping Column	---	---	---	---	---	---	---	---	Tons Produced
3-02-019-49	Crude Oil Storage Tanks	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-02-019-50	Solvent/Water Separator	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-02-019-60	Wastewater Evaporator	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-02-019-97	Soybean Oil Production: Complete Process-Solvent Loss(Plant-specific)	---	---	---	---	---	---	---	---	Tons Processed
3-02-019-98	Soybean Oil Production: Complete Process-Solvent Loss (average)	---	---	---	---	---	4.9	---	---	Tons Processed
3-02-019-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Beef Cattle Feedlots - 211</u>										
3-02-020-01	Feedlots: General	---	---	---	---	---	---	---	---	Each-Year Capacity
3-02-020-02	Feedlots: General	---	---	---	---	---	---	---	---	Each Throughput
<u>Eggs and Poultry Production - 254</u>										
3-02-021-01	Manure Handling: Dry	---	---	---	---	---	---	---	---	Each-Year Capacity
3-02-021-02	Manure Handling: Dry	---	---	---	---	---	---	---	---	Each Throughput
3-02-021-05	Manure Handling: Wet	---	---	---	---	---	---	---	---	Each-Year Capacity
3-02-021-06	Manure Handling: Wet	---	---	---	---	---	---	---	---	Each Throughput
<u>Cotton Seed Delinting - 723</u>										
3-02-022-01	Acid Delinting of Cotton Seeds	---	---	---	---	---	---	---	---	Tons Delinted
<u>Seed Products and Processing - 0180, 5191</u>										
3-02-026-01	Seed Handling: General	---	---	---	---	---	---	---	---	Tons Processed
<u>Mushroom Growing - 182</u>										
3-02-028-01	General	---	---	---	---	---	---	---	---	Tons Produced
<u>Dairy Products - 2021, 2022, 2023, 2024, 2026</u>										
3-02-030-01	Milk: Spray Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-02-030-10	Whey Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-02-030-20	Cheese Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-02-030-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Export Grain Elevators - 4491, 4221</u>										
3-02-031-03	Cleaning	3	0.45	---	---	---	---	---	---	Tons Processed
3-02-031-04	Drying	1.1	0.67	---	---	---	---	---	---	Tons Processed
3-02-031-05	Unloading	1	---	---	---	---	---	---	---	Tons Processed
3-02-031-06	Loading	1	---	---	---	---	---	---	---	Tons Processed
3-02-031-07	Removal from Bins (Tunnel Belt)	1.4	---	---	---	---	---	---	---	Tons Processed
3-02-031-08	Elevator Legs (Headhouse)	1.5	---	---	---	---	---	---	---	Tons Processed
3-02-031-09	Tripper (Gallery Belt)	1	---	---	---	---	---	---	---	Tons Processed
3-02-031-10	Removal from Bins (Tunnel Belt)	---	---	---	---	---	---	---	---	Tons Shipped or Received
3-02-031-11	Elevator Legs (Headhouse)	---	---	---	---	---	---	---	---	Tons Shipped or Received
<u>Bakeries - 2051, 2052</u>										
3-02-032-01	Bread Baking: Sponge-Dough Process	---	---	---	---	---	Footnote 36	---	---	Tons Baked

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Bakeries - 2051, 2052</u></i>										
3-02-032-02	Bread Baking: Straight-Dough Process	---	---	---	---	---	Footnote 36	---	---	Tons Baked
3-02-032-03	Material Handling and Transferring	---	---	---	---	---	---	---	---	Tons Processed
3-02-032-04	Flour Storage	---	---	---	---	---	---	---	---	Tons Processed
3-02-032-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Tobacco Processing - 2111, 2121, 2131, 2141</u></i>										
3-02-033-99	Other Not Classified	---	---	---	0.48	---	0.34	---	---	Tons Produced
<i><u>Baker's Yeast Manufacturing - Dry Yeast - 2000, 2090, 2099</u></i>										
3-02-034-04	Intermediate Fermentor (F4 Stage)	---	---	---	---	---	36	---	---	Tons Produced
3-02-034-05	Stock Fermentor (F5 Stage)	---	---	---	---	---	5	---	---	Tons Produced
3-02-034-06	Pitch Fermentor (F6 Stage)	---	---	---	---	---	5	---	---	Tons Produced
3-02-034-07	Trade Fermentor (F7 Stage)	---	---	---	---	---	5	---	---	Tons Produced
3-02-034-10	Wastewater Treatment	---	---	---	---	---	---	---	---	1000 Gallons Treated
3-02-034-15	Extrusion	---	---	---	---	---	---	---	---	Tons Processed
3-02-034-20	Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-02-034-21	Drying Chamber	---	---	---	---	---	---	---	---	Tons Produced
3-02-034-22	Rotolouvre Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-02-034-23	Airlift Dryer: Batch Process	---	---	---	---	---	---	---	---	Tons Produced
3-02-034-24	Airlift Dryer: Continuous Process	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Baker's Yeast Manufacturing - Compressed Yeast - 2000, 2090, 2099</u></i>										
3-02-035-04	Intermediate Fermentor (F4 Stage)	---	---	---	---	---	---	---	---	Tons Produced
3-02-035-05	Stock Fermentor (F5 Stage)	---	---	---	---	---	---	---	---	Tons Produced
3-02-035-06	Pitch Fermentor (F6 Stage)	---	---	---	---	---	---	---	---	Tons Produced
3-02-035-07	Trade Fermentor (F7 Stage)	---	---	---	---	---	---	---	---	Tons Produced
3-02-035-10	Wastewater Treatment	---	---	---	---	---	---	---	---	1000 Gallons Treated
3-02-035-30	Harvesting	---	---	---	---	---	---	---	---	Tons Processed
3-02-035-31	Harvesting: Centrifuge	---	---	---	---	---	---	---	---	Tons Processed
3-02-035-32	Harvesting: Plate and Frame Filter Press	---	---	---	---	---	---	---	---	Tons Processed
3-02-035-33	Harvesting: Rotary Vacuum Filter	---	---	---	---	---	---	---	---	Tons Processed
3-02-035-34	Harvesting: Mixers	---	---	---	---	---	---	---	---	Tons Processed
3-02-035-35	Harvesting: Extrusion	---	---	---	---	---	---	---	---	Tons Processed
3-02-035-36	Harvesting: Cutting	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Baker's Yeast Manufacturing - Compressed Yeast - 2000, 2090, 2099</u>										
3-02-035-40	Packaging	---	---	---	---	---	---	---	---	Tons Processed
<u>Deep Fat Frying - 2099, 2017, 2051, 2092</u>										
3-02-036-01	Continuous Deep Fat Fryer: Potato Chips	1.6	---	0.39	---	---	0.02	---	---	Tons Produced
3-02-036-02	Continuous Deep Fat Fryer: Other Snack Chips	0.56	---	0.24	---	---	0.085	---	---	Tons Produced
3-02-036-03	Batch Deep Fat Fryer: Potato Chips	---	---	---	---	---	---	---	---	Tons Produced
3-02-036-04	Gas-fired Toaster: Snack Chips	---	---	---	---	---	---	---	---	Tons Produced
<u>Animal/Poultry Rendering - 2077</u>										
3-02-038-01	General	---	---	---	---	---	---	---	---	Tons Processed
3-02-038-02	Size Reduction	---	---	---	---	---	---	---	---	Tons Processed
3-02-038-03	Cooking	---	---	---	---	---	---	---	---	Tons Processed
3-02-038-04	Storage	---	---	---	---	---	---	---	---	Tons Processed
3-02-038-05	Material Handling	---	---	---	---	---	---	---	---	Tons Processed
3-02-038-11	Blood Dryer: Natural Gas Direct Fired	---	---	---	---	---	---	---	---	Tons Produced
3-02-038-12	Blood Dryer: Steam-coil Indirect Heated	---	---	---	---	---	---	---	---	Tons Produced
<u>Carob Kibble - 2041</u>										
3-02-039-01	Roaster	6	0.72	---	---	---	---	---	---	Tons Roasted
3-02-039-02	Receiving	---	---	---	---	---	---	---	---	Tons Processed
<u>Cereal - 2043</u>										
3-02-040-01	Dryer	---	0.66	---	---	---	---	---	---	Tons Dried
3-02-040-02	Cereal Conveying	---	---	---	---	---	---	---	---	Tons Conveyed
3-02-040-03	Cereal Packaging	---	---	---	---	---	---	---	---	Tons Packaged
3-02-040-04	Cereal Coating	---	---	---	---	---	---	---	---	Tons Coated
<u>Vinegar Manufacturing - 2000, 2090, 2099</u>										
3-02-042-01	Fermentation: Alcohol	---	---	---	---	---	---	---	---	Tons Processed
<u>Equipment Leaks - 0700, 2000</u>										
3-02-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Wastewater, Aggregate - 0700, 2000</u>										
3-02-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-02-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Wastewater, Points of Generation - 0700, 2000</u>										
3-02-825-01	Mineral Oil Stripper	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-02-825-02	Desolventizer/Toaster	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-02-825-03	Condensate from Condensers	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-02-825-04	Wastewater Separator	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-02-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Fugitive Emissions - 2000</u>										
3-02-888-01	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-02-888-02	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-02-888-03	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-02-888-04	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-02-888-05	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
<u>Fuel Fired Equipment - 2000</u>										
3-02-900-01	Distillate Oil (No. 2): Process Heaters	---	---	---	143.6S	20	0.2	---	---	1000 Gallons Burned
3-02-900-02	Residual Oil: Process Heaters	---	---	---	158.6S	55	0.28	---	---	1000 Gallons Burned
3-02-900-03	Natural Gas: Process Heaters	---	---	---	0.6	140	2.8	---	---	Million Cubic Feet Burned
3-02-900-05	Liquified Petroleum Gas (LPG): Process Heaters	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>Fuel Fired Equipment - 0700, 2000</u>										
3-02-910-01	Broiling Food: Natural Gas	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
<u>Other Not Specified - 2000</u>										
3-02-999-98	Other Not Classified	---	---	---	---	---	---	---	---	Tons Input
3-02-999-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Output
<u>INDUSTRIAL PROCESSES -Primary Metal Production</u>										
<u>Aluminum Ore (Bauxite) - 1099</u>										
3-03-000-01	Crushing/Handling	---	---	---	---	---	---	---	---	Tons Processed
3-03-000-02	Drying Oven	---	0.7	---	1.4	---	---	---	---	Tons Processed
3-03-000-03	Fine Ore Storage	---	0.0007	---	3	---	---	---	---	Tons Handled
3-03-000-04	Loading and Unloading	---	---	---	---	---	---	---	---	Tons Processed
<u>Aluminum Ore (Electro-reduction) - 3334</u>										
3-03-001-01	Prebaked Reduction Cell	---	54.5	---	60	0.003	0.1	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Aluminum Ore (Electro-reduction) - 3334</u>										
3-03-001-02	Horizontal Stud Soderberg Cell	---	56.8	---	---	---	1	---	---	Tons Produced
3-03-001-03	Vertical Stud Soderberg Cell	---	---	---	---	---	1	---	---	Tons Produced
3-03-001-04	Materials Handling	10	5.8	---	---	---	---	---	---	Tons Produced
3-03-001-05	Anode Baking Furnace	---	---	---	---	---	1	---	---	Tons Produced
3-03-001-06	Degassing	---	---	---	---	---	---	---	---	Tons Produced
3-03-001-07	Roof Vents	---	---	---	---	---	2.7	---	---	Tons Produced
3-03-001-08	Prebake: Fugitive Emissions	---	2.9	---	---	---	---	---	---	Tons Produced
3-03-001-09	H.S.S.: Fugitive Emissions	---	3.1	---	---	---	---	---	---	Tons Produced
3-03-001-10	V.S.S.: Fugitive Emissions	---	3.7	---	---	---	---	---	---	Tons Produced
3-03-001-11	Anode Baking: Fugitive Emissions	---	---	---	---	---	---	---	---	Tons Produced
3-03-001-99	Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Aluminum Hydroxide Calcining - 3334</u>										
3-03-002-01	Overall Process	---	24	---	---	---	0.02	---	---	Tons Produced
<u>By-product Coke Manufacturing - 3312</u>										
3-03-003-02	Oven Charging	0.48	---	---	<sup>21</sup> 0.02	0.03	2.5	0.6	---	Tons Charged
3-03-003-03	Oven Pushing	1.15	0.5	---	3.3	0.03	0.2	0.07	---	Tons Charged
3-03-003-04	Quenching	See App. C	See App. C	---	---	0.6	---	---	---	Tons Charged
3-03-003-05	Coal Unloading	0.00011	0.000054	---	---	---	---	---	---	Tons Charged
3-03-003-06	Oven Underfiring	0.47	---	---	---	0.04	2	---	---	Tons Charged
3-03-003-07	Coal Crushing/Handling	---	---	---	---	---	---	---	---	Tons Charged
3-03-003-08	Oven/Door Leaks	0.54	0.51	---	0.294	0.01	1.5	0.6	---	Tons Charged
3-03-003-09	Coal Conveying	---	---	---	---	---	---	---	---	Tons Processed
3-03-003-10	Coal Crushing	0.11	---	---	---	---	---	---	---	Tons Charged
3-03-003-11	Coal Screening	---	---	---	---	---	---	---	---	Tons Processed
3-03-003-12	Coke: Crushing/Screening/Handling	---	---	---	---	---	---	---	---	Tons Processed
3-03-003-13	Coal Preheater	3.5	3.4	---	---	---	0.3	---	---	Tons Charged
3-03-003-14	Topside Leaks	---	0.08	---	0.1	0.01	1.5	---	---	Tons Charged
3-03-003-15	Gas By-product Plant	---	---	---	---	---	---	---	---	Million Cubic Feet Processed
3-03-003-16	Coal Storage Pile	---	---	---	---	---	---	---	---	Tons Charged
3-03-003-17	Combustion Stack: Coke Oven Gas (COG)	0.47	0.45	---	<sup>21</sup> See App. C	---	---	---	---	Tons Charged



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>By-product Coke Manufacturing - 3312</i></u>										
3-03-003-18	Combustion Stack: Blast Furnace Gas (BFG)	0.17	---	---	<sup>21</sup> 1.08	---	---	---	---	Tons Charged
3-03-003-31	By-product Coke Manufacturing	---	---	---	---	---	---	---	---	Tons Produced
3-03-003-32	Flushing-liquor Circulation Tank	---	---	---	---	---	---	---	---	Tons Produced
3-03-003-33	Excess-ammonia Liquor Tank	---	---	---	---	---	---	---	---	Tons Produced
3-03-003-34	Tar Dehydrator	---	---	---	---	---	---	---	---	Tons Produced
3-03-003-35	Tar Interceding Sump	---	---	---	---	---	---	---	---	Tons Produced
3-03-003-36	Tar Storage	---	---	---	---	---	---	---	---	Tons Produced
3-03-003-41	Light Oil Sump	---	---	---	---	---	---	---	---	Tons Produced
3-03-003-42	Light Oil Decanter/Condenser Vent	---	---	---	---	---	---	---	---	Tons Produced
3-03-003-43	Wash Oil Decanter	---	---	---	---	---	---	---	---	Tons Produced
3-03-003-44	Wash-oil Circulation Tank	---	---	---	---	---	---	---	---	Tons Produced
3-03-003-51	By-product Coke Manufacturing	---	---	---	---	---	---	---	---	Tons Produced
3-03-003-52	Tar Bottom Final Cooler	---	---	---	---	---	---	---	---	Tons Produced
3-03-003-53	Naphthalene Processing/Handling	---	---	---	---	---	---	---	---	Tons Produced
3-03-003-61	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
3-03-003-99	Not Classified	---	---	---	---	---	---	---	---	Tons Charged
<u><i>Coke Manufacture: Beehive Process - 3312</i></u>										
3-03-004-01	General	---	97.8	---	---	---	---	---	---	Tons Charged
<u><i>Primary Copper Smelting - 3331</i></u>										
3-03-005-02	Multiple Hearth Roaster	45	23.8	---	280	---	---	---	0.15	Tons Processed
3-03-005-03	Reverberatory Smelting Furnace after Roaster	50	13.6	---	160	---	---	---	0.072	Tons Processed
3-03-005-04	Converter (All Configurations)	36	21.2	---	740	---	---	---	0.27	Tons Processed
3-03-005-05	Fire (Furnace) Refining	---	9.2	---	---	---	---	---	---	Tons Processed
3-03-005-06	Ore Concentrate Dryer	10	4.8	---	1	---	---	---	---	Tons Processed
3-03-005-07	Reverberatory Smelting Furnace w/ Ore Charge w/o Roasting	---	13.5	---	---	---	---	---	---	Tons Processed
3-03-005-08	Refined Metal Finishing Operations	---	---	---	---	---	---	---	---	Tons Processed
3-03-005-09	Fluidized Bed Roaster	55	29.2	---	360	---	---	---	---	Tons Processed
3-03-005-10	Electric Smelting Furnace	100	58	---	240	---	---	---	---	Tons Processed
3-03-005-11	Electrolytic Refining	---	---	---	---	---	---	---	---	Tons Processed
3-03-005-12	Flash Smelting	140	83	---	820	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Primary Copper Smelting - 3331</u></i>										
3-03-005-13	Roasting: Fugitive Emissions	2.6	1.4	---	1	---	---	---	---	Tons Processed
3-03-005-14	Reverberatory Furnace: Fugitive Emissions	0.4	0.17	---	<sup>21</sup> 4	---	---	---	---	Tons Processed
3-03-005-15	Converter: Fugitive Emissions	4.4	2.6	---	130	---	---	---	---	Tons Processed
3-03-005-16	Anode Refining Furnace: Fugitive Emissions	0.5	0.46	---	0.1	---	---	---	---	Tons Processed
3-03-005-17	Slag Cleaning Furnace: Fugitive Emissions	8	7.7	---	6	---	---	---	---	Tons Processed
3-03-005-18	Converter Slag Return: Fugitive Emissions	---	---	---	0.1	---	---	---	---	Tons Processed
3-03-005-19	Unpaved Road Traffic: Fugitive Emissions	---	---	---	---	---	---	---	---	Miles Travelled
3-03-005-21	Noranda Reactor	---	---	---	---	---	---	---	---	Tons Processed
3-03-005-22	Slag Cleaning Furnace	10	7.7	---	6	---	---	---	---	Tons Processed
3-03-005-23	Reverberatory Furnace with Converter	86	9.7	---	320	---	---	---	---	Tons Processed
3-03-005-24	AFT MHR+RF/FBR+EF	36	21.2	---	600	---	---	---	---	Tons Processed
3-03-005-25	Fluid Bed Roaster with Reverberatory Furnace and Converter	86	19.1	---	360	---	---	---	---	Tons Processed
3-03-005-26	Dryer with Electric Furnace and Cleaning Furnace and Converter	146	17.3	---	1	---	---	---	---	Tons Processed
3-03-005-27	Dryer with Flash Furnace and Converter	150	4.8	---	1	---	---	---	---	Tons Processed
3-03-005-28	Norander Reactor and Converter	---	---	---	---	---	---	---	---	Tons Processed
3-03-005-29	Multiple Hearth Roaster with Reverberatory Furnace and Converter	131	19	---	280	---	---	---	---	Tons Processed
3-03-005-30	Fluid Bed Roaster with Electric Furnace and Converter	136	19.1	---	600	---	---	---	---	Tons Processed
3-03-005-31	Reverberatory Furnace After Multiple Hearth Roaster	50	13.5	---	180	---	---	---	---	Tons Processed
3-03-005-32	Reverberatory Furnace After Fluid Bed Roaster	50	13.5	---	160	---	---	---	---	Tons Processed
3-03-005-33	Electric Furnace After Concentrate Dryer	100	58	---	240	---	---	---	---	Tons Processed
3-03-005-34	Flash Furnace After Concentrate Dryer	140	83	---	820	---	---	---	---	Tons Processed
3-03-005-35	Electric Furnace After Fluid Bed Roaster	---	58	---	---	---	---	---	---	Tons Processed
3-03-005-41	Concentrate Dryer Followed by Noranda Reactors and Converter	---	---	---	<sup>27</sup> 1	---	---	---	---	Tons Processed
3-03-005-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Ferroalloy, Open Furnace - 3313</u></i>										
3-03-006-01	50% FeSi: Electric Smelting Furnace	See App. C	44	---	0.07	0.1	4.5	---	0.29	Tons Produced
3-03-006-02	75% FeSi: Electric Smelting Furnace	See App. C	199	---	0.07	0.1	---	---	---	Tons Produced
3-03-006-03	90% FeSi: Electric Smelting Furnace	564	355	---	0.07	0.1	---	---	---	Tons Produced
3-03-006-04	Silicon Metal: Electric Smelting Furnace	872	750	---	0.07	0.1	71.8	---	0.0031	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Ferroalloy, Open Furnace - 3313</i></u>										
3-03-006-05	Silicomanganese: Electric Smelting Furnace	192	177	---	---	0.1	---	---	0.0057	Tons Produced
3-03-006-06	80% Ferromanganese	28	24	---	---	---	---	---	---	Tons Produced
3-03-006-07	80% Ferrochromium	157	143	---	---	---	---	---	---	Tons Produced
3-03-006-08	Raw Material Unloading	---	---	---	---	---	---	---	---	Tons Processed
3-03-006-09	Raw Material Crushing	---	---	---	---	---	---	---	---	Tons Processed
3-03-006-10	Ore Screening	---	---	---	---	---	---	---	---	Tons Processed
3-03-006-11	Ore Dryer	---	---	---	---	---	---	---	---	Tons Processed
3-03-006-13	Raw Material Storage	---	---	---	---	---	---	---	---	Tons Processed
3-03-006-14	Raw Material Transfer	---	---	---	---	---	---	---	---	Tons Processed
3-03-006-15	Ferromanganese: Blast Furnace	---	---	---	---	---	16	---	---	Tons Produced
3-03-006-16	Ferrosilicon: Blast Furnace	---	---	---	---	---	16	---	---	Tons Produced
3-03-006-17	Cast House	---	---	---	---	---	2.8	---	---	Tons Produced
3-03-006-18	Mix House/Weighing	---	---	---	---	---	---	---	---	Tons Processed
3-03-006-19	Raw Material Charging	---	---	---	---	---	---	---	---	Tons Processed
3-03-006-20	Tapping	---	---	---	---	---	---	---	---	Tons Processed
3-03-006-21	Casting	---	---	---	---	---	---	---	---	Tons Processed
3-03-006-22	Cooling	---	---	---	---	---	---	---	---	Tons Produced
3-03-006-23	Product Crushing	---	---	---	---	---	---	---	---	Tons Produced
3-03-006-24	Product Storage	---	---	---	---	---	---	---	---	Tons Processed
3-03-006-25	Product Loading	---	---	---	---	---	---	---	---	Tons Processed
3-03-006-51	Sealed Furnace: Ferromanganese: Electric Arc Furnace	---	---	---	---	---	---	---	---	Tons Produced
3-03-006-52	Sealed Furnace: Ferrochromium: Electric Arc Furnace	---	---	---	---	---	---	---	---	Tons Produced
3-03-006-53	Sealed Furnace: Ferrochromium Silica: Electric Arc Furnace	---	---	---	---	---	---	---	---	Tons Produced
3-03-006-54	Sealed Furnace: EAF - Other Alloys: Specify in Comment	---	---	---	---	---	---	---	---	Tons Produced
3-03-006-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Ferroalloy, Semi-covered Furnace - 3313</i></u>										
3-03-007-01	Ferromanganese: Electric Arc Furnace	See App. C	10.8	---	0.01	0.1	1.4	---	0.11	Tons Produced
3-03-007-02	Electric Arc Furnace: Other Alloys/Specify	---	---	---	---	---	---	---	---	Tons Produced
3-03-007-03	Ferrochromium: Electric Arc Furnace	---	---	---	---	---	8.2	---	---	Tons Produced
3-03-007-04	Ferrochromium Silicon: Electric Arc Furnace	---	---	---	---	---	8.2	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Iron Production (See 3-03-015 for Integrated Iron &amp; Steel MACT) - 3312</i>										
3-03-008-01	Ore Charging	---	41.8	---	---	---	---	---	---	Tons Produced
3-03-008-02	Agglomerate Charging	---	15.2	---	---	---	---	---	---	Tons Produced
3-03-008-04	Loader: Hi-Silt	0.026	0.013	---	---	---	---	---	---	Tons Transferred
3-03-008-05	Loader: Low-Silt	0.0088	0.0044	---	---	---	---	---	---	Tons Transferred
3-03-008-08	Slag Crushing and Sizing	---	---	---	---	---	---	---	---	Tons Processed
3-03-008-09	Slag Removal and Dumping	---	---	---	---	---	---	---	---	Tons Processed
3-03-008-11	Raw Material Stockpiles, Coke Breeze, Limestone, Ore Fines	---	---	---	---	---	---	---	---	Tons Produced
3-03-008-12	Raw Material Transfer/Handling	---	---	---	---	---	---	---	---	Tons Produced
3-03-008-13	Windbox	11.1	1.67	---	---	0.3	1.4	44.7	---	Tons Produced
3-03-008-14	Discharge End	6.8	1.02	---	---	---	---	---	---	Tons Produced
3-03-008-15	Sinter Breaker	---	---	---	---	---	---	---	---	Tons Produced
3-03-008-16	Hot Screening	---	---	---	---	---	---	---	---	Tons Produced
3-03-008-17	Cooler	---	0.45	---	0.14	---	---	---	---	Tons Produced
3-03-008-18	Cold Screening	---	---	---	---	---	---	---	---	Tons Produced
3-03-008-19	Sinter Process (Combined Code includes 15,16,17,18)	---	0.12	---	---	---	0.05	---	---	Tons Produced
3-03-008-20	Sinter Conveyor: Transfer Station	---	0.02	---	---	---	---	---	---	Tons Transferred
3-03-008-21	Unload Ore, Pellets, Limestone, into Blast Furnace	0.0024	0.0012	---	---	---	---	---	---	Tons Transferred
3-03-008-22	Raw Material Stockpile: Ore, Pellets, Limestone, Coke, Sinter	---	---	---	---	---	4.8	---	---	Tons Processed
3-03-008-23	Charge Materials: Transfer/Handling	---	---	---	---	---	---	---	---	Tons Processed
3-03-008-24	Blast Heating Stoves	---	---	---	---	---	0.01	---	---	Tons Processed
3-03-008-25	Cast House	0.6	0.31	---	3	0.03	2.8	---	---	Tons Processed
3-03-008-26	Blast Furnace Slips	87	33	---	---	---	---	---	---	Each Occurred
3-03-008-27	Lump Ore Unloading	0.0003	0.0002	---	---	---	---	---	---	Tons Transferred
3-03-008-28	Blast Furnace: Local Evacuation	---	---	---	---	---	---	---	---	Tons Processed
3-03-008-29	Blast Furnace: Taphole and Trough	---	---	---	---	---	---	---	---	Tons Processed
3-03-008-31	Unpaved Roads: Light Duty Vehicles	1.8	1	---	---	---	---	---	---	Miles Travelled
3-03-008-32	Unpaved Roads: Medium Duty Vehicles	7.3	4.1	---	---	---	---	---	---	Miles Travelled
3-03-008-33	Unpaved Roads: Heavy Duty Vehicles	14	7.6	---	---	---	---	---	---	Miles Travelled
3-03-008-34	Paved Roads: All Vehicle Types	0.78	0.44	---	---	---	---	---	---	Miles Travelled
3-03-008-41	Flue Dust Unloading	---	---	---	---	---	---	---	---	Tons Transferred

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Iron Production (See 3-03-015 for Integrated Iron &amp; Steel MACT) - 3312</i>										
3-03-008-42	Blended Ore Unloading	---	---	---	---	---	---	---	---	Tons Transferred
3-03-008-99	See Comment	---	---	---	---	---	---	---	---	Tons Produced
<i>Steel Manufacturing (See 3-03-015 for Integrated Iron &amp; Steel MACT) - 3312</i>										
3-03-009-01	Open Hearth Furnace: Stack	21.1	17.5	---	2.8	---	0.17	---	---	Tons Produced
3-03-009-04	Electric Arc Furnace: Alloy Steel (Stack)	11.3	6.55	---	0.07	0.2	0.35	18	---	Tons Produced
3-03-009-06	Charging: Electric Arc Furnace	---	---	---	---	---	0.001	---	---	Tons Produced
3-03-009-07	Tapping: Electric Arc Furnace	---	---	---	---	---	0.005	---	---	Tons Produced
3-03-009-08	Electric Arc Furnace: Carbon Steel (Stack)	0.00935	22.04	---	0.07	0.2	0.35	18	0 - 0.08	Footnote 37
3-03-009-10	Pickling	---	---	---	---	---	---	---	---	Tons Produced
3-03-009-11	Soaking Pits	---	0.03	---	---	---	0.59	---	---	Tons Produced
3-03-009-12	Grinding	---	---	---	---	---	---	---	---	Tons Produced
3-03-009-13	Basic Oxygen Furnace: Open Hood-Stack	28.5	13.1	---	---	0.08	0.001	138	---	Tons Produced
3-03-009-14	Basic Oxygen Furnace: Closed Hood-Stack	28.5	13.1	---	---	---	0.001	138	---	Tons Produced
3-03-009-15	Hot Metal (Iron) Transfer to Steelmaking Furnace	0.19	0.09	---	---	---	0.001	---	---	Tons Produced
3-03-009-16	Charging: BOF	0.6	0.34	---	---	---	0.001	---	---	Tons Produced
3-03-009-17	Tapping: BOF	0.92	0.41	---	---	0.02	0.005	---	---	Tons Produced
3-03-009-18	Charging: Open Hearth	---	---	---	---	---	0.001	---	---	Tons Produced
3-03-009-19	Tapping: Open Hearth	---	---	---	---	---	0.002	---	---	Tons Produced
3-03-009-20	Hot Metal Desulfurization	---	0.22	---	---	---	---	---	---	Tons Processed
3-03-009-21	Teeming (Unleaded Steel)	0.07	0.03	---	---	---	0.002	---	---	Tons Produced
3-03-009-22	Continuous Casting	---	---	---	---	0.05	---	---	---	Tons Produced
3-03-009-23	Steel Furnace Slag Tapping and Dumping	---	0.9	---	---	---	0.002	---	---	Tons Produced
3-03-009-24	Steel Furnace Slag Processing	---	0.29	---	---	---	---	---	---	Tons Produced
3-03-009-25	Teeming (Leaded Steel)	0.81	0.36	---	---	---	0.002	---	---	Tons Produced
3-03-009-26	Electric Induction Furnace	---	---	---	---	---	---	---	---	Tons Produced
3-03-009-27	Steel Scrap Preheater	---	---	---	---	---	---	---	---	Tons Produced
3-03-009-28	Argon-oxygen Decarburization	---	---	---	---	---	---	---	---	Tons Produced
3-03-009-29	Steel Plate Burner/Torch Cutter	---	---	---	---	---	---	---	---	Tons Produced
3-03-009-30	Q-BOP Melting and Refining	---	---	---	---	---	---	---	---	Tons Produced
3-03-009-31	Hot Rolling	---	---	---	---	---	---	---	---	Tons Produced
3-03-009-32	Scarfig	0.1	0.1	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Steel Manufacturing (See 3-03-015 for Integrated Iron &amp; Steel MACT) - 3312</i>										
3-03-009-33	Reheat Furnaces	---	0.08	---	---	0.8	0.01	---	---	Tons Produced
3-03-009-34	Heat Treating Furnaces: Annealing	---	---	---	---	0.1	---	---	---	Tons Produced
3-03-009-35	Cold Rolling	---	---	---	---	---	---	---	---	Tons Produced
3-03-009-36	Coating: Tin, Zinc, etc.	---	---	---	---	1.9	0.07	---	---	Tons Produced
3-03-009-98	Other Not Classified	---	---	---	---	---	---	---	---	Each Processed
3-03-009-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i>Lead Production - 3339</i>										
3-03-010-01	Sintering: Single Stream	106.5	208.7	---	275	---	---	---	105	Tons Processed
3-03-010-02	Blast Furnace Operation	180.5	321.3	---	22.5	---	---	---	0.0001	Footnote 38
3-03-010-03	Dross Reverberatory Furnace	20	19.6	---	---	---	---	---	2.9	Tons Processed
3-03-010-04	Ore Crushing	6	---	---	---	---	---	---	0.3	Tons Crushed
3-03-010-05	Materials Handling (Includes 11, 12, 13, 04, 14)	5	4.25	---	---	---	---	---	---	Tons Produced
3-03-010-06	Sintering: Dual Stream Feed End	213	181	---	550	---	---	---	174	Tons Processed
3-03-010-07	Sintering: Dual Stream Discharge End	---	---	---	---	---	---	---	---	Tons Processed
3-03-010-08	Slag Fume Furnace	4.6	1.29	---	2.9	---	---	---	---	Tons Produced
3-03-010-09	Lead Drossing	0.48	0.47	---	---	---	---	---	---	Tons Produced
3-03-010-10	Raw Material Crushing and Grinding	2.26	0.85	---	---	---	---	---	---	Tons Processed
3-03-010-11	Raw Material Unloading	---	0.34	---	---	---	---	---	---	Tons Processed
3-03-010-12	Raw Material Storage Piles	---	0.26	---	---	---	---	---	---	Tons Processed
3-03-010-13	Raw Material Transfer	---	0.43	---	---	---	---	---	---	Tons Processed
3-03-010-14	Sintering Charge Mixing	---	1.9	---	---	---	---	---	---	Tons Processed
3-03-010-15	Sinter Crushing/Screening	---	0.12	---	---	---	---	---	---	Tons Processed
3-03-010-16	Sinter Transfer	---	0.015	---	---	---	---	---	---	Tons Processed
3-03-010-17	Sinter Fines Return Handling	---	4.8	---	---	---	---	---	---	Tons Processed
3-03-010-18	Blast Furnace Charging	---	---	---	---	---	---	---	---	Tons Produced
3-03-010-19	Blast Furnace Tapping (Metal and Slag)	---	0.07	---	---	---	---	---	---	Tons Produced
3-03-010-20	Blast Furnace Lead Pouring	0.93	0.93	---	---	---	---	---	---	Tons Produced
3-03-010-21	Blast Furnace Slag Pouring	0.47	0.13	---	---	---	---	---	---	Tons Produced
3-03-010-22	Lead Refining/Silver Retort	1.8	1.76	---	---	---	---	---	---	Tons Produced
3-03-010-23	Lead Casting	0.87	0.85	---	---	---	---	---	---	Tons Produced
3-03-010-24	Reverberatory or Kettle Softening	3	2.94	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Lead Production - 3339</u>										
3-03-010-25	Sinter Machine Leakage	0.68	0.67	---	---	---	---	---	---	Tons Processed
3-03-010-26	Sinter Dump Area	0.01	0.0008	---	---	---	---	---	---	Tons Processed
3-03-010-27	Vacuum Distillation	---	---	---	---	---	---	---	---	Tons Produced
3-03-010-28	Tetrahedrite Dryer	---	---	---	---	---	---	---	---	Tons Processed
3-03-010-29	Sinter Machine (Weak Gas)	---	---	---	<sup>21</sup> 550	---	---	---	---	Tons Produced
3-03-010-30	Sinter Storage	---	---	---	---	---	---	---	---	Tons Processed
3-03-010-31	Speiss Pit	---	---	---	---	---	---	---	---	Tons Processed
3-03-010-32	Ore Screening	---	---	---	---	---	---	---	---	Tons Processed
3-03-010-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Molybdenum - 1061</u>										
3-03-011-01	Mining: General	---	---	---	---	---	---	---	---	100 Tons Mined
3-03-011-02	Milling: General	---	---	---	---	---	---	---	---	100 Tons Produced
3-03-011-99	Other Not Classified	---	---	---	---	---	---	---	---	100 Tons Produced
<u>Titanium - 3339, 3369, 3356, 3364</u>										
3-03-012-01	Chlorination	---	---	---	---	---	---	---	---	Tons Produced
3-03-012-02	Drying Titanium Sand Ore (Cyclone Exit)	0.5	0.43	---	---	---	---	---	---	Tons Processed
3-03-012-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Gold - 1041, 3341, 3339</u>										
3-03-013-01	General Processes	---	---	---	---	---	---	---	---	Tons Processed
3-03-013-02	Fines Crushing	---	---	---	---	---	---	---	---	Tons Processed
<u>Barium Ore Processing - 3295</u>										
3-03-014-01	Ore Grinding	---	---	---	---	---	---	---	---	Tons Processed
3-03-014-02	Reduction Kiln	---	---	---	---	---	---	---	---	Tons Processed
3-03-014-03	Dryers/Calciners	---	---	---	---	---	---	---	---	Tons Processed
3-03-014-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Integrated Iron and Steel Manufacturing (See also 3-03-008 &amp; 3-03-009) - 3300, 3320</u>										
3-03-015-01	Integrated Iron and Steel Foundries	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-02	Sintering: Raw Materials Handling	---	---	---	---	---	---	---	---	Tons Processed
3-03-015-03	Sintering: Windbox	---	---	---	---	---	---	---	---	Tons Processed
3-03-015-04	Sintering: Discharge End	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Integrated Iron and Steel Manufacturing (See also 3-03-008 &amp; 3-03-009) - 3300, 3320</i>										
3-03-015-05	Sintering: Cooler	---	---	---	---	---	---	---	---	Tons Processed
3-03-015-06	Sintering: Cold Screen	---	---	---	---	---	---	---	---	Tons Processed
3-03-015-10	Blast Furnace: Slip	---	---	---	---	---	---	---	---	Each Occurred
3-03-015-11	Blast Furnace: Charging	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-12	Blast Furnace: Casting, Uncontrolled Casthouse Roof Monitor	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-13	Blast Furnace: Casting, Furnace with Local Evacuation	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-14	Blast Furnace: Taphole and Trough Only	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-18	Hot Metal Desulfurization	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-20	Basic Oxygen Furnace (BOF)	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-21	BOF, Top Blown Furnace: Charging	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-22	BOF, Top Blown Furnace: Melting and Refining	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-23	BOF, Top Blown Furnace: Tapping	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-24	BOF, Top Blown Furnace: Hot Metal Transfer	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-30	QBOP: Melting and Refining	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-40	Electric Arc Furnace (EAF): Charging	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-41	EAF: Melting and Refining	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-42	EAF: Tapping	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-43	EAF: Slagging	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-50	Open Hearth Furnace: Charging	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-51	Open Hearth Furnace: Melting and Refining	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-52	Open Hearth Furnace: Tapping	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-53	Open Hearth Furnace: Hot Metal Transfer	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-54	Open Hearth Furnace: Slagging	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-60	Teeming: Leaded Steel	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-61	Teeming: Unleaded Steel	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-70	Machine Scarfing	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-71	Manual Scarfing	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-80	Miscellaneous Combustion Sources	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-81	Miscellaneous Combustion Sources: Blast Furnace Stoves	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-82	Miscellaneous Combustion Sources: Boilers	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-83	Miscellaneous Combustion Sources: Soaking Pits	---	---	---	---	---	---	---	---	Tons Produced



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Integrated Iron and Steel Manufacturing (See also 3-03-008 &amp; 3-03-009) - 3300, 3320</u></i>										
3-03-015-84	Miscellaneous Combustion Sources: Reheat Furnaces	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-90	Open Dust Sources	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-91	Continuous Drop: Conveyor Transfer Station	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-92	Pile Formation Stackers: Pellet Ore	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-93	Pile Formation Stackers: Lump Ore	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-94	Pile Formation Stackers: Coal	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-95	Batch Drops Front End Loader Truck: High Silt Slag	---	---	---	---	---	---	---	---	Tons Produced
3-03-015-96	Batch Drops Front End Loader Truck: Low Silt Slag	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Taconite Iron Ore Processing - 1011</u></i>										
3-03-023-01	Primary Crushing	0.2	---	---	---	---	---	---	---	Tons Produced
3-03-023-02	Tertiary Crusher	79.8	---	---	---	---	---	---	---	Tons Produced
3-03-023-03	Ore Screening	---	---	---	---	---	---	---	---	Tons Screened
3-03-023-04	Ore Transfer	0.1	0.085	---	---	---	---	---	---	Tons Produced
3-03-023-05	Ore Storage	---	---	---	---	---	---	---	---	Tons Stored
3-03-023-06	Dry Grinding/Milling	---	---	---	---	---	---	---	---	Tons Ground
3-03-023-07	Bentonite Storage	---	---	---	---	---	---	---	---	Tons Stored
3-03-023-08	Bentonite Blending	19	---	---	---	---	---	---	---	Tons Stored
3-03-023-09	Traveling Grate Feed (use 3-03-023-79)	0.64	---	---	---	---	---	---	---	Tons Produced
3-03-023-10	Traveling Grate Discharge (use 3-03-023-80)	1.32	---	---	---	---	---	---	---	Tons Produced
3-03-023-11	Chip Regrinding	---	---	---	---	---	---	---	---	Tons Reground
3-03-023-12	Indurating Furnace: Gas Fired (see 3-03-023-51 thru -88)	29.2	24.8	---	---	---	---	---	---	Tons Produced
3-03-023-13	Indurating Furnace: Oil Fired (see 3-03-023-51 thru -88)	29.2	24.8	---	---	---	---	---	---	Tons Produced
3-03-023-14	Indurating Furnace: Coal Fired (see 3-03-023-51 thru -88)	29.2	24.8	---	---	---	---	---	---	Tons Produced
3-03-023-15	Pellet Cooler	0.12	---	---	---	---	---	---	---	Tons Produced
3-03-023-16	Pellet Transfer to Storage	3.4	1.5	---	---	---	---	---	---	Tons Produced
3-03-023-17	Magnetic Separation	---	---	---	---	---	---	---	---	Tons Fed
3-03-023-18	Non-magnetic Separation	---	---	---	---	---	---	---	---	Tons Fed
3-03-023-19	Kiln (see 3-03-023-51 thru -88)	---	---	---	---	---	---	---	---	Tons Processed
3-03-023-20	Conveyors, Transfer, and Loading (see 3-03-023-51 thru -88)	---	---	---	---	---	---	---	---	Tons Processed
3-03-023-21	Haul Road: Rock	11	6.2	---	---	---	---	---	---	Miles Travelled

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Taconite Iron Ore Processing - 1011</i>										
3-03-023-22	Haul Road: Taconite	9.3	5.2	---	---	---	---	---	---	Miles Travelled
3-03-023-25	Primary Crusher Return Conveyor Transfer	---	---	---	---	---	---	---	---	Tons Transferred
3-03-023-27	Secondary Crushing Line (includes Feed & Discharge Pts)	---	---	---	---	---	---	---	---	Tons Crushed
3-03-023-28	Secondary Crusher Return Conveyor Transfer	---	---	---	---	---	---	---	---	Tons Transferred
3-03-023-30	Tertiary Crushing Line (includes Feed & Discharge Pts)	---	---	---	---	---	---	---	---	Tons Crushed
3-03-023-31	Tertiary Crushing Line Discharge Conveyor	---	---	---	---	---	---	---	---	Tons Transferred
3-03-023-34	Grinder Feed	---	---	---	---	---	---	---	---	Tons Ground
3-03-023-36	Classification	---	---	---	---	---	---	---	---	Tons Fed
3-03-023-38	Secondary Grinding	---	---	---	---	---	---	---	---	Tons Ground
3-03-023-40	Tailings Basin	---	---	---	---	---	---	---	---	Tons Produced
3-03-023-41	Conveyor Transfer to Concentrator	---	---	---	---	---	---	---	---	Tons Transferred
3-03-023-44	Concentrate Storage	---	---	---	---	---	---	---	---	Tons Stored
3-03-023-45	Bentonite Transfer to Blending	3.2	---	---	---	---	---	---	---	Tons Transferred
3-03-023-47	Green Pellet Screening	---	---	---	---	---	---	---	---	Tons Fed
3-03-023-48	Hearth Layer Feed to Furnace	---	---	---	---	---	---	---	---	Tons Produced
3-03-023-49	Grate/Kiln Furnace Feed	---	---	---	---	---	---	---	---	Tons Produced
3-03-023-50	Grate/Kiln Furnace Discharge	0.82	---	0.00035	---	---	---	---	---	Tons Produced
3-03-023-51	Induration: Grate/Kiln, Gas-fired, Acid Pellets	7.4	0.63	0.022	<sup>21</sup> 0.29	1.5	See App. C	0.014	---	Tons Produced
3-03-023-52	Induration: Grate/Kiln, Gas-fired, Flux Pellets	7.4	0.63	0.022	---	<sup>27</sup> 1.5	See App. C	<sup>27</sup> 0.1	---	Tons Produced
3-03-023-53	Induration: Grate/Kiln, Gas & Oil-fired, Acid Pellets	---	---	0.04	---	---	---	---	---	Tons Produced
3-03-023-54	Induration: Grate/Kiln, Gas & Oil-fired, Flux Pellets	---	---	0.04	---	---	---	---	---	Tons Produced
3-03-023-55	Induration: Grate/Kiln, Coke-fired, Acid Pellets	---	---	---	<sup>21</sup> 1.9	---	---	---	---	Tons Produced
3-03-023-56	Induration: Grate/Kiln, Coke-fired, Flux Pellets	---	---	---	---	---	---	---	---	Tons Produced
3-03-023-57	Induration: Grate/Kiln, Coke & Coal-fired, Acid Pellets	---	---	---	<sup>21</sup> 2.3	---	---	---	---	Tons Produced
3-03-023-58	Induration: Grate/Kiln, Coke & Coal-fired, Flux Pellets	---	---	---	---	---	---	---	---	Tons Produced
3-03-023-59	Induration: Grate/Kiln, Coal-fired, Acid Pellets	---	---	---	---	---	---	---	---	Tons Produced
3-03-023-60	Induration: Grate/Kiln, Coal-fired, Flux Pellets	---	---	---	---	---	---	---	---	Tons Produced
3-03-023-61	Induration: Grate/Kiln, Coal & Oil-fired, Acid Pellets	---	---	---	---	---	---	---	---	Tons Produced
3-03-023-62	Induration: Grate/Kiln, Coal & Oil-fired, Flux Pellets	---	---	---	---	---	---	---	---	Tons Produced
3-03-023-69	Vertical Shaft Furnace Feed	---	---	---	---	---	---	---	---	Tons Produced
3-03-023-70	Vertical Shaft Furnace Discharge	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Taconite Iron Ore Processing - 1011</u></i>										
3-03-023-71	Induration: Vertical Shaft, Gas-fired, Acid Pellets, Top Gas Stack	16	---	---	---	0.2	0.013	0.077	---	Tons Produced
3-03-023-72	Induration: Vertical Shaft, Gas-fired, Flux Pellets, Top Gas Stack	16	---	---	---	---	0.013	---	---	Tons Produced
3-03-023-73	Induration: Vertical Shaft, Gas-fired, Acid Pellets, Bottom Gas Stack	---	---	---	---	---	0.046	---	---	Tons Produced
3-03-023-74	Induration: Vertical Shaft, Gas-fired, Flux Pellets, Bottom Gas Stack	---	---	---	---	---	0.046	---	---	Tons Produced
3-03-023-79	Straight Grate Furnace Feed	0.63	---	---	---	---	---	---	---	Tons Produced
3-03-023-80	Straight Grate Furnace Discharge	1.4	---	---	---	---	---	---	---	Tons Produced
3-03-023-81	Induration: Straight Grate, Gas-fired, Acid Pellets	---	---	---	---	---	---	0.039	---	Tons Produced
3-03-023-82	Induration: Straight Grate, Gas-fired, Flux Pellets	---	---	---	---	2.5	---	---	---	Tons Produced
3-03-023-83	Induration: Straight Grate, Oil-fired, Acid Pellets	1.2	---	---	---	---	---	---	---	Tons Produced
3-03-023-84	Induration: Straight Grate, Oil-fired, Flux Pellets	1.2	---	---	---	---	---	---	---	Tons Produced
3-03-023-85	Induration: Straight Grate, Coke-fired, Acid Pellets	---	---	---	---	---	---	<sup>27</sup> 0.039	---	Tons Produced
3-03-023-86	Induration: Straight Grate, Coke-fired, Flux Pellets	---	---	---	---	---	---	---	---	Tons Produced
3-03-023-87	Induration: Straight Grate, Coke & Gas-fired, Acid Pellets	---	---	---	---	0.44	---	0.15	---	Tons Produced
3-03-023-88	Induration: Straight Grate, Coke & Gas-fired, Flux Pellets	---	---	---	---	---	---	---	---	Tons Produced
3-03-023-93	Hearth Layer Screen	---	---	---	---	---	---	---	---	Tons Produced
3-03-023-95	Pellet Screen	10	---	---	---	---	---	---	---	Tons Produced
3-03-023-96	Pellet Storage Bin Loading	3.7	---	---	---	---	---	---	---	Tons Produced
3-03-023-97	Secondary Storage Bin Loading	---	---	---	---	---	---	---	---	Tons Produced
3-03-023-98	Tertiary Storage Bin Loading	---	---	---	---	---	---	---	---	Tons Produced
3-03-023-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Metal Mining (General Processes) - 1011, 1099</u></i>										
3-03-024-01	Primary Crushing: Low Moisture Ore	0.5	0.05	---	---	---	---	---	---	Tons Processed
3-03-024-02	Secondary Crushing: Low Moisture Ore	1.2	0.1	---	---	---	---	---	---	Tons Processed
3-03-024-03	Tertiary Crushing: Low Moisture Ore	2.7	0.16	---	---	---	---	---	---	Tons Processed
3-03-024-04	Material Handling: Low Moisture Ore	See App. C	0.06	---	---	---	---	---	---	Tons Processed
3-03-024-05	Primary Crushing: High Moisture Ore	0.02	0.009	---	---	---	---	---	---	Tons Processed
3-03-024-06	Secondary Crushing: High Moisture Ore	0.05	0.02	---	---	---	---	---	---	Tons Processed
3-03-024-07	Tertiary Crushing: High Moisture Ore	0.06	0.02	---	---	---	---	---	---	Tons Processed
3-03-024-08	Material Handling: High Moisture Ore	0.01	0.004	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Metal Mining (General Processes) - 1011, 1099</u></i>										
3-03-024-09	Dry Grinding with Air Conveying	28.8	26	---	---	---	---	---	---	Tons Processed
3-03-024-10	Dry Grinding without Air Conveying	2.4	0.31	---	---	---	---	---	---	Tons Processed
3-03-024-11	Ore Drying	19.7	12	---	---	1.6	0.004	---	---	Tons Processed
<i><u>Zinc Production - 3339</u></i>										
3-03-030-02	Multiple Hearth Roaster	227	159	---	---	---	---	---	---	Tons Processed
3-03-030-03	Sinter Strand	125	89	---	0.64	---	---	---	---	Tons Processed
3-03-030-05	Vertical Retort/Electrothermal Furnace	14.3	93	---	1.13	---	---	---	---	Tons Processed
3-03-030-06	Electrolytic Processor	6.6	3	---	---	---	---	---	---	Tons Processed
3-03-030-07	Flash Roaster	2000	1840	---	404.4	---	---	---	---	Tons Processed
3-03-030-08	Fluid Bed Roaster	2167	1994	---	223.5	---	---	---	---	Tons Processed
3-03-030-09	Raw Material Handling and Transfer	---	3.4	---	---	---	---	---	---	Tons Processed
3-03-030-10	Sinter Breaking and Cooling	---	1.3	---	---	---	---	---	---	Tons Processed
3-03-030-11	Zinc Casting	1.35	2.1	---	---	---	---	---	---	Tons Produced
3-03-030-12	Raw Material Unloading	0.4	0.23	---	---	---	---	---	0.13	Tons Processed
3-03-030-13	Suspension Roaster	---	---	---	---	---	---	---	---	Tons Processed
3-03-030-14	Crushing/Screening	---	---	---	---	---	---	---	---	Tons Processed
3-03-030-15	Zinc Melting	---	---	---	---	---	---	---	---	Tons Processed
3-03-030-16	Alloying	---	---	---	---	---	---	---	---	Tons Processed
3-03-030-17	Leaching	---	---	---	---	---	---	---	---	Tons Produced
3-03-030-18	Purification	---	---	---	---	---	---	---	---	Tons Produced
3-03-030-19	Sinter Plant Wind Box	---	---	---	---	---	---	---	---	Tons Produced
3-03-030-20	Sinter Plant Discharge and Screens	---	---	---	---	---	---	---	---	Tons Produced
3-03-030-21	Retort Furnace	---	---	---	---	---	---	---	---	Tons Produced
3-03-030-22	Flue Dust Handling	---	---	---	---	---	---	---	---	Tons Produced
3-03-030-23	Dross Handling	---	---	---	---	---	---	---	---	Tons Produced
3-03-030-24	Roasting: Fugitive Emissions	---	---	---	---	---	---	---	---	Tons Produced
3-03-030-25	Sinter Plant, Wind Box: Fugitive Emissions	0.24 - 1.1	---	---	---	---	---	---	---	Tons Produced
3-03-030-26	Sinter Plant, Discharge Screens: Fugitive Emissions	0.56 - 2.44	---	---	---	---	---	---	---	Tons Produced
3-03-030-27	Retort Building: Fugitive Emissions	2 - 4	---	---	---	---	---	---	---	Tons Produced
3-03-030-28	Casting: Fugitive Emissions	2.52	---	---	---	---	---	---	---	Tons Produced
3-03-030-29	Electric Retort	20	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Zinc Production - 3339</u>										
3-03-030-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Leadbearing Ore Crushing and Grinding - 3300, 3330, 3339, 3369</u>										
3-03-031-01	Lead Ore w/ 5.1% Lead Content	6	---	---	---	---	---	---	0.3	Tons Processed
3-03-031-02	Zinc Ore w/ 0.2% Lead Content	6	---	---	---	---	---	---	0.012	Tons Processed
3-03-031-03	Copper Ore w/ 0.2% Lead Content	6.4	---	---	---	---	---	---	0.012	Tons Processed
3-03-031-04	Lead-Zinc Ore w/ 2% Lead Content	6	---	---	---	---	---	---	0.12	Tons Processed
3-03-031-05	Copper-Lead Ore w/ 2% Lead Content	6.4	---	---	---	---	---	---	0.12	Tons Processed
3-03-031-06	Copper-Zinc Ore w/ 0.2% Lead Content	6.4	---	---	---	---	---	---	0.012	Tons Processed
3-03-031-07	Copper-Lead-Zinc w/ 2% Lead Content	6.4	---	---	---	---	---	---	0.12	Tons Processed
<u>Alumina Processing - Bayer Process - 3300</u>										
3-03-040-01	Bayer Process	---	---	---	---	---	---	---	---	Tons Processed
3-03-040-10	Ore Crushing/Grinding	---	---	---	---	---	---	---	---	Tons Produced
3-03-040-11	Mixer	---	---	---	---	---	---	---	---	Tons Produced
3-03-040-12	Digester	---	---	---	---	---	---	---	---	Tons Produced
3-03-040-13	Filter/Wash	---	---	---	---	---	---	---	---	Tons Produced
3-03-040-14	Hydrolization/Cooling	---	---	---	---	---	---	---	---	Tons Produced
3-03-040-15	Precipitate Filtering/Washing	---	---	---	---	---	---	---	---	Tons Produced
3-03-040-16	Calcination/Heating	---	---	---	---	---	---	---	---	Tons Produced
3-03-040-17	Cooling of Alumina	---	---	---	---	---	---	---	---	Tons Produced
<u>Equipment Leaks - 3300</u>										
3-03-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Wastewater, Aggregate - 3300</u>										
3-03-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-03-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Wastewater, Points of Generation - 3300</u>										
3-03-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Fugitive Emissions - 1000, 3300</u>										
3-03-888-01	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-03-888-02	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-03-888-03	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Fugitive Emissions - 1000, 3300</i></u>										
3-03-888-04	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-03-888-05	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Fuel Fired Equipment - 1000, 3300</i></u>										
3-03-900-01	Distillate Oil (No. 2): Process Heaters	---	---	---	143.6S	20	0.2	---	---	1000 Gallons Burned
3-03-900-02	Residual Oil: Process Heaters	---	---	---	158.6S	55	0.28	---	---	1000 Gallons Burned
3-03-900-03	Natural Gas: Process Heaters	---	---	---	0.6	140	2.8	---	---	Million Cubic Feet Burned
3-03-900-04	Process Gas: Process Heaters	---	---	---	---	---	2.8	---	---	Million Cubic Feet Burned
3-03-900-11	Distillate Oil (No. 2): Incinerators	---	---	---	---	---	0.34	---	---	1000 Gallons Burned
3-03-900-12	Residual Oil: Incinerators	---	---	---	---	---	0.56	---	---	1000 Gallons Burned
3-03-900-13	Natural Gas: Incinerators	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-03-900-14	Process Gas: Incinerators	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-03-900-21	Distillate Oil (No. 2): Flares	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-03-900-22	Residual Oil: Flares	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-03-900-23	Natural Gas: Flares	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-03-900-24	Process Gas: Flares	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
<u><i>Other Not Classified - 1000, 3300</i></u>										
3-03-999-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>INDUSTRIAL PROCESSES -Secondary Metal Production</i></u>										
<u><i>Aluminum - 3341, 3353, 3354, 3355, 3363, 3365</i></u>										
3-04-001-01	Sweating Furnace	14.5	13.3	---	0.02	---	---	---	---	Footnote 39
3-04-001-02	Smelting Furnace/Crucible	1.9	1.7	---	---	---	---	---	---	Footnote 39
3-04-001-03	Smelting Furnace/Reverberatory	4.3	2.6	---	---	---	0.2	---	---	Footnote 39
3-04-001-04	Fluxing: Chlorination	1000	532	---	---	---	---	---	---	Tons Processed
3-04-001-05	Fluxing: Fluoridation	---	---	---	---	---	---	---	---	Tons Produced
3-04-001-06	Degassing	---	---	---	---	---	---	---	---	Tons Produced
3-04-001-07	Hot Dross Processing	---	---	---	---	---	---	---	---	Tons Produced
3-04-001-08	Crushing/Screening	---	---	---	---	---	---	---	---	Tons Produced
3-04-001-09	Burning/Drying	---	---	---	2.9	0.9	---	---	---	Tons Produced
3-04-001-10	Foil Rolling	---	---	---	---	---	---	---	---	Tons Produced
3-04-001-11	Foil Converting	---	---	---	---	---	2.4	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Aluminum - 3341, 3353, 3354, 3355, 3363, 3365</u>										
3-04-001-12	Annealing Furnace	---	---	---	---	---	---	---	---	Tons Produced
3-04-001-13	Slab Furnace	---	---	---	---	---	---	---	---	Tons Produced
3-04-001-14	Pouring/Casting	---	---	---	0.02	0.01	0.14	---	---	Tons Charged
3-04-001-15	Sweating Furnace: Grate	---	---	---	---	---	---	---	---	Tons Produced
3-04-001-16	Dry Milling Dross	---	---	---	---	---	---	---	---	Tons Produced
3-04-001-17	Wet Milling Dross	---	---	---	---	---	---	---	---	Tons Produced
3-04-001-18	Leaching	---	---	---	---	---	---	---	---	Tons Produced
3-04-001-20	Can Manufacture	---	---	---	---	0.7	---	---	---	Tons Produced
3-04-001-21	Roasting	---	---	---	---	---	---	---	---	Tons Produced
3-04-001-30	Damagging	---	---	---	---	---	---	---	---	Tons Produced
3-04-001-31	Raw Material Charging	---	---	---	---	---	---	---	---	Tons Charged
3-04-001-32	Raw Material Storage	---	---	---	---	---	---	---	---	Tons Stored
3-04-001-33	Tapping	---	---	---	---	---	---	---	---	Tons Produced
3-04-001-50	Rolling/Drawing/Extruding	---	---	---	---	---	---	---	---	Tons Produced
3-04-001-60	Material Handling	---	---	---	---	---	---	---	---	Tons Processed
3-04-001-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Copper - 3341, 3364, 3366, 3369</u>										
3-04-002-04	Electric Induction Furnace	20	---	---	---	---	---	---	---	Tons Fed
3-04-002-07	Scrap Dryer (Rotary)	---	253	---	---	---	---	---	---	Tons Fed
3-04-002-08	Wire Burning: Incinerator	---	253	---	12.8	---	0.6	---	---	Tons Fed
3-04-002-09	Sweating Furnace	---	---	---	---	---	---	---	---	Tons Fed
3-04-002-10	Charge with Scrap Copper: Cupolas	0.0003	0.00027	---	---	---	0.18	---	---	Tons Fed
3-04-002-11	Charge with Insulated Copper Wire: Cupolas	230	211.6	---	---	---	0.6	---	---	Footnote 40
3-04-002-12	Charge with Scrap Copper And Brass: Cupolas	70	64.4	---	---	---	0.18	---	---	Tons Fed
3-04-002-13	Charge with Scrap Iron: Cupolas	---	---	---	---	---	---	---	---	Tons Processed
3-04-002-14	Charge with Copper: Reverberatory Furnace	5.1	5.1	---	---	---	0.2	---	---	Tons Fed
3-04-002-15	Charge with Brass and Bronze: Reverberatory Furnace	36	21.2	---	---	---	0.2	---	---	Tons Fed
3-04-002-16	Charge with Copper: Rotary Furnace	---	---	---	---	---	---	---	---	Tons Fed
3-04-002-17	Charge with Brass and Bronze: Rotary Furnace	300	177	---	---	---	2.4	---	---	Tons Fed
3-04-002-18	Charge with Copper: Crucible and Pot Furnace	---	---	---	---	---	---	---	---	Tons Fed
3-04-002-19	Charge with Brass and Bronze: Crucible and Pot Furnace	21	12.4	---	0.5	---	---	---	---	Tons Fed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Copper - 3341, 3364, 3366, 3369</i>										
3-04-002-20	Charge with Copper: Electric Arc Furnace	5	5	---	---	---	---	---	---	Tons Fed
3-04-002-21	Charge with Brass and Bronze: Electric Arc Furnace	11	6.5	---	---	---	---	---	---	Tons Fed
3-04-002-23	Charge with Copper: Electric Induction	7	7	---	---	---	---	---	---	Tons Fed
3-04-002-24	Charge with Brass and Bronze: Electric Induction	20	20	---	---	---	---	---	---	Tons Fed
3-04-002-30	Scrap Metal Pretreatment	---	---	---	---	---	---	---	---	Tons Fed
3-04-002-31	Scrap Dryer	---	8.2	---	---	---	---	---	---	Tons Fed
3-04-002-32	Wire Incinerator	---	8.2	---	---	---	---	---	---	Tons Fed
3-04-002-33	Sweating Furnace	---	0.45	---	---	---	---	---	---	Tons Fed
3-04-002-34	Cupola Furnace	---	2.2	---	---	---	---	---	---	Tons Fed
3-04-002-35	Reverberatory Furnace	---	3.1	---	---	---	---	---	---	Tons Fed
3-04-002-36	Rotary Furnace	---	2.6	---	---	---	---	---	---	Tons Fed
3-04-002-37	Crucible Furnace	---	0.29	---	---	---	---	---	---	Tons Fed
3-04-002-38	Electric Induction Furnace	---	0.04	---	---	---	---	---	---	Tons Fed
3-04-002-39	Casting Operations	---	0.015	---	---	---	---	---	---	Tons Produced
3-04-002-40	Charge with Copper: Holding Furnace	---	---	---	---	---	---	---	---	Tons Fed
3-04-002-41	Charge with Copper: Holding Furnace	---	---	---	---	---	---	---	---	Tons Fed
3-04-002-42	Charge with Other Alloy (7%): Reverberatory Furnace	---	---	---	---	---	---	---	5	Tons Produced
3-04-002-43	Charge with High Lead Alloy (58%): Reverberatory Furnace	---	---	---	---	---	---	---	50	Tons Produced
3-04-002-44	Charge with Red/Yellow Brass: Reverberatory Furnace	---	---	---	---	---	---	---	13.2	Tons Produced
3-04-002-50	Charge with Copper: Converter	---	---	---	---	---	---	---	---	Tons Fed
3-04-002-51	Charge with Brass and Bronze: Converter	---	---	---	---	---	---	---	---	Tons Fed
3-04-002-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i>Grey Iron Foundries - 3321</i>										
3-04-003-01	Cupola	See App. C	12.4	---	1.25	0.1	0.18	145	0.1 - 1.1	Footnote 41
3-04-003-02	Reverberatory Furnace	2.1	1.7	---	---	5.8	0.15	---	0.012 - 0.14	Footnote 42
3-04-003-03	Electric Induction Furnace	0.9	0.86	---	---	---	---	---	0.009 - 0.1	Footnote 42
3-04-003-04	Electric Arc Furnace	12.7	11.6	---	0.24	0.04 - 0.6	0.06 - 0.3	1 - 37	0.17	Footnote 43
3-04-003-05	Annealing Operation	---	---	---	---	1	0.1	---	---	Tons Processed
3-04-003-10	Inoculation	4	---	---	---	---	0.005	---	---	Tons Inoculated
3-04-003-14	Scrap Metal Preheating	---	---	---	---	---	---	---	---	Tons Processed
3-04-003-15	Charge Handling	0.6	0.36	---	---	---	---	---	---	Tons Charged



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Grey Iron Foundries - 3321</u>										
3-04-003-16	Tapping	---	---	---	---	---	---	---	---	Tons Produced
3-04-003-17	Pouring Ladle	---	---	---	---	---	---	---	---	Tons Charged
3-04-003-18	Pouring, Cooling	---	2.06	---	---	---	---	---	---	Tons Produced
3-04-003-19	Core Making, Baking	---	---	---	---	---	---	---	---	Tons Produced
3-04-003-20	Pouring/Casting	4.2	2.06	---	0.02	0.01	0.14	---	---	Tons Charged
3-04-003-21	Magnesium Treatment	---	---	---	---	---	---	---	---	Tons Produced
3-04-003-22	Refining	---	---	---	---	---	---	---	---	Tons Produced
3-04-003-25	Castings Cooling	---	1.4	---	---	---	---	---	---	Tons Charged
3-04-003-30	Miscellaneous Casting-Fabricating	---	---	---	---	---	---	---	---	Tons Processed
3-04-003-31	Casting Shakeout	3.2	2.24	---	---	---	1.2	---	---	Footnote 44
3-04-003-32	Casting Knock Out	---	---	---	---	---	1.2	---	---	Tons Handled
3-04-003-33	Shakeout Machine	---	---	---	---	---	1.2	---	---	Tons Handled
3-04-003-40	Grinding/Cleaning	17	1.7	---	---	---	---	---	---	Tons Charged
3-04-003-41	Casting Cleaning/Tumblers	---	---	---	---	---	---	---	---	Tons Cleaned
3-04-003-42	Casting Cleaning/Chippers	---	---	---	---	---	---	---	---	Tons Cleaned
3-04-003-50	Sand Grinding/Handling	---	0.54	---	---	---	---	---	---	Tons Handled
3-04-003-51	Core Ovens	---	2.22	---	0.038	0.5	---	---	---	Tons Handled
3-04-003-52	Sand Grinding/Handling	---	6	---	---	---	---	---	---	Tons Charged
3-04-003-53	Core Ovens	---	0.9	---	---	0.5	---	---	---	Tons Charged
3-04-003-54	Core Ovens	---	---	---	---	0.5	---	---	---	Gallons Used
3-04-003-55	Sand Dryer	---	---	---	---	---	---	---	---	Tons Handled
3-04-003-56	Sand Silo	---	---	---	---	---	---	---	---	Tons Handled
3-04-003-57	Conveyors/Elevators	---	---	---	---	---	---	---	---	Tons Handled
3-04-003-58	Sand Screens	---	---	---	---	---	---	---	---	Tons Handled
3-04-003-60	Castings Finishing	---	0.0045	---	---	---	---	---	---	Tons Charged
3-04-003-70	Shell Core Machine	---	---	---	0.32	0.5	---	---	---	Tons Produced
3-04-003-71	Core Machines/Other	---	---	---	---	0.5	---	---	---	Tons Produced
3-04-003-98	Other Not Classified	1.494	---	---	<sup>21</sup> 0.063	---	---	---	---	Tons Processed
3-04-003-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Charged
<u>Lead - 3341, 3364</u>										
3-04-004-01	Pot Furnace	---	0.2	---	---	---	---	---	---	Tons Charged

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Lead - 3341, 3364</u>										
3-04-004-02	Reverberatory Furnace	323	193.8	---	80	0.3	---	---	65	Footnote 45
3-04-004-03	Blast Furnace (Cupola)	307	129	---	53	0.1	---	18	104	Footnote 46
3-04-004-04	Rotary Sweating Furnace	32 - 70	64	---	---	---	---	---	7 -16	Footnote 47
3-04-004-05	Reverberatory Sweating Furnace	51	31	---	---	---	---	---	---	Tons Charged
3-04-004-06	Pot Furnace Heater: Distillate Oil	---	---	---	143.6S	20	0.2	---	---	1000 Gallons Burned
3-04-004-07	Pot Furnace Heater: Natural Gas	---	---	---	0.6	100	2.8	---	---	Million Cubic Feet Burned
3-04-004-08	Barton Process Reactor (Oxidation Kettle)	< 40	40	---	---	---	---	---	0.44	Tons Produced
3-04-004-09	Casting	0.04	0.87	---	---	---	---	---	0.01	Tons Cast
3-04-004-10	Battery Breaking	---	---	---	---	---	---	---	---	Tons Charged
3-04-004-11	Scrap Crushing	---	---	---	---	---	---	---	---	Tons Charged
3-04-004-12	Sweating Furnace: Fugitive Emissions	1.6 - 3.5	2.35	---	---	---	---	---	0.4 - 1.8	Tons Charged
3-04-004-13	Smelting Furnace: Fugitive Emissions	8.6 - 24.2	10	---	---	---	---	---	0.2 - 0.6	Footnote 48
3-04-004-14	Kettle Refining: Fugitive Emissions	0.002	0.002	---	---	---	---	---	0.0006	Footnote 48
3-04-004-15	Agglomeration Furnace	---	---	---	---	---	---	---	---	Tons Processed
3-04-004-16	Furnace Charging	---	---	---	---	---	---	---	---	Tons Produced
3-04-004-17	Furnace Lead/Slagtapping	---	---	---	---	---	---	---	---	Tons Produced
3-04-004-18	Electric Furnace	---	---	---	---	---	---	---	---	Tons Charged
3-04-004-19	Raw Material Dryer	---	---	---	---	---	---	---	---	Tons Charged
3-04-004-20	Raw Material Unloading	---	---	---	---	---	---	---	---	Tons Processed
3-04-004-21	Raw Material Transfer/Conveying	---	---	---	---	---	---	---	---	Tons Processed
3-04-004-22	Raw Material Storage Pile	---	---	---	---	---	---	---	---	Tons Processed
3-04-004-23	Slag Breaking	---	---	---	---	---	---	---	---	Tons Processed
3-04-004-24	Size Separation	---	---	---	---	---	---	---	---	Tons Processed
3-04-004-25	Casting: Fugitive Emissions	0.002	---	---	---	---	---	---	0.0007	Tons Produced
3-04-004-26	Kettle Refining	0.03	---	---	---	---	---	---	0.01	Tons Produced
3-04-004-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Lead Battery Manufacture - 3691</u>										
3-04-005-01	Overall Process	0.9	---	---	---	---	---	---	1.177	Tons Produced
3-04-005-02	Casting Furnace	0.04	---	---	---	---	---	---	0.059	Tons Produced
3-04-005-03	Paste Mixer	0.21	---	---	---	---	---	---	0.192	Tons Produced
3-04-005-04	Three Process Operation	0.64	---	---	---	---	---	---	0.815	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Lead Battery Manufacture - 3691</u></i>										
3-04-005-05	Overall Process	125 - 139	125	---	---	---	---	---	15.3 - 17.7	1000 Each Produced
3-04-005-06	Grid Casting	1.8 - 3.13	2.84	---	---	---	---	---	0.77 - 0.9	1000 Each Produced
3-04-005-07	Paste Mixing	2.2 - 4.32	4.32	---	---	---	---	---	1.1 - 2.49	1000 Each Produced
3-04-005-08	Lead Oxide Mill (Baghouse Outlet)	0.11	0.08	---	---	---	---	---	0.11	1000 Each Produced
3-04-005-09	Three Process Operation	29.2 - 92.6	84	---	---	---	---	---	10.6 - 14.6	1000 Each Produced
3-04-005-10	Lead Reclaiming Furnace	1.54 - 6.68	1.67	---	---	---	---	---	0.77 - 1.38	1000 Each Produced
3-04-005-11	Small Parts Casting	0.19	0.19	---	---	---	---	---	0.1	1000 Each Produced
3-04-005-12	Formation	32.1 - 32.4	32.4	---	---	---	---	---	---	1000 Each Produced
3-04-005-13	Barton Process: Oxidation Kettle	---	---	---	---	---	---	---	---	Tons Processed
3-04-005-21	Overall Process	---	---	---	---	---	---	---	---	Tons Processed
3-04-005-22	Grid Casting	---	---	---	---	---	---	---	0.139	Tons Processed
3-04-005-23	Paste Mixing	---	---	---	---	---	---	---	1.72	Tons Processed
3-04-005-24	Lead Oxide Mill (Baghouse Outlet)	---	---	---	---	---	---	---	---	Tons Processed
3-04-005-25	Three Process Operation	---	---	---	---	---	---	---	---	Tons Processed
3-04-005-26	Lead Reclaiming Furnace	---	---	---	---	---	---	---	5.9	Tons Processed
3-04-005-27	Small Parts Casting	---	---	---	---	---	---	---	---	Tons Processed
3-04-005-28	Formation	---	---	---	---	---	---	---	---	Tons Processed
3-04-005-29	Grid Cast/Paste Mix: Combined Operation	---	---	---	---	---	---	---	---	1000 Each Produced
3-04-005-30	Paste Mix/Lead Charge: Combined Operation	---	---	---	---	---	---	---	---	1000 Each Produced
3-04-005-31	Wash and Paint	---	---	---	---	---	---	---	---	1000 Each Produced
3-04-005-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Magnesium - 3341</u></i>										
3-04-006-01	Pot Furnace	4	3.7	---	---	2.5	2.4	---	---	Tons Processed
3-04-006-02	Dow Seawater Process	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-05	Dow Seawater Process: Neutralization Tank	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-06	Dow Seawater Process: HCl Absorbers	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-07	Dow Seawater Process: Evaporator	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-08	Dow Seawater Process: Filtering/Concentration	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-09	Dow Seawater Process: Shelf Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-10	Dow Seawater Process: Rotary Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-11	Dow Seawater Process: Prilling	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Magnesium - 3341</u></i>										
3-04-006-12	Dow Seawater Process: Granule Storage Tanks	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-13	Dow Seawater Process: Electrolysis	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-14	Dow Seawater Process: Regenerative Furnaces	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-30	Natural Lead Industrial (NLI) Brine Process	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-35	NLI Brine Process: MgCl2 Melt/Purification	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-36	NLI Brine Process: 2nd Vessel, Further Purification	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-37	NLI Brine Process: Electrolysis	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-50	American Magnesium Process	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-55	American Magnesium Process: Purification II	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-56	American Magnesium Process: Electrolysis	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-60	American Magnesium Process: Chlorine Recovery	---	---	---	---	---	---	---	---	Tons Produced
3-04-006-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Steel Foundries - 3324, 3325</u></i>										
3-04-007-01	Electric Arc Furnace	13	---	---	0.24	0.2	0.35	---	---	Tons Processed
3-04-007-02	Open Hearth Furnace	11	---	---	---	0.01	0.17	---	---	Tons Processed
3-04-007-03	Open Hearth Furnace with Oxygen Lance	10	8.5	---	---	---	0.17	---	---	Tons Processed
3-04-007-04	Heat Treating Furnace	---	---	---	277.3	80.7	0.6	---	---	Tons Processed
3-04-007-05	Electric Induction Furnace	0.01	0.09	---	---	---	---	---	---	Tons Processed
3-04-007-06	Sand Grinding/Handling	---	0.54	---	---	---	---	---	---	Tons Processed
3-04-007-07	Core Ovens	---	2.22	---	---	---	---	---	---	Tons Processed
3-04-007-08	Pouring/Casting	2.8	2.8	---	0.02	0.01	0.14	---	---	Tons Processed
3-04-007-09	Casting Shakeout	---	26.2	---	---	---	1.2	---	---	Tons Processed
3-04-007-10	Casting Knock Out	---	---	---	---	---	1.2	---	---	Tons Handled
3-04-007-11	Cleaning	---	1.7	---	---	---	---	---	---	Tons Processed
3-04-007-12	Charge Handling	---	0.36	---	---	---	---	---	---	Tons Processed
3-04-007-13	Castings Cooling	1.4	1.4	---	---	---	---	---	---	Tons Processed
3-04-007-14	Shakeout Machine	---	---	---	---	---	1.2	---	---	Tons Handled
3-04-007-15	Finishing	---	0.0045	---	47.66	---	1.1	---	---	Tons Processed
3-04-007-16	Sand Grinding/Handling	---	6	---	---	---	---	---	---	Tons Processed
3-04-007-17	Core Ovens	---	0.9	---	---	0.5	---	---	---	Tons Processed
3-04-007-18	Core Ovens	---	---	---	---	0.5	---	---	---	Gallons Used

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Steel Foundries - 3324, 3325</u>										
3-04-007-20	Sand Dryer	---	---	---	---	---	---	---	---	Tons Handled
3-04-007-21	Sand Silo	---	---	---	---	---	---	---	---	Tons Handled
3-04-007-22	Muller	---	---	---	---	---	---	---	---	Tons Handled
3-04-007-23	Conveyors/Elevators	---	---	---	---	---	---	---	---	Tons Handled
3-04-007-24	Sand Screens	---	---	---	---	---	---	---	---	Tons Handled
3-04-007-25	Casting Cleaning/Tumblers	---	---	---	---	---	---	---	---	Tons Cleaned
3-04-007-26	Casting Cleaning/Chippers	---	---	---	---	---	---	---	---	Tons Cleaned
3-04-007-30	Shell Core Machine	---	---	---	---	0.5	---	---	---	Tons Produced
3-04-007-31	Core Machines/Other	---	---	---	---	0.5	---	---	---	Tons Produced
3-04-007-32	Electric Arc Furnace: Baghouse	---	---	---	---	---	---	---	---	Tons Handled
3-04-007-33	Electric Arc Furnace: Baghouse Dust Handling	---	---	---	---	---	---	---	---	Tons Handled
3-04-007-35	Raw Material Unloading	---	---	---	---	---	---	---	---	Tons Handled
3-04-007-36	Conveyors/Elevators: Raw Material	---	---	---	---	---	---	---	---	Tons Handled
3-04-007-37	Raw Material Silo	---	---	---	---	---	---	---	---	Tons Stored
3-04-007-39	Scrap Centrifugation	---	---	---	---	---	---	---	---	Tons Processed
3-04-007-40	Reheating Furnace: Natural Gas	---	---	---	---	---	---	---	---	Tons Reheated
3-04-007-41	Scrap Heating	---	---	---	---	---	---	---	---	Tons Processed
3-04-007-42	Crucible	---	---	---	---	---	---	---	---	Tons Processed
3-04-007-43	Pneumatic Converter Furnace	---	---	---	---	---	---	---	---	Tons Processed
3-04-007-44	Ladle	---	---	---	---	---	---	---	---	Tons Processed
3-04-007-45	Fugitive Emissions: Furnace	---	---	---	---	---	---	---	---	Tons Processed
3-04-007-60	Alloy Feeding	---	---	---	---	---	---	---	---	Tons Handled
3-04-007-65	Billet Cutting	---	---	---	---	---	---	---	---	Tons Handled
3-04-007-68	Scrap Handling	---	---	---	---	---	---	---	---	Tons Handled
3-04-007-70	Slag Storage Pile	---	---	---	---	---	---	---	---	Tons Handled
3-04-007-75	Slag Crushing	---	---	---	---	---	---	---	---	Tons Handled
3-04-007-80	Limerock Handling	---	---	---	---	---	---	---	---	Tons Handled
3-04-007-85	Roof Monitors - Hot Metal Transfer	---	---	---	---	---	---	---	---	Tons Handled
3-04-007-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Zinc - 3341</u>										
3-04-008-01	Retort Furnace	47	47	---	---	---	---	---	---	Footnote 49

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Zinc - 3341</i>										
3-04-008-02	Horizontal Muffle Furnace	45	---	---	---	---	2.4	---	---	Tons Produced
3-04-008-03	Pot Furnace	0.1	0.09	---	---	---	2.4	---	---	Tons Produced
3-04-008-05	Galvanizing Kettle	5	5	---	---	---	---	---	---	Tons Used
3-04-008-06	Calcining Kiln	89	---	---	18.3	---	---	---	---	Footnote 49
3-04-008-07	Concentrate Dryer	---	---	---	---	---	---	---	---	Tons Processed
3-04-008-09	Rotary Sweat Furnace	11 - 25	16.6	---	---	---	2.4	---	---	Footnote 49
3-04-008-10	Muffle Sweat Furnace	10.8 - 32	19.7	---	---	---	2.4	---	---	Footnote 49
3-04-008-11	Electric Resistance Sweat Furnace	< 10	10	---	---	---	2.4	---	---	Footnote 49
3-04-008-12	Crushing/Screening of Zinc Residues	4.25	---	---	---	---	---	---	---	Tons Processed
3-04-008-14	Kettle-Sweat Furnace: Clean Metallic Scrap	---	---	---	---	---	---	---	---	Tons Produced
3-04-008-18	Reverberatory Sweat Furnace: Clean Metallic Scrap	---	---	---	---	---	---	---	---	Tons Produced
3-04-008-24	Kettle-Sweat Furnace: General Metallic Scrap	11	11	---	---	---	2.4	---	---	Footnote 49
3-04-008-28	Reverberatory Sweat Furnace: General Metallic Scrap	13	13	---	---	---	2.4	---	---	Footnote 50
3-04-008-34	Kettle-Sweat Furnace: Residual Metallic Scrap	25	15	---	---	---	2.4	---	---	Footnote 49
3-04-008-38	Reverberatory Sweat Furnace: Residual Metallic Scrap	32	19	---	---	---	2.4	---	---	Footnote 50
3-04-008-40	Alloying	---	---	---	---	---	---	---	---	Tons Produced
3-04-008-41	Scrap Melting: Crucible	---	---	---	---	---	2.5	---	---	Tons Produced
3-04-008-42	Scrap Melting: Reverberatory Furnace	---	---	---	---	---	0.2	---	---	Tons Produced
3-04-008-43	Scrap Melting: Electric Induction Furnace	---	---	---	---	---	0.18	---	---	Tons Produced
3-04-008-51	Retort and Muffle Distillation: Pouring	0.4 - 0.8	0.6	---	---	---	---	---	---	Tons Produced
3-04-008-52	Retort and Muffle Distillation: Casting	0.2 - 0.4	0.3	---	---	---	---	---	---	Tons Produced
3-04-008-53	Graphite Rod Distillation	---	---	---	---	---	---	---	---	Tons Produced
3-04-008-54	Retort Distillation/Oxidation	20 - 40	30	---	20.96	---	---	---	---	Tons Produced
3-04-008-55	Muffle Distillation/Oxidation	20 - 40	30	---	40.21	---	---	---	---	Tons Produced
3-04-008-61	Reverberatory Sweating	1.3	0.78	---	---	---	2.4	---	---	Tons Produced
3-04-008-62	Rotary Sweating	0.9	0.54	---	---	---	2.4	---	---	Tons Produced
3-04-008-63	Muffle Sweating	1.07	0.64	---	---	---	2.4	---	---	Tons Produced
3-04-008-64	Kettle (Pot) Sweating	0.56	0.34	---	---	---	2.4	---	---	Tons Produced
3-04-008-65	Electric Resistance Sweating	0.5	0.5	---	---	---	2.4	---	---	Footnote 51
3-04-008-66	Sodium Carbonate Leaching	---	---	---	---	---	---	---	---	Tons Produced
3-04-008-67	Kettle (Pot) Melting Furnace	0.005	0.005	---	---	---	2.4	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Zinc - 3341</u>										
3-04-008-68	Crucible Melting Furnace	0.005	0.005	---	---	---	2.5	---	---	Tons Produced
3-04-008-69	Reverberatory Melting Furnace	0.005	0.005	---	---	---	0.2	---	---	Tons Produced
3-04-008-70	Electric Induction Melting Furnace	0.005	0.005	---	---	---	0.18	---	---	Tons Produced
3-04-008-71	Alloying Retort Distillation	---	---	---	---	---	---	---	---	Tons Produced
3-04-008-72	Retort and Muffle Distillation	2.36	2.36	---	---	---	---	---	---	Tons Produced
3-04-008-73	Casting	0.015	0.015	---	---	---	---	---	---	Tons Produced
3-04-008-74	Graphite Rod Distillation	---	---	---	---	---	---	---	---	Tons Produced
3-04-008-75	Retort Distillation/Oxidation	---	---	---	---	---	---	---	---	Tons Produced
3-04-008-76	Muffle Distillation/Oxidation	---	---	---	---	---	---	---	---	Tons Produced
3-04-008-77	Retort Reduction	---	---	---	---	---	---	---	---	Tons Produced
3-04-008-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Malleable Iron - 3322</u>										
3-04-009-01	Annealing	---	---	---	---	---	0.1	---	---	Tons Charged
3-04-009-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Charged
<u>Nickel - 3341</u>										
3-04-010-01	Flux Furnace	---	---	---	---	---	---	---	---	Tons Processed
3-04-010-02	Mixing/Blending/Grinding/Screening	---	---	---	---	---	---	---	---	Tons Processed
3-04-010-04	Heat Treat Furnace	---	---	---	---	---	---	---	---	Tons Processed
3-04-010-05	Induction Furnace (Inlet Air)	---	---	---	---	---	---	---	---	Tons Processed
3-04-010-06	Induction Furnace (Under Vacuum)	---	---	---	---	---	---	---	---	Tons Processed
3-04-010-07	Electric Arc Furnace with Carbon Electrode	---	---	---	60	0.003	0.1	---	---	Tons Processed
3-04-010-08	Electric Arc Furnace	---	---	---	0.24	0.32	0.18	---	---	Tons Processed
3-04-010-10	Finishing: Pickling/Neutralizing	---	---	---	---	---	---	---	---	Tons Processed
3-04-010-11	Finishing: Grinding	---	---	---	---	---	---	---	---	Tons Processed
3-04-010-15	Multiple Hearth Roaster	---	---	---	---	---	---	---	---	Tons Processed
3-04-010-16	Converters	---	---	---	---	---	---	---	---	Tons Processed
3-04-010-17	Reverberatory Furnace	---	---	---	---	---	---	---	---	Tons Processed
3-04-010-18	Electric Furnace	---	---	---	---	---	---	---	---	Tons Processed
3-04-010-19	Sinter Machine	---	---	---	---	---	---	---	---	Tons Processed
3-04-010-61	Roasting: Fugitive Emissions	---	---	---	---	---	---	---	---	Tons Produced
3-04-010-62	Reverberatory Furnace: Fugitive Emissions	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Nickel - 3341</u>										
3-04-010-63	Converter: Fugitive Emissions	---	---	---	---	---	---	---	---	Tons Produced
3-04-010-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Furnace Electrode Manufacture - 3624</u>										
3-04-020-01	Calcination	---	---	---	---	---	0.06	---	---	Tons Processed
3-04-020-02	Mixing	---	---	---	---	---	---	---	---	Tons Processed
3-04-020-03	Pitch Treating	---	---	---	---	---	---	---	---	Tons Processed
3-04-020-04	Bake Furnaces	---	---	---	1.6	---	1	---	---	Tons Processed
3-04-020-05	Grafitization of Coal by Heating Process	---	---	---	---	---	---	---	---	Tons Produced
3-04-020-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Metal Heat Treating - 3398</u>										
3-04-022-01	Furnace: General	---	---	---	---	---	0.1	---	---	Tons Processed
3-04-022-10	Quench Bath	---	---	---	---	---	280	---	---	Tons Processed
3-04-022-11	Quenching	---	---	---	---	---	---	---	---	Gallons Used
<u>Lead Cable Coating - 3357, 3315</u>										
3-04-040-01	General	0.6	0.36	---	---	---	---	---	0.5	Tons Processed
<u>Miscellaneous Casting and Fabricating - 3300</u>										
3-04-049-01	Wax Burnout Oven	---	---	---	---	---	---	---	---	Tons Burned
3-04-049-02	Wax Burnout Oven	---	---	---	---	---	---	---	---	Tons Consumed
3-04-049-99	Wax Burnout Oven	---	---	---	---	---	---	---	---	Tons Burned
<u>Miscellaneous Casting Fabricating - 3300</u>										
3-04-050-01	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
3-04-050-99	Other Not Classified	---	---	---	---	---	---	---	---	Each Processed
<u>Metallic Lead Products - 3300, 3340, 3350, 3356, 3360, 3369, 3400</u>										
3-04-051-01	Ammunition	---	---	---	---	---	---	---	< 1	Tons Processed
3-04-051-02	Bearing Metals	---	---	---	---	---	---	---	---	Tons Processed
3-04-051-03	Other Sources of Lead	---	---	---	---	---	---	---	1.5	Tons Processed
<u>Equipment Leaks - 3300, 3340, 3350, 3356, 3360, 3369, 3400</u>										
3-04-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Wastewater, Aggregate - 3300, 3400</u>										
3-04-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Wastewater, Aggregate - 3300, 3400</u>										
3-04-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Wastewater, Points of Generation - 3300, 3400</u>										
3-04-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Fugitive Emissions - 3300, 3400</u>										
3-04-888-01	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-04-888-02	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-04-888-03	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-04-888-04	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-04-888-05	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
<u>Fuel Fired Equipment - 3300, 3400</u>										
3-04-900-01	Distillate Oil (No. 2): Process Heaters	---	---	---	143.6S	20	0.2	---	---	1000 Gallons Burned
3-04-900-02	Residual Oil: Process Heaters	---	---	---	158.6S	55	0.28	---	---	1000 Gallons Burned
3-04-900-03	Natural Gas: Process Heaters	---	---	---	0.6	140	2.8	---	---	Million Cubic Feet Burned
3-04-900-04	Process Gas: Process Heaters	---	---	---	950S	140	2.8	---	---	Million Cubic Feet Burned
3-04-900-11	Distillate Oil (No. 2): Incinerators	---	---	---	---	---	0.4	---	---	1000 Gallons Burned
3-04-900-12	Residual Oil: Incinerators	---	---	---	---	---	0.56	---	---	1000 Gallons Burned
3-04-900-13	Natural Gas: Incinerators	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-04-900-14	Process Gas: Incinerators	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-04-900-21	Distillate Oil (No. 2): Flares	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-04-900-22	Residual Oil: Flares	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-04-900-23	Natural Gas: Flares	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-04-900-24	Process Gas: Flares	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-04-900-31	Distillate Oil (No. 2): Furnaces	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-04-900-32	Residual Oil: Furnaces	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-04-900-33	Natural Gas: Furnaces	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
3-04-900-34	Process Gas: Furnaces	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
3-04-900-35	Propane: Furnaces	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>Other Not Classified - 3300, 3400</u>										
3-04-999-99	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><b>INDUSTRIAL PROCESSES -Mineral Products</b></i>										
<i><b>Asphalt Roofing Manufacture - 2952</b></i>										
3-05-001-01	Asphalt Blowing: Saturant (Use 3-05-050-10 for MACT)	6.6	6.8	---	---	---	1.46	0.27	---	Tons Processed
3-05-001-02	Asphalt Blowing: Coating (Use 3-05-050-10 for MACT)	24	25	---	---	---	1.86	0.27	---	Tons Processed
3-05-001-03	Felt Saturation: Dipping Only	0.5	0.5	---	---	---	0.02	0.02	---	Tons Processed
3-05-001-04	Felt Saturation: Dipping/Spraying	3.14	2.26	---	---	---	0.03	0.25	---	Tons Processed
3-05-001-05	General	6.3	---	---	---	---	0.48	2.9	---	Tons Processed
3-05-001-06	Shingles and Rolls: Spraying Only	---	---	---	---	---	---	---	---	Tons Processed
3-05-001-07	Shingles and Rolls: Mineral Dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-001-08	Shingles and Rolls: Coating	---	---	---	---	---	---	---	---	Tons Processed
3-05-001-10	Blowing (Use 3-05-050-01 for MACT)	---	---	---	---	---	---	0.27	---	Tons Processed
3-05-001-11	Dipping Only	---	---	---	---	---	0.02	---	---	Tons Processed
3-05-001-12	Spraying Only	---	---	---	---	---	0.01	---	---	Tons Processed
3-05-001-13	Dipping/Spraying	---	---	---	---	---	0.03	---	---	Tons Processed
3-05-001-14	Asphaltic Felt: Coating	---	---	---	---	---	---	---	---	Tons Processed
3-05-001-15	Storage Bins: Steam Drying Drums	---	---	---	---	---	---	---	---	Tons Processed
3-05-001-16	Shingle Saturation: Dip Saturator, Drying-in Drum, Hot Looper & Coater	1.2	---	---	---	---	---	---	---	Tons Produced
3-05-001-17	Shingle Saturation: Dip Saturator, Drying-in Drum and Coater	---	---	---	---	---	---	0.0019	---	Tons Produced
3-05-001-18	Shingle Saturation: Dip Saturator, Drying-in Drum and Hot Looper	---	---	---	---	---	---	---	---	Tons Produced
3-05-001-19	Shingle Sat'ion: Spray/Dip Satur, Drying-in Drm, Hot Looper, Coatr & Str Tk	3.2	---	---	---	---	---	---	---	Tons Produced
3-05-001-20	Storage Bins: Ferric Chloride	---	---	---	---	---	---	---	---	Tons Stored
3-05-001-21	Storage Bins: Mineral Stabilizer	---	---	---	---	---	---	---	---	Tons Stored
3-05-001-30	Fixed Roof Tank: Asphalt/Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-05-001-31	Fixed Roof Tank: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-05-001-32	Floating Roof Tank: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-05-001-33	Floating Roof Tank: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-05-001-34	Blown Saturant Storage	---	---	---	---	---	---	---	---	Tons Stored
3-05-001-35	Blown Coating Storage	---	---	---	---	---	---	---	---	Tons Stored

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Asphalt Roofing Manufacture - 2952</u></i>										
3-05-001-40	Granules Unloading	---	---	---	---	---	---	---	---	Tons Handled
3-05-001-41	Granules Storage	---	---	---	---	---	---	---	---	Tons Stored
3-05-001-42	Mineral Dust Unloading	---	---	---	---	---	---	---	---	Tons Handled
3-05-001-43	Mineral Dust Storage	---	---	---	---	---	---	---	---	Tons Stored
3-05-001-44	Granules Transport Screw Conveyor and Bucket Elevator	---	---	---	---	---	---	---	---	Tons Handled
3-05-001-45	Mineral Dust Transport Screw Conveyor and Bucket Elevator	---	---	---	---	---	---	---	---	Tons Handled
3-05-001-46	Sand Surge Bin	---	---	---	---	---	---	---	---	Tons Handled
3-05-001-47	Granules Surge Bin	---	---	---	---	---	---	---	---	Tons Handled
3-05-001-50	Mineral Dust (Filler) and Asphalt Coating Mixer	---	---	---	---	---	---	---	---	Tons Produced
3-05-001-51	Granules	---	---	---	---	---	---	---	---	Tons Produced
3-05-001-52	Sand Applicator	---	---	---	---	---	---	---	---	Tons Produced
3-05-001-53	Cooling Rolls	---	---	---	---	---	---	---	---	Tons Produced
3-05-001-54	Finish Floating Looper	---	---	---	---	---	---	---	---	Tons Produced
3-05-001-98	Other Not Classified	---	---	---	---	---	---	---	---	Gallons Processed
3-05-001-99	See Comment	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Asphalt Concrete - 2951</u></i>										
3-05-002-01	Rotary Dryer: Conventional Plant (see 3-05-002-50 -51 -52 for subtypes)	---	---	---	0.073	---	0.028	---	---	Tons Produced
3-05-002-02	Hot Elevators, Screens, Bins and Mixer	---	0.03	---	0.07	---	---	---	---	Tons Produced
3-05-002-03	Storage Piles	---	0.12	---	---	---	---	---	---	Tons Processed
3-05-002-04	Cold Aggregate Handling	---	---	---	---	---	---	---	---	Tons Processed
3-05-002-05	Drum Dryer: Hot Asphalt Plants (see 3-05-002-55 & -58 for subtypes)	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-06	Asphalt Heater: Natural Gas (Use 3-05-050-20 for MACT)	---	---	---	0.6	140	2.8	---	---	Million Cubic Feet Burned
3-05-002-07	Asphalt Heater: Residual Oil (Use 3-05-050-21 for MACT)	---	---	---	159S	55	0.28	---	---	1000 Gallons Burned
3-05-002-08	Asphalt Heater: Distillate Oil (Use 3-05-050-22 for MACT)	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-05-002-09	Asphalt Heater: LPG (Use 3-05-050-23 for MACT)	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-05-002-10	Asphalt Heater: Waste Oil	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-05-002-11	Rotary Dryer Conventional Plant with Cyclone use 3-05-002-01 w/CTL	---	0.36	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Asphalt Concrete - 2951</u></i>										
3-05-002-12	Heated Asphalt Storage Tanks: Drum Mix	---	---	---	---	---	---	---	---	Tons Stored
3-05-002-13	Storage Silo	---	---	---	---	---	---	---	---	Tons Stored
3-05-002-14	Truck Load-out	---	---	---	---	---	---	---	---	Tons Loaded
3-05-002-15	In Place Recycling: Propane	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-16	Cold Aggregate Feed Bins	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-17	Cold Aggregate Conveyors and Elevators	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-20	Elevators: Batch Process	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-21	Elevators: Continuous Process	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-30	Hot Bins and Screens: Batch Process	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-31	Hot Bins and Screens: Continuous Process	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-40	Mixers: Batch Process	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-41	Mixers: Continuous Process	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-42	Mixers: Drum Mix Process (use 3-05-002-005 and subtypes)	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-50	Conventional Continuous Mix (outside of drum) Plant: Rotary Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-51	Conventional Batch Mix Plant: Rotary Dryer, Natural Gas - Fired	32	4.5	0.0041	<sup>21</sup> 0.005	0.025	---	0.34	---	Tons Produced
3-05-002-52	Conventional Batch Mix Plant: Rotary Dryer, Oil - Fired	32	4.5	0.045	<sup>21</sup> 0.24	0.17	---	0.069	---	Tons Produced
3-05-002-55	Drum Mix Plant: Rotary Drum Dryer / Mixer, Natural Gas - Fired	19	4.3	0.081	<sup>21</sup> 0.0033	0.03	---	0.056	---	Tons Produced
3-05-002-56	Drum Mix Plant: Rotary Drum Dryer / Mixer, Natural Gas, Parallel Flow	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-57	Drum Mix Plant: Rotary Drum Dryer / Mixer, Natural Gas, Counterflow	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-58	Drum Mix Plant: Rotary Drum Dryer / Mixer, Oil - Fired	19	4.3	0.026	<sup>21</sup> 0.056	0.075	---	0.036	---	Tons Produced
3-05-002-59	Drum Mix Plant: Rotary Drum Dryer / Mixer, Oil - Fired, Parallel Flow	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-60	Drum Mix Plant: Rotary Drum Dryer / Mixer, Oil - Fired, Counterflow	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-90	Haul Roads: General	---	---	---	---	---	---	---	---	Tons Processed
3-05-002-98	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
3-05-002-99	See Comment	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Brick Manufacture - 3251</u></i>										
3-05-003-01	Raw Material Drying	70	41	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Brick Manufacture - 3251</i>										
3-05-003-02	Raw Material Grinding & Screening	See App. C	See App. C	---	---	---	---	---	---	Tons Processed
3-05-003-03	Storage of Raw Materials	34	12	---	---	---	---	---	---	Tons Stored
3-05-003-04	Curing	0.07	---	---	0.02	0.29	0.03	0.07	---	Tons Produced
3-05-003-05	Raw Material Handling and Transferring	---	---	---	---	---	---	---	---	Tons Processed
3-05-003-06	Pulverizing	---	---	---	---	---	---	---	---	Tons Processed
3-05-003-07	Calcining	---	---	---	---	---	---	---	---	Tons Processed
3-05-003-08	Screening	---	1.4	---	---	---	---	---	---	Tons Processed
3-05-003-09	Blending and Mixing	---	---	---	---	---	---	---	---	Tons Processed
3-05-003-10	Curing and Firing: Sawdust Fired Tunnel Kilns	0.34	0.26	0.59	<sup>21</sup> 0.67	0.37	0.024	1.6	0.00015	Tons Produced
3-05-003-11	Curing and Firing: Gas-fired Tunnel Kilns	0.37	0.28	0.59	<sup>21</sup> 0.67	0.35	0.024	1.2	0.00015	Tons Produced
3-05-003-12	Curing and Firing: Oil-fired Tunnel Kilns	0.59	0.32	---	3.95S	1.05	0.007	0.12	---	Tons Produced
3-05-003-13	Curing and Firing: Coal-fired Tunnel Kilns	1.2	0.76	0.59	7.31S	0.51	0.024	0.8	0.00015	Tons Produced
3-05-003-14	Curing and Firing: Gas-fired Periodic Kilns	0.065	0.034	---	---	0.5	0.01	0.15	---	Tons Produced
3-05-003-15	Curing and Firing: Oil-fired Periodic Kilns	0.88	0.47	---	5.9S	1.62	0.01	0.19	---	Tons Produced
3-05-003-16	Curing and Firing: Coal-fired Periodic Kilns	18.84A	10	---	12.13S	2.35	0.02	2.39	---	Tons Produced
3-05-003-17	Raw Material Unloading	---	---	---	---	---	---	---	---	Tons Processed
3-05-003-18	Tunnel Kiln: Wood-fired	---	---	---	---	---	---	---	---	Tons Produced
3-05-003-19	Transfer and Conveying	---	---	---	---	---	---	---	---	Tons Processed
3-05-003-21	General	---	---	---	---	---	---	---	---	Tons Handled
3-05-003-22	Firing: Natural Gas-fired Tunnel Kiln Firing High-Sulfur Material	---	---	---	<sup>21</sup> 5.1	0.35	---	1.2	---	Tons Produced
3-05-003-30	Curing and Firing: Dual Fuel-fired Periodic Kiln	---	---	---	---	---	---	---	---	Tons Produced
3-05-003-31	Curing and Firing: Dual Fuel Fired Tunnel Kiln	---	---	---	---	---	---	---	---	Tons Produced
3-05-003-32	Curing and Firing: Gas-fired Kiln, Other Type	---	---	---	---	---	---	---	---	Tons Produced
3-05-003-33	Curing and Firing: Oil-fired Kiln, Other Type	---	---	---	---	---	---	---	---	Tons Produced
3-05-003-34	Curing and Firing: Coal-fired Kiln, Other Type	---	---	---	---	---	---	---	---	Tons Produced
3-05-003-35	Curing and Firing: Dual Fuel-fired Kiln, Other Type	---	---	---	---	---	---	---	---	Tons Produced
3-05-003-40	Primary Crusher	---	---	---	---	---	---	---	---	Tons Processed
3-05-003-42	Extrusion Line	---	---	---	---	---	---	---	---	Tons Produced
3-05-003-50	Brick Dryer: Heated With Waste Heat From Kiln Cooling Zone	0.077	---	---	---	---	0.03	---	---	Tons Produced
3-05-003-51	Brick Dryer: Heated With Waste Heat And Supplemental Gas Burners	0.077	---	---	---	0.098	0.03	0.31	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Brick Manufacture - 3251</u></i>										
3-05-003-55	Coal Crushing And Storage System	---	---	---	---	---	---	---	---	Tons Processed
3-05-003-60	Sawdust Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-05-003-61	Sawdust Dryer: Heated With Exhaust From Sawdust-fired Kiln	1.3	0.25	0.056	---	---	0.18	---	0.00012	Tons Produced
3-05-003-70	Firing: Natural Gas-fired Tunnel Kiln Firing Structural Clay Tile	1	---	---	---	---	---	---	---	Tons Produced
3-05-003-97	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
3-05-003-98	Other Not Classified	---	---	---	---	---	---	---	---	Gallons Processed
3-05-003-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Calcium Carbide - 2819</u></i>										
3-05-004-01	Electric Furnace: Hoods and Main Stack	26	22	---	3	---	---	---	---	Footnote 50
3-05-004-02	Coke Dryer	2	1	---	3	0.2	---	---	---	Footnote 50
3-05-004-03	Furnace Room Vents	26	24	---	---	---	---	---	---	Footnote 50
3-05-004-04	Tap Fume Vents	---	---	---	---	---	---	---	---	Tons Produced
3-05-004-05	Primary/Secondary Crushing	---	---	---	---	---	---	---	---	Tons Produced
3-05-004-06	Circular Charging: Conveyor	---	---	---	---	---	---	---	---	Tons Produced
3-05-004-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Castable Refractory - 3255</u></i>										
3-05-005-01	Fire Clay: Rotary Dryer	65	16	---	---	---	---	---	---	Tons Fed
3-05-005-02	Raw Material Crushing/Processing	120	61.2	---	---	---	---	---	---	Tons Fed
3-05-005-03	Electric Arc Melt Furnace	50	46	---	---	---	---	---	---	Tons Fed
3-05-005-04	Curing Oven	0.2	0.1	---	---	0.16	1	---	---	Tons Fed
3-05-005-05	Molding and Shakeout	25	20	---	---	---	---	---	---	Tons Fed
3-05-005-06	Fire Clay: Rotary Calciner	120	30	---	---	<sup>27</sup> 1.7	---	---	---	Tons Fed
3-05-005-07	Fire Clay: Tunnel Kiln	---	---	---	---	---	---	---	---	Tons Fed
3-05-005-08	Chromite-Magnesite Ore: Rotary Dryer	1.7	0.41	---	---	---	---	---	---	Tons Processed
3-05-005-09	Chromite-Magnesite Ore: Tunnel Kiln	0.82	0.69	---	---	---	---	---	---	Tons Processed
3-05-005-98	Other Not Classified	---	---	---	---	---	---	---	---	Gallons Processed
3-05-005-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Fed
<i><u>Cement Manufacturing (Dry Process) - 3241</u></i>										
3-05-006-06	Kilns	256	108	---	10.8	6	---	0.21	0.12	Footnote 52
3-05-006-07	Raw Material Unloading	---	0.1	---	---	---	---	---	---	Tons Unloaded

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Cement Manufacturing (Dry Process) - 3241</u>										
3-05-006-08	Raw Material Piles	---	1.4	---	---	---	---	---	---	Ton-Years Stored
3-05-006-09	Primary Crushing	---	0.26	---	---	---	---	---	---	Tons Processed
3-05-006-10	Secondary Crushing	---	1.13	---	---	---	---	---	---	Tons Processed
3-05-006-11	Screening	---	---	---	---	---	---	---	---	Tons Processed
3-05-006-12	Raw Material Transfer	---	0.15	---	---	---	---	---	---	Tons Handled
3-05-006-13	Raw Material Grinding and Drying	64	54	---	---	---	---	---	0.04	Tons Produced
3-05-006-14	Clinker Cooler	9.2	0.8	---	---	---	---	---	---	Tons Produced
3-05-006-15	Clinker Piles	---	---	---	---	---	---	---	---	Tons Produced
3-05-006-16	Clinker Transfer	---	---	---	---	---	---	---	---	Tons Produced
3-05-006-17	Clinker Grinding	96	82	---	---	---	---	---	0.04	Tons Produced
3-05-006-18	Cement Silos	---	---	---	---	---	---	---	---	Tons Produced
3-05-006-19	Cement Load Out	---	0.2	---	---	---	---	---	---	Tons Produced
3-05-006-20	Predryer	---	---	---	---	---	---	---	---	Tons Produced
3-05-006-21	Pulverized Coal Kiln Feed Units	---	---	---	---	---	---	---	---	Tons Processed
3-05-006-22	Preheater Kiln	250	---	---	<sup>21</sup> 0.55	4.8	---	0.98	---	Tons Produced
3-05-006-23	Preheater/Precalciner Kiln	---	---	---	<sup>21</sup> 1.1	4.2	---	3.7	---	Tons Produced
3-05-006-24	Raw Mill Feed Belt	---	---	---	---	---	---	---	---	Tons Processed
3-05-006-25	Raw Mill Weigh Hopper	---	---	---	---	---	---	---	---	Tons Processed
3-05-006-26	Raw Mill Air Separator	---	---	---	---	---	---	---	---	Tons Processed
3-05-006-27	Finish Grinding Mill Feed Belt	---	---	---	---	---	---	---	---	Tons Processed
3-05-006-28	Finish Grinding Mill Weigh Hopper	---	---	---	---	---	---	---	---	Tons Processed
3-05-006-29	Finish Grinding Mill Air Separator	---	---	---	---	---	---	---	---	Tons Processed
3-05-006-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Cement Manufacturing (Wet Process) - 3241</u>										
3-05-007-06	Kilns	130	31	---	10.8	7.4	---	0.12	0.1	Footnote 53
3-05-007-07	Raw Material Unloading	---	0.1	---	---	---	---	---	---	Tons Unloaded
3-05-007-08	Raw Material Piles	---	1.4	---	---	---	---	---	---	Ton-Years Stored
3-05-007-09	Primary Crushing	---	0.26	---	---	---	---	---	---	Tons Processed
3-05-007-10	Secondary Crushing	---	1.13	---	---	---	---	---	---	Tons Processed
3-05-007-11	Screening	---	---	---	---	---	---	---	---	Tons Processed
3-05-007-12	Raw Material Transfer	---	0.15	---	---	---	---	---	---	Tons Handled

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Cement Manufacturing (Wet Process) - 3241</i></u>										
3-05-007-14	Clinker Cooler	---	0.8	---	---	---	---	---	---	Tons Produced
3-05-007-15	Clinker Piles	---	---	---	---	---	---	---	---	Tons Produced
3-05-007-16	Clinker Transfer	---	---	---	---	---	---	---	---	Tons Produced
3-05-007-17	Clinker Grinding	32	27	---	---	---	---	---	0.02	Tons Produced
3-05-007-18	Cement Silos	---	---	---	---	---	---	---	---	Tons Produced
3-05-007-19	Cement Load Out	---	---	---	---	---	---	---	---	Tons Produced
3-05-007-27	Finish Grinding Mill Feed Belt	---	---	---	---	---	---	---	---	Tons Processed
3-05-007-28	Finish Grinding Mill Weigh Hopper	---	---	---	---	---	---	---	---	Tons Processed
3-05-007-29	Finish Grinding Mill Air Separator	---	---	---	---	---	---	---	---	Tons Processed
3-05-007-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u><i>Ceramic Clay/Tile Manufacture - 3261</i></u>										
3-05-008-01	Drying (use SCC 3-05-008-13)	70	35.7	---	---	---	---	---	---	Tons Fed
3-05-008-02	Comminution - Crushing, Grinding, & Milling	76	64.6	---	---	---	---	---	---	Tons Processed
3-05-008-03	Raw Material Storage	---	---	---	---	---	---	---	---	Tons Processed
3-05-008-04	Screening and floating (use SCC 3-05-008-16)	---	---	---	---	---	---	---	---	Tons Fed
3-05-008-05	Granulation - Direct Mixing of Ceramic Powder and Binder Solution	---	---	---	---	---	---	---	---	Tons Processed
3-05-008-06	Raw Material Handling and Transfer	---	---	---	---	---	---	---	---	Tons Processed
3-05-008-07	Grinding, dry (use SCC 3-05-008-02)	---	---	---	---	---	---	---	---	Tons Processed
3-05-008-10	Granulation - Natural Gas-fired Spray Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-05-008-11	Drying - Infrared (IR) Drying Prior to Firing	---	---	---	---	---	---	---	---	Tons Produced
3-05-008-12	Glazing and firing kiln (use SCCs 3-05-008-45 & -50)	---	---	---	---	---	---	---	---	Tons Fed
3-05-008-13	Drying - Convection Drying Prior to Firing	2.3	---	---	---	---	---	---	---	Tons Produced
3-05-008-16	Sizing - Vibrating Screens	---	---	---	---	---	---	---	---	Tons Processed
3-05-008-18	Air Classifier	---	---	---	---	---	---	---	---	Tons Processed
3-05-008-21	Calcining--Natural Gas-fired Rotary Calciner	---	---	---	---	---	---	---	---	Tons Processed
3-05-008-22	Calcining--Fuel Oil-fired Rotary Calciner	---	---	---	---	---	---	---	---	Tons Processed
3-05-008-23	Calcining--Natural Gas-fired Fluidized Bed Calciner	---	---	---	---	---	---	---	---	Tons Processed
3-05-008-24	Calcining--Fuel Oil-fired Fluidized Bed Calciner	---	---	---	---	---	---	---	---	Tons Processed
3-05-008-28	Mixing - Raw Mat'ls, Binders, Plasticizers, Surfactants, & Other Agent	---	---	---	---	---	---	---	---	Tons Processed
3-05-008-30	Forming - General	---	---	---	---	---	---	---	---	Tons Produced



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Ceramic Clay/Tile Manufacture - 3261</u></i>										
3-05-008-31	Forming - Tape Casters	---	---	---	---	---	---	---	---	Tons Produced
3-05-008-35	Green Machining-Grindg, Cutg, or Laminatg Formed Ceramics Prior to Fir	---	---	---	---	---	---	---	---	Tons Processed
3-05-008-40	Presinter Thermal Processing - Natural Gas-fired Kiln	---	---	---	---	---	---	---	---	Tons Processed
3-05-008-41	Presinter Thermal Processing - Fuel Oil-fired Kiln	---	---	---	---	---	---	---	---	Tons Processed
3-05-008-43	Glaze Preparation - Ballmill or Attrition Mill	---	---	---	---	---	---	---	---	Tons Processed
3-05-008-45	Ceramic Glaze Spray Booth	19	---	---	---	---	---	---	3	Tons Used
3-05-008-50	Firing - Natural Gas-fired Kiln	0.49	---	---	<sup>21, 54</sup> 44S	0.54	0.43	3.3	---	Tons Produced
3-05-008-54	Firing - Fuel Oil-fired Kiln	---	---	---	---	---	---	---	---	Tons Produced
3-05-008-56	Refiring Kiln - Refiring after Decal, Paint, or Ink Applied; Natural-g	0.067	---	---	---	---	---	---	---	Tons Produced
3-05-008-58	Cooler - Cooling Ceramics Following Firing	0.11	---	---	---	---	---	---	---	Tons Produced
3-05-008-60	Final Processing - Grinding and Polishing	---	---	---	---	---	---	---	---	Tons Produced
3-05-008-70	Final Processing - Annealing	---	---	---	---	---	---	---	---	Tons Produced
3-05-008-80	Final Processing - Surface Coating	---	---	---	---	---	---	---	---	Tons Produced
3-05-008-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Clay and Fly Ash Sintering - 3295</u></i>										
3-05-009-01	Fly Ash Sintering	110	68	---	---	---	---	---	---	Footnote 55
3-05-009-02	Clay/Coke Sintering	40	20.4	---	---	---	---	---	---	Footnote 55
3-05-009-03	Natural Clay/Shale Sintering	12	6.36	---	---	---	---	---	---	Footnote 55
3-05-009-04	Raw Clay/Shale Crushing/Screening	12	0.25	---	---	---	---	---	---	Tons Processed
3-05-009-05	Raw Clay/Shale Transfer/Conveying	---	0.4	---	---	---	---	---	---	Tons Processed
3-05-009-06	Raw Clay/Shale Storage Piles	---	---	---	---	---	---	---	---	Tons Processed
3-05-009-07	Sintered Clay/Coke Product Crushing/Screening	15	12.8	---	---	---	---	---	---	Footnote 55
3-05-009-08	Sintered Clay/Shale Product Crushing/Screening	12	---	---	---	---	---	---	---	Tons Produced
3-05-009-09	Expanded Shale Clinker Cooling	---	---	---	---	---	---	---	---	Tons Produced
3-05-009-10	Expanded Shale Storage	---	---	---	---	---	---	---	---	Tons Produced
3-05-009-15	Rotary Kiln	---	---	---	---	---	---	---	---	Tons Processed
3-05-009-16	Dryer	70	62.6	---	---	---	---	---	---	Tons Dried
3-05-009-17	Clay Reciprocating Grate Clinker Cooler	0.314	0.18	---	---	---	---	---	---	Tons Processed
3-05-009-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Coal Mining, Cleaning, and Material Handling (See 305310) - 1111, 1221, 1222</i>										
3-05-010-01	Fluidized Bed	26	---	0.042	1.4	0.16	0.098	---	---	Tons Dried
3-05-010-02	Flash or Suspension	16	---	---	0.52	---	---	---	---	Footnote 56
3-05-010-03	Multilouvered	3.7	---	0.075	---	---	---	---	---	Tons Dried
3-05-010-04	Rotary	---	---	---	---	---	---	---	---	Tons Dried
3-05-010-05	Cascade	---	---	---	---	---	---	---	---	Tons Dried
3-05-010-06	Continuous Carrier	---	---	---	---	---	---	---	---	Tons Dried
3-05-010-07	Screen	---	---	---	---	---	---	---	---	Tons Dried
3-05-010-08	Unloading	0.02	0.006	---	---	---	---	---	---	Tons Shipped
3-05-010-09	Raw Coal Storage	---	---	---	---	---	---	---	---	Tons Shipped
3-05-010-10	Crushing	0.02	0.006	---	---	---	---	---	---	Tons Shipped
3-05-010-11	Coal Transfer	---	---	---	---	---	---	---	---	Tons Shipped
3-05-010-12	Screening	---	---	---	---	---	---	---	---	Tons Shipped
3-05-010-13	Air Tables	---	---	---	---	---	---	---	---	Tons Shipped
3-05-010-14	Cleaned Coal Storage	---	---	---	---	---	---	---	---	Tons Shipped
3-05-010-15	Loading	---	---	---	---	---	---	---	---	Tons Shipped
3-05-010-16	Loading: Clean Coal	---	---	---	---	---	---	---	---	Tons Shipped
3-05-010-17	Secondary Crushing	---	---	---	---	---	---	---	---	Tons Shipped
3-05-010-21	Overburden Removal	---	---	---	---	---	---	---	---	Tons Mined
3-05-010-22	Drilling/Blasting	---	---	---	---	---	---	---	---	Tons Mined
3-05-010-23	Loading	---	0.05	---	---	---	---	---	---	Tons Mined
3-05-010-24	Hauling	---	2.1	---	---	---	---	---	---	Miles Travelled
3-05-010-30	Topsoil Removal	0.06	---	---	---	---	---	---	---	Tons Removed
3-05-010-31	Scrapers: Travel Mode	14.6	---	---	---	---	---	---	---	Miles Travelled
3-05-010-32	Topsoil Unloading	0.04	---	---	---	---	---	---	---	Tons Processed
3-05-010-33	Overburden	1.3	0.16	---	---	---	---	---	---	Each Drilled
3-05-010-34	Coal Seam: Drilling	0.22	0.028	---	---	---	---	---	---	Each Drilled
3-05-010-35	Blasting: Coal Overburden	---	---	---	---	---	---	---	---	Each Occurred
3-05-010-36	Dragline: Overburden Removal	0.06	0.009	---	---	---	---	---	---	Cubic Yards Removed
3-05-010-37	Truck Loading: Overburden	---	0.015	---	---	---	---	---	---	Tons Loaded
3-05-010-38	Truck Loading: Coal	0.04	0.005	---	---	---	---	---	---	Tons Loaded
3-05-010-39	Hauling: Haul Trucks	17.2	2.1	---	---	---	---	---	---	Miles Travelled

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Coal Mining, Cleaning, and Material Handling (See 305310) - 1111, 1221, 1222</u></i>										
3-05-010-40	Truck Unloading: End Dump - Coal	0.007	0.001	---	---	---	---	---	---	Tons Processed
3-05-010-41	Truck Unloading: Bottom Dump - Coal	0.066	0.01	---	---	---	---	---	---	Tons Processed
3-05-010-42	Truck Unloading: Bottom Dump - Overburden	0.002	0.001	---	---	---	---	---	---	Tons Processed
3-05-010-43	Open Storage Pile: Coal	---	17060	---	---	---	---	---	---	Acre-Years Existing
3-05-010-44	Train Loading: Coal	---	0.0059	---	---	---	---	---	---	Tons Loaded
3-05-010-45	Bulldozing: Overburden	---	---	---	---	---	---	---	---	Hour Operated
3-05-010-46	Bulldozing: Coal	49.4	---	---	---	---	---	---	---	Hour Operated
3-05-010-47	Grading	5.37	3.33	---	---	---	---	---	---	Miles Travelled
3-05-010-48	Overburden Replacement	0.012	0.006	---	---	---	---	---	---	Tons Processed
3-05-010-49	Wind Erosion: Exposed Areas	760	380	---	---	---	---	---	---	Acre-Years Existing
3-05-010-50	Vehicle Traffic: Light/Medium Vehicles	2.79	1.56	---	---	---	---	---	---	Miles Travelled
3-05-010-51	Surface Mining Operations: Open Storage Pile: Spoils	---	---	---	---	---	---	---	---	Tons Processed
3-05-010-60	Surface Mining Operations: Primary Crusher	---	---	---	---	---	---	---	---	Tons Processed
3-05-010-61	Surface Mining Operations: Secondary Crusher	---	---	---	---	---	---	---	---	Tons Processed
3-05-010-62	Surface Mining Operations: Screens	---	---	---	---	---	---	---	---	Tons Processed
3-05-010-90	Haul Roads: General	---	---	---	---	---	---	---	---	Tons Processed
3-05-010-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Shipped
<i><u>Concrete Batching - 3270, 1771, 3292</u></i>										
3-05-011-01	General (Non-fugitive)	0.2	0.1	---	---	---	---	---	---	Cubic Yards Produced
3-05-011-06	Transfer: Sand/Aggregate to Elevated Bins	0.029	0.03	---	---	---	---	---	---	Tons Processed
3-05-011-07	Cement Unloading: Storage Bins	0.24	0.14	---	---	---	---	---	---	Tons Processed
3-05-011-08	Weight Hopper Loading of Cement/Sand/Aggregate	0.02	0.01	---	---	---	---	---	---	Tons Processed
3-05-011-09	Mixer Loading of Cement/Sand/Aggregate	0.04	0.02	---	---	---	---	---	---	Tons Processed
3-05-011-10	Loading of Transit Mix Truck	0.02	0.01	---	---	---	---	---	---	Tons Processed
3-05-011-11	Loading of Dry-batch Truck	0.04	0.02	---	---	---	---	---	---	Tons Loaded
3-05-011-12	Mixing: Wet	---	---	---	---	---	---	---	---	Cubic Yards Produced
3-05-011-13	Mixing: Dry	---	---	---	---	---	---	---	---	Cubic Yards Produced
3-05-011-14	Transferring: Conveyors/Elevators	---	---	---	---	---	---	---	---	Cubic Yards Produced
3-05-011-15	Storage: Bins/Hoppers	---	---	---	---	---	---	---	---	Cubic Yards Produced
3-05-011-20	Asbestos/Cement Products	---	0.1	---	---	---	---	---	---	Tons Produced
3-05-011-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Fiberglass Manufacturing - 3296, 3229</u></i>										
3-05-012-01	Regenerative Furnace (Wool-type Fiber)	25 - 30	20.9	---	10	5	0.2	0.25	---	Tons Processed
3-05-012-02	Recuperative Furnace (Wool-type Fiber)	22	26.1	---	10	1.7	0.2	0.25	---	Tons Processed
3-05-012-03	Electric Furnace (Wool-type Fiber)	0.5	0.48	---	0.04	0.27	0.2	0.05	---	Tons Processed
3-05-012-04	Forming: Rotary Spun (Wool-type Fiber)	See App. C	54	---	---	---	---	---	---	Tons Processed
3-05-012-05	Curing Oven: Rotary Spun (Wool-type Fiber)	---	9	---	---	---	---	---	---	Tons Processed
3-05-012-06	Cooling (Wool-type Fiber)	---	1.3	---	---	---	---	---	---	Tons Processed
3-05-012-07	Unit Melter Furnace (Wool-type Fiber)	9	8.6	---	0.6	0.3	---	0.25	---	Tons Processed
3-05-012-08	Forming: Flame Attenuation (Wool-type Fiber)	2	1.9	---	---	---	0.3	---	---	Tons Processed
3-05-012-09	Curing: Flame Attenuation (Wool-type Fiber)	6	6	---	---	2	7	3.5	---	Tons Processed
3-05-012-11	Regenerative Furnace (Textile-type Fiber)	16	15	---	30	20	0.2	1	---	Tons Processed
3-05-012-12	Recuperative Furnace (Textile-type Fiber)	2	1.9	---	3	20	0.2	0.5	---	Tons Processed
3-05-012-13	Unit Melter Furnace (Textile-type Fiber)	6	5.7	---	---	20	---	0.9	---	Tons Processed
3-05-012-14	Forming Process (Textile-type Fiber)	1	0.5	---	---	---	---	---	---	Tons Processed
3-05-012-15	Curing Oven (Textile-type Fiber)	1.2	1.2	---	---	2.6	---	1.5	---	Tons Processed
3-05-012-21	Raw Material: Unloading/Conveying	3	1.5	---	---	---	---	---	---	Tons Processed
3-05-012-22	Raw Material: Storage Bins	0.2	0.1	---	---	---	---	---	---	Tons Processed
3-05-012-23	Raw Material: Mixing/Weighing	0.6	0.3	---	---	---	---	---	---	Tons Processed
3-05-012-24	Raw Material: Crushing/Charging	---	---	---	---	---	---	---	---	Tons Processed
3-05-012-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Frit Manufacture - 2899</u></i>										
3-05-013-01	General (use 3-05-013-05 or 3-05-013-06)	---	---	---	---	---	---	---	---	Tons Charged
3-05-013-02	Weighing of raw materials	---	---	---	---	---	---	---	---	Tons Processed
3-05-013-03	Dry Mixing of raw materials	---	---	---	---	---	---	---	---	Tons Processed
3-05-013-04	Smelting Furnace Charging	---	---	---	---	---	---	---	---	Tons Charged
3-05-013-05	Rotary Smelting Furnace	16	15	---	---	16	---	4.8	---	Tons Fed
3-05-013-06	Continuous Smelting Furnace	16	15	---	---	16	---	4.8	---	Tons Fed
3-05-013-10	Water Spray Quenching to shatter material into small particles	---	---	---	---	---	---	---	---	Tons Quenched
3-05-013-11	Rotary Dryer (usually not used with a continuous furnace)	---	---	---	---	---	---	---	---	Tons Fed
3-05-013-15	Dry Milling of quenched frit with a ball mill	---	---	---	---	---	---	---	---	Tons Processed
3-05-013-16	Product Screening	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Frit Manufacture - 2899</u>										
3-05-013-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Charged
<u>Glass Manufacture - 3211, 3221, 3229</u>										
3-05-014-01	Furnace/General	2	---	---	---	---	---	---	---	Tons Produced
3-05-014-02	Container Glass: Melting Furnace	1.4	1.32	---	3.4	6.2	0.2	0.2	---	Tons Produced
3-05-014-03	Flat Glass: Melting Furnace	2	1.9	---	3	8	0.1	0.1	---	Tons Produced
3-05-014-04	Pressed and Blown Glass: Melting Furnace	17.4	16.5	---	5.6	8.5	0.3	0.2	---	Tons Produced
3-05-014-05	Presintering	---	---	---	---	---	---	---	---	Tons Processed
3-05-014-06	Container Glass: Forming/Finishing	---	---	---	---	---	8.7	---	---	Tons Produced
3-05-014-07	Flat Glass: Forming/Finishing	---	---	---	---	---	---	---	---	Tons Produced
3-05-014-08	Pressed and Blown Glass: Forming/Finishing	---	---	---	---	---	9	---	---	Tons Produced
3-05-014-10	Raw Material Handling (All Types of Glass)	---	---	---	---	---	---	---	---	Tons Processed
3-05-014-11	General	---	---	---	---	---	---	---	---	Tons Processed
3-05-014-12	Hold Tanks	---	---	---	---	---	---	---	---	Tons Processed
3-05-014-13	Cullet: Crushing/Grinding	---	---	---	---	---	---	---	---	Tons Processed
3-05-014-14	Ground Cullet Beading Furnace	---	---	---	5.6	8.5	0.3	---	---	Tons Produced
3-05-014-15	Glass Etching with Hydrofluoric Acid Solution	---	0.5	---	---	---	---	---	---	Gallons Consumed
3-05-014-16	Glass Manufacturing	---	---	---	---	---	---	---	---	Tons Produced
3-05-014-17	Briquetting	---	---	---	---	---	---	---	---	Tons Processed
3-05-014-18	Pelletizing	---	---	---	---	---	---	---	---	Tons Processed
3-05-014-20	Mirror Plating: General	---	---	---	---	---	---	---	---	1000 Square Feet Processed
3-05-014-21	Demineralizer: General	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-05-014-99	See Comment	---	---	---	---	---	---	---	---	Tons Produced
<u>Gypsum Manufacture - 3275</u>										
3-05-015-01	Rotary Ore Dryer	0.16	0.013	---	---	---	---	---	---	Square Feet-Hours Flow
3-05-015-02	Primary Grinder/Roller Mills	2.6	2.2	---	---	---	---	---	---	Tons Produced
3-05-015-03	Not Classified	90	---	---	---	---	---	---	---	Tons Throughput
3-05-015-04	Conveying	---	0.15	---	---	---	---	---	---	Tons Throughput
3-05-015-05	Primary Crushing: Gypsum Ore	---	0.26	---	---	---	---	---	---	Tons Processed
3-05-015-06	Secondary Crushing: Gypsum Ore	---	1.13	---	---	---	---	---	---	Tons Processed
3-05-015-07	Screening: Gypsum Ore	---	---	---	---	---	---	---	---	Tons Processed
3-05-015-08	Stockpile: Gypsum Ore	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Gypsum Manufacture - 3275</i></u>										
3-05-015-09	Storage Bins: Gypsum Ore	---	---	---	---	---	---	---	---	Tons Processed
3-05-015-10	Storage Bins: Landplaster	---	---	---	---	---	---	---	---	Tons Produced
3-05-015-11	Continuous Kettle: Calciner	41	26	---	---	---	---	---	---	Tons Produced
3-05-015-12	Flash Calciner	37	14	---	---	---	---	---	---	Tons Produced
3-05-015-13	Impact Mill	100	85	---	---	---	---	---	---	Tons Produced
3-05-015-14	Storage Bins: Stucco	---	---	---	---	---	---	---	---	Tons Produced
3-05-015-15	Tube/Ball Mills	---	---	---	---	---	---	---	---	Tons Produced
3-05-015-16	Mixers	---	---	---	---	---	---	---	---	Tons Produced
3-05-015-17	Bagging	---	---	---	---	---	---	---	---	Tons Produced
3-05-015-18	Mixers/Conveyors	---	---	---	---	---	---	---	---	Tons Produced
3-05-015-19	Forming Line	---	---	---	---	---	---	---	---	Tons Produced
3-05-015-20	Drying Kiln	---	---	---	---	---	---	---	---	Tons Produced
3-05-015-21	End Sawing (8 Ft.)	8	6.8	---	---	---	---	---	---	1000 Square Feet Sawed
3-05-015-22	End Sawing (12 Ft.)	5	4.25	---	---	---	---	---	---	1000 Square Feet Sawed
3-05-015-99	See Comment	---	---	---	---	---	---	---	---	Tons Throughput
<u><i>Lime Manufacture - 3274</i></u>										
3-05-016-01	Primary Crushing	0.017	---	---	---	---	---	---	---	Tons Processed
3-05-016-02	Secondary Crushing/Screening	0.62	---	---	---	---	---	---	---	Tons Processed
3-05-016-03	Calcining: Vertical Kiln	8	5	---	8.2	2.8	0.02	---	---	Tons Produced
3-05-016-04	Calcining: Rotary Kiln (See SCC Codes 3-05-016-18,-19,-20,-21)	350	42	---	6.71	2.8	---	2	---	Tons Produced
3-05-016-05	Calcining: Gas-fired Calcimatic Kiln	97	---	---	---	0.15	---	---	---	Tons Produced
3-05-016-06	Fluidized Bed Kiln	---	---	---	---	---	---	---	---	Tons Produced
3-05-016-07	Raw Material Transfer and Conveying	---	0.18	---	---	---	---	---	---	Tons Processed
3-05-016-08	Raw Material Unloading	---	0.1	---	---	---	---	---	---	Tons Processed
3-05-016-09	Hydrator: Atmospheric	---	---	---	---	---	---	---	---	Tons Produced
3-05-016-10	Raw Material Storage Piles	---	1.4	---	---	---	---	---	---	Tons Processed
3-05-016-11	Product Cooler	6.8	---	---	---	---	---	---	---	Tons Produced
3-05-016-12	Pressure Hydrator	0.1	0.07	---	---	---	---	---	---	Tons Produced
3-05-016-13	Lime Silos	---	---	---	---	---	---	---	---	Tons Produced
3-05-016-14	Packing/Shipping	---	---	---	---	---	---	---	---	Tons Produced
3-05-016-15	Product Transfer and Conveying	2.2	---	---	---	---	---	---	---	Tons Loaded

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Lime Manufacture - 3274</i></u>										
3-05-016-16	Primary Screening	---	---	---	---	---	---	---	---	Tons Processed
3-05-016-17	Multiple Hearth Calciner	---	---	---	---	---	---	---	---	Tons Produced
3-05-016-18	Calcining: Coal-fired Rotary Kiln	350	42	2.3	<sup>21</sup> 5.4	3.1	---	1.5	---	Tons Manufactured
3-05-016-19	Calcining: Gas-fired Rotary Kiln	---	---	---	---	3.5	---	2.2	---	Tons Manufactured
3-05-016-20	Calcining: Coal- and Gas-fired Rotary Kiln	80	9.6	---	---	---	---	<sup>27</sup> 0.83	---	Tons Manufactured
3-05-016-21	Calcining: Coal- and Coke-fired Rotary Kiln	---	---	---	---	---	---	---	---	Tons Manufactured
3-05-016-22	Calcining: Coal-fired Rotary Preheater Kiln	---	---	---	---	---	---	---	---	Tons Manufactured
3-05-016-23	Calcining: Gas-fired Parallel Flow Regenerative Kiln	---	---	---	<sup>27</sup> 0.0012	<sup>27</sup> 0.24	---	<sup>27</sup> 0.45	---	Tons Manufactured
3-05-016-24	Conveyor Transfer - Primary Crushed Material	---	---	---	---	---	---	---	---	Tons Processed
3-05-016-25	Secondary/Tertiary Screening	---	---	---	---	---	---	---	---	Tons Processed
3-05-016-26	Product Loading, Enclosed Truck	0.61	---	---	---	---	---	---	---	Tons Processed
3-05-016-27	Product Loading, Open Truck	1.5	---	---	---	---	---	---	---	Tons Processed
3-05-016-28	Pulverizing	---	---	---	---	---	---	---	---	Tons Processed
3-05-016-29	Tertiary Screening After Pulverizing	---	---	---	---	---	---	---	---	Tons Processed
3-05-016-30	Screening After Calcination	---	---	---	---	---	---	---	---	Tons Manufactured
3-05-016-31	Crushing and Pulverizing After Calcinating	---	---	---	---	---	---	---	---	Tons Manufactured
3-05-016-32	Milling	---	---	---	---	---	---	---	---	Tons Manufactured
3-05-016-33	Separator After Hydrator	---	---	---	---	---	---	---	---	Tons Processed
3-05-016-40	Vehicle Traffic	---	---	---	---	---	---	---	---	Tons Produced
3-05-016-50	Quarrying Raw Limestone	---	---	---	---	---	---	---	---	Tons Mixed
3-05-016-60	Waste Treatment	---	---	---	---	---	---	---	---	Tons Produced
3-05-016-99	See Comment	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Mineral Wool - 3296</i></u>										
3-05-017-01	Cupola	16	20.2	---	0.02	1.6	---	250	---	Footnote 45
3-05-017-02	Reverberatory Furnace	4.8	4.6	---	---	---	---	---	---	Footnote 45
3-05-017-03	Blow Chamber	12	15.6	---	<sup>21</sup> 0.087	---	0.9	---	---	Footnote 45
3-05-017-04	Curing Oven	3.6	3.8	---	<sup>21</sup> 1.2	0.16	1	---	---	Footnote 45
3-05-017-05	Cooler	2.4	1.9	---	<sup>21</sup> 0.068	---	0.04	---	---	Footnote 45
3-05-017-06	Granulated Products Processing	---	---	---	---	---	---	---	---	Tons Handled
3-05-017-07	Handling Operations	---	---	---	---	---	---	---	---	Tons Handled
3-05-017-08	Packaging Operations	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Mineral Wool - 3296</u>										
3-05-017-09	Batt Application	---	---	---	---	---	---	---	---	Tons Processed
3-05-017-10	Storage of Oils and Binders	---	---	---	---	---	---	---	---	Tons Stored
3-05-017-11	Mixing of Oils and Binders	---	---	---	---	---	---	---	---	Tons Processed
3-05-017-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Perlite Manufacturing - 3295</u>										
3-05-018-01	Vertical Furnace	21	19	---	---	---	---	---	---	Tons Charged
3-05-018-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Phosphate Rock - 1475</u>										
3-05-019-01	Drying	5.7	4.8	---	---	---	---	0.34	---	Tons Processed
3-05-019-02	Grinding	1.5	0.93	---	---	---	---	---	---	Tons Processed
3-05-019-03	Transfer/Storage	2	1	---	---	---	---	---	---	Tons Processed
3-05-019-04	Open Storage	40	14.4	---	---	---	---	---	---	Tons Processed
3-05-019-05	Calcining	15	15	---	---	---	---	---	---	Tons Processed
3-05-019-06	Rotary Dryer	---	---	---	---	---	---	---	---	Tons Dried
3-05-019-07	Ball Mill	1.46	0.45	---	---	---	---	---	---	Tons Milled
3-05-019-08	Mineral Products Benification	---	---	---	---	---	---	---	---	Tons Processed
3-05-019-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Stone Quarrying - Processing (See also 305320) - 1411, 1422, 1423, 1429, 1499</u>										
3-05-020-01	Primary Crushing	---	---	---	---	---	---	---	---	Tons Processed
3-05-020-02	Secondary Crushing/Screening	---	---	---	---	---	---	---	---	Tons Processed
3-05-020-03	Tertiary Crushing/Screening	---	---	---	---	---	---	---	---	Tons Processed
3-05-020-04	Recrushing/Screening	---	---	---	---	---	---	---	---	Tons Processed
3-05-020-05	Fines Mill	---	---	---	---	---	---	---	---	Tons Processed
3-05-020-06	Miscellaneous Operations: Screen/Convey/Handling	---	---	---	---	---	---	---	---	Tons Processed
3-05-020-07	Open Storage	---	0.12	---	---	---	---	---	---	Ton-Years Stored
3-05-020-08	Cut Stone: General	---	---	---	---	---	---	---	---	Tons Processed
3-05-020-09	Blasting: General	---	---	---	---	---	---	---	---	Tons Processed
3-05-020-10	Drilling	---	---	---	---	---	---	---	---	Tons Processed
3-05-020-11	Hauling	---	6.2	---	---	---	---	---	---	Miles Travelled
3-05-020-12	Drying	---	5	---	---	---	---	---	---	Tons Dried
3-05-020-13	Bar Grizzlies	---	---	---	---	---	---	---	---	Tons Processed



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Stone Quarrying - Processing (See also 305320) - 1411, 1422, 1423, 1429, 1499</u>										
3-05-020-14	Shaker Screens	---	---	---	---	---	---	---	---	Tons Processed
3-05-020-15	Vibrating Screens	---	---	---	---	---	---	---	---	Tons Processed
3-05-020-16	Revolving Screens	---	---	---	---	---	---	---	---	Tons Processed
3-05-020-17	Pugmill	---	---	---	---	---	---	---	---	Tons Processed
3-05-020-18	Drilling with Liquid Injection	---	---	---	---	---	---	---	---	Feet Drilled
3-05-020-20	Drilling	---	---	---	---	---	---	---	---	Feet Drilled
3-05-020-21	Fines Screening	---	---	---	---	---	---	---	---	Tons Processed
3-05-020-31	Truck Unloading	---	---	---	---	---	---	---	---	Tons Processed
3-05-020-32	Truck Loading: Conveyor	---	---	---	---	---	---	---	---	Tons Loaded
3-05-020-33	Truck Loading: Front End Loader	---	---	---	---	---	---	---	---	Tons Loaded
3-05-020-99	Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Salt Mining - 1499</u>										
3-05-021-01	General	---	---	---	---	---	---	---	---	Tons Mined
3-05-021-02	Granulation: Stack Dryer	---	---	---	---	---	---	---	---	Tons Granulated
3-05-021-03	Filtration: Vacuum Filter	---	---	---	---	---	---	---	---	Tons Produced
3-05-021-04	Crushing	---	---	---	---	---	---	---	---	Tons Handled
3-05-021-05	Screening	---	---	---	---	---	---	---	---	Tons Handled
3-05-021-06	Conveying	---	---	---	---	---	---	---	---	Tons Handled
<u>Potash Production - 1474</u>										
3-05-022-01	Mine: Grinding/Drying	---	13.5	---	---	---	---	---	---	Tons Processed
3-05-022-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Magnesium Carbonate - 1459</u>										
3-05-024-01	Mine/Process	---	---	---	---	---	---	---	---	Tons Produced
3-05-024-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Construction Sand and Gravel - 1442, 1446</u>										
3-05-025-01	Total Plant: General	0.1	---	---	---	---	---	---	---	Tons Produced
3-05-025-02	Aggregate Storage	---	0.12	---	---	---	---	---	---	Tons Produced
3-05-025-03	Material Transfer and Conveying	0.029	0.0064	---	---	---	---	---	---	Tons Produced
3-05-025-04	Hauling	---	6.2	---	---	---	---	---	---	Miles Travelled
3-05-025-05	Pile Forming: Stacker	---	0.06	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Construction Sand and Gravel - 1442, 1446</u>										
3-05-025-06	Bulk Loading	0.02	0.0024	---	---	---	---	---	---	Tons Produced
3-05-025-07	Storage Piles	---	1329	---	---	---	---	---	---	Acre-Years Existing
3-05-025-08	Dryer (See 3-05-027-20 thru -24 for Industrial Sand Dryers)	---	---	---	---	---	---	---	---	Tons Produced
3-05-025-09	Cooler (See 3-05-027-30 for Industrial Sand Coolers)	---	---	---	---	---	---	---	---	Tons Produced
3-05-025-10	Crushing	---	---	---	---	---	---	---	---	Tons Produced
3-05-025-11	Screening	---	0.12	---	---	---	---	---	---	Tons Produced
3-05-025-12	Overburden Removal	---	---	---	---	---	---	---	---	Tons Processed
3-05-025-13	Excavating	---	---	---	---	---	---	---	---	Tons Processed
3-05-025-14	Drilling and Blasting	---	---	---	---	---	---	---	---	Tons Produced
3-05-025-22	Rodmilling: Fine Crushing of Construction Sand	---	---	---	---	---	---	---	---	Tons Produced
3-05-025-23	Fine Screening of Construction Sand Following Dewatering or Rodmilling	---	---	---	---	---	---	---	---	Tons Produced
3-05-025-99	Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Diatomaceous Earth - 1499, 3295</u>										
3-05-026-01	Handling	---	---	---	---	---	---	---	---	Tons Produced
3-05-026-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Industrial Sand and Gravel - 1423, 3273</u>										
3-05-027-01	Primary Crushing of Raw Material	---	---	---	---	---	---	---	---	Tons Processed
3-05-027-05	Secondary Crushing	---	---	---	---	---	---	---	---	Tons Processed
3-05-027-09	Grinding: Size Reduction to 50 Microns or Smaller	---	---	---	---	---	---	---	---	Tons Processed
3-05-027-13	Screening: Size Classification	---	---	---	---	---	---	---	---	Tons Processed
3-05-027-17	Draining: Removal of Moisture to About 6% After Froth Flotation	---	---	---	---	---	---	---	---	Tons Fed
3-05-027-20	Sand Drying: Gas- or Oil-fired Rotary or Fluidized Bed Dryer	2	---	---	---	0.031	---	---	---	Tons Produced
3-05-027-21	Sand Drying: Gas-fired Rotary Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-05-027-22	Sand Drying: Oil-fired Rotary Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-05-027-23	Sand Drying: Gas-fired Fluidized Bed Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-05-027-24	Sand Drying: Oil-fired Fluidized Bed Dryer	---	---	---	---	---	---	---	---	Tons Produced
3-05-027-30	Cooling of Dried Sand	---	---	---	---	---	---	---	---	Tons Cooled
3-05-027-40	Final Classifying: Screening to Classify Sand by Size	---	---	---	---	---	---	---	---	Tons Produced
3-05-027-60	Sand Handling, Transfer, and Storage	---	---	---	---	---	---	---	---	Tons Stored

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Lightweight Aggregate Manufacture - 3295</u>										
3-05-029-10	Rotary Kiln	130	---	0.84	5.6	---	---	0.59	---	Tons Fed
3-05-029-20	Clinker Cooler	---	---	---	---	---	---	---	---	Tons Fed
<u>Ceramic Electric Parts - 3264</u>										
3-05-030-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Asbestos Mining - 1499</u>										
3-05-031-01	Surface Blasting	---	---	---	---	---	---	---	---	Tons Processed
3-05-031-02	Surface Drilling	---	---	---	---	---	---	---	---	Tons Processed
3-05-031-03	Cobbing	---	---	---	---	---	---	---	---	Tons Processed
3-05-031-04	Loading	---	---	---	---	---	---	---	---	Tons Processed
3-05-031-05	Convey/Haul Asbestos	---	---	---	---	---	---	---	---	Tons Processed
3-05-031-06	Convey/Haul Waste	---	---	---	---	---	---	---	---	Tons Processed
3-05-031-07	Unloading	---	---	---	---	---	---	---	---	Tons Processed
3-05-031-08	Overburden Stripping	---	---	---	---	---	---	---	---	Tons Removed
3-05-031-09	Ventilation of Process Operations	---	---	---	---	---	---	---	---	Tons Processed
3-05-031-10	Stockpiling	---	---	---	---	---	---	---	---	Tons Processed
3-05-031-11	Tailing Piles	---	---	---	---	---	---	---	---	Tons Processed
3-05-031-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Asbestos Milling - 1499</u>										
3-05-032-01	Crushing	---	---	---	---	---	---	---	---	Tons Processed
3-05-032-02	Drying	---	---	---	---	---	---	---	---	Tons Processed
3-05-032-03	Recrushing	---	---	---	---	---	---	---	---	Tons Processed
3-05-032-04	Screening	---	---	---	---	---	---	---	---	Tons Processed
3-05-032-05	Fiberizing	---	---	---	---	---	---	---	---	Tons Processed
3-05-032-06	Bagging	---	---	---	---	---	---	---	---	Tons Processed
3-05-032-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Vermiculite - 1499</u>										
3-05-033-01	General	---	---	---	0.47	0.08	---	---	---	Tons Produced
3-05-033-12	Screening of Crude Vermiculite Ore	---	---	---	---	---	---	---	---	1000 Pounds Processed
3-05-033-19	Blending of Vermiculite Ore	---	---	---	---	---	---	---	---	1000 Pounds Processed
3-05-033-21	Vermiculite Concentrate Drying: Rotary Dryer, Gas-fired	---	---	---	---	---	---	---	---	1000 Pounds Fed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Vermiculite - 1499</u></i>										
3-05-033-22	Vermiculite Concentrate Drying: Rotary Dryer, Oil-fired	---	---	---	---	---	---	---	---	1000 Pounds Fed
3-05-033-26	Vermiculite Concentrate Drying: Fluidized Bed Dryer, Gas-fired	---	---	---	---	---	---	---	---	1000 Pounds Fed
3-05-033-27	Vermiculite Concentrate Drying: Fluidized Bed Dryer, Oil-fired	---	---	---	---	---	---	---	---	1000 Pounds Fed
3-05-033-31	Crushing of Dried Vermiculite Concentrate	---	---	---	---	---	---	---	---	1000 Pounds Processed
3-05-033-36	Screening: Size Classification of Crushed Vermiculite Concentrate	---	---	---	---	---	---	---	---	1000 Pounds Processed
3-05-033-41	Conveying of Vermiculite Concentrate to Storage	---	---	---	---	---	---	---	---	1000 Pounds Processed
3-05-033-51	Exfoliation of Vermiculite Concentrate: Gas-fired Vertical Furnace	---	---	---	---	---	---	---	---	1000 Pounds Produced
3-05-033-52	Exfoliation of Vermiculite Concentrate: Oil-fired Vertical Furnace	---	---	---	---	---	---	---	---	1000 Pounds Produced
3-05-033-61	Product Grinding: Grinding of Exfoliated Vermiculite	---	---	---	---	---	---	---	---	1000 Pounds Produced
3-05-033-66	Product Classifying: Air Classification of Exfoliated Vermiculite	---	---	---	---	---	---	---	---	1000 Pounds Produced
<i><u>Feldspar - 1459</u></i>										
3-05-034-01	Ball Mill	25.8	8.4	---	---	---	---	---	---	Tons Milled
3-05-034-02	Dryer	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Abrasive Grain Processing - 3291</u></i>										
3-05-035-01	Primary Crushing	---	---	---	---	---	---	---	---	Tons Processed
3-05-035-02	Secondary Crushing	---	---	---	---	---	---	---	---	Tons Processed
3-05-035-03	Final Crushing	---	---	---	---	---	---	---	---	Tons Processed
3-05-035-04	Crushed Grain Screening	---	---	---	---	---	---	---	---	Tons Processed
3-05-035-05	Washing/Drying	---	---	---	---	---	---	---	---	Tons Processed
3-05-035-06	Final Screening	---	---	---	---	---	---	---	---	Tons Processed
3-05-035-07	Air Classification	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Bonded Abrasives Manufacturing - 3291</u></i>										
3-05-036-01	Mixing	---	---	---	---	---	---	---	---	Tons Processed
3-05-036-02	Molding	---	---	---	---	---	---	---	---	Tons Processed
3-05-036-03	Steam Autoclaving	---	---	---	---	---	---	---	---	Tons Processed
3-05-036-04	Drying	---	---	---	---	---	---	---	---	Tons Processed
3-05-036-05	Firing or Curing	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Bonded Abrasives Manufacturing - 3291</u></i>										
3-05-036-06	Cooling	---	---	---	---	---	---	---	---	Tons Processed
3-05-036-07	Final Machining	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Coated Abrasives Manufacturing - 3291</u></i>										
3-05-037-01	Printing of Backing	---	---	---	---	---	---	---	---	1000 Square Feet Processed
3-05-037-02	Make Coat Application	---	---	---	---	---	---	---	---	1000 Square Feet Processed
3-05-037-03	Grain Application	---	---	---	---	---	---	---	---	1000 Square Feet Processed
3-05-037-04	Drying	---	---	---	---	---	---	---	---	1000 Square Feet Processed
3-05-037-05	Size Coat Application	---	---	---	---	---	---	---	---	1000 Square Feet Processed
3-05-037-06	Final Drying and Curing	---	---	---	---	---	---	---	---	1000 Square Feet Processed
3-05-037-07	Roll Winding	---	---	---	---	---	---	---	---	1000 Square Feet Processed
3-05-037-08	Final Production	---	---	---	---	---	---	---	---	1000 Square Feet Processed
<i><u>Pyrrhotite - 1479</u></i>										
3-05-039-01	Fluid Bed Roaster	---	---	---	---	---	---	---	---	Tons Processed
3-05-039-02	Reduction Kiln	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Mining and Quarrying of Nonmetallic Minerals - 1400</u></i>										
3-05-040-01	Open Pit Blasting	---	---	---	---	---	---	---	---	100 Tons Processed
3-05-040-02	Open Pit Drilling	---	---	---	---	---	---	---	---	100 Tons Processed
3-05-040-03	Open Pit Cobbing	---	---	---	---	---	---	---	---	100 Tons Processed
3-05-040-10	Underground Ventilation	---	---	---	---	---	---	---	---	100 Tons Processed
3-05-040-20	Loading	---	---	---	---	---	---	---	---	100 Tons Processed
3-05-040-21	Convey/Haul Material	---	---	---	---	---	---	---	---	100 Tons Processed
3-05-040-22	Convey/Haul Waste	---	---	---	---	---	---	---	---	100 Tons Processed
3-05-040-23	Unloading	---	---	---	---	---	---	---	---	100 Tons Processed
3-05-040-24	Overburden Stripping	---	---	---	---	---	---	---	---	100 Tons Processed
3-05-040-25	Stockpiling	---	---	---	---	---	---	---	---	100 Tons Processed
3-05-040-30	Primary Crusher	---	---	---	---	---	---	---	---	100 Tons Processed
3-05-040-31	Secondary Crusher	---	---	---	---	---	---	---	---	100 Tons Processed
3-05-040-32	Ore Concentrator	---	---	---	---	---	---	---	---	100 Tons Processed
3-05-040-33	Ore Dryer	---	---	---	---	---	---	---	---	100 Tons Processed
3-05-040-34	Screening	---	---	---	---	---	---	---	---	100 Tons Processed
3-05-040-36	Tailing Piles	---	---	---	---	---	---	---	---	100 Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Mining and Quarrying of Nonmetallic Minerals - 1400</i>										
3-05-040-99	Other Not Classified	---	---	---	---	---	---	---	---	100 Tons Processed
<i>Clay processing: Kaolin - multiple (See Appendix D)</i>										
3-05-041-01	Mining	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-02	Raw material storage	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-03	Raw material transfer	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-15	Raw material crushing, NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-19	Raw material grinding, NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-29	Screening, NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-30	Drying, rotary dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-31	Drying, spray dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-32	Drying, apron dryer	1.2	---	---	---	---	---	---	---	Tons Produced
3-05-041-33	Drying, vibrating grate dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-39	Drying, dryer NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-40	Calcining, rotary calciner	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-41	Calcining, multiple hearth furnace	34	16	---	---	---	---	---	---	Tons Produced
3-05-041-42	Calcining, flash calciner	1100	560	---	---	---	---	---	---	Tons Produced
3-05-041-49	Calcining, calciner NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-50	Product grinding	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-51	Product screening/classification	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-60	Bleaching	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-70	Product transfer	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-71	Product storage	---	---	---	---	---	---	---	---	Tons Processed
3-05-041-72	Product packaging	---	---	---	---	---	---	---	---	Tons Processed
<i>Clay processing: Ball clay - multiple (See Appendix D)</i>										
3-05-042-01	Mining	---	---	---	---	---	---	---	---	Tons Processed
3-05-042-02	Raw material storage	---	---	---	---	---	---	---	---	Tons Processed
3-05-042-03	Raw material transfer	---	---	---	---	---	---	---	---	Tons Processed
3-05-042-15	Raw material crushing, NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-042-19	Raw material grinding, NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-042-30	Drying, rotary dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-042-31	Drying, spray dryer	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Clay processing: Ball clay - multiple (See Appendix D)</i>										
3-05-042-32	Drying, apron dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-042-33	Drying, vibrating grate dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-042-39	Drying, dryer NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-042-50	Product grinding	---	---	---	---	---	---	---	---	Tons Processed
3-05-042-70	Product transfer	---	---	---	---	---	---	---	---	Tons Processed
3-05-042-71	Product storage	---	---	---	---	---	---	---	---	Tons Processed
3-05-042-72	Product packaging	---	---	---	---	---	---	---	---	Tons Processed
<i>Clay processing: Fire clay - multiple (See Appendix D)</i>										
3-05-043-01	Mining	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-02	Raw material storage	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-03	Raw material transfer	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-15	Raw material crushing, NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-19	Raw material grinding, NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-29	Screening, NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-30	Drying, rotary dryer	65	16	---	---	---	---	---	---	Tons Processed
3-05-043-31	Drying, spray dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-32	Drying, apron dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-33	Drying, vibrating grate dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-39	Drying, dryer NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-40	Calcining, rotary calciner	120	14	---	---	<sup>27</sup> 1.7	---	---	---	Tons Processed
3-05-043-41	Calcining, multiple hearth furnace	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-42	Calcining, flash calciner	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-49	Calcining, calciner NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-50	Product grinding	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-51	Product screening/classification	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-70	Product transfer	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-71	Product storage	---	---	---	---	---	---	---	---	Tons Processed
3-05-043-72	Product packaging	---	---	---	---	---	---	---	---	Tons Processed
<i>Clay processing: Bentonite - multiple (See Appendix D)</i>										
3-05-044-01	Mining	---	---	---	---	---	---	---	---	Tons Processed
3-05-044-02	Raw material storage	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Clay processing: Bentonite - multiple (See Appendix D)</i>										
3-05-044-03	Raw material transfer	---	---	---	---	---	---	---	---	Tons Processed
3-05-044-15	Raw material crushing, NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-044-19	Raw material grinding, NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-044-30	Drying, rotary dryer	290	20	---	---	---	---	---	---	Tons Produced
3-05-044-31	Drying, spray dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-044-32	Drying, apron dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-044-33	Drying, vibrating grate dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-044-39	Drying, dryer NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-044-50	Product grinding	---	---	---	---	---	---	---	---	Tons Processed
3-05-044-51	Product screening/classification	---	---	---	---	---	---	---	---	Tons Processed
3-05-044-70	Product transfer	---	---	---	---	---	---	---	---	Tons Processed
3-05-044-71	Product storage	---	---	---	---	---	---	---	---	Tons Processed
3-05-044-72	Product packaging	---	---	---	---	---	---	---	---	Tons Processed
<i>Clay processing: Fuller's earth - multiple (See Appendix D)</i>										
3-05-045-01	Mining	---	---	---	---	---	---	---	---	Tons Processed
3-05-045-02	Raw material storage	---	---	---	---	---	---	---	---	Tons Processed
3-05-045-03	Raw material transfer	---	---	---	---	---	---	---	---	Tons Processed
3-05-045-15	Raw material crushing, NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-045-19	Raw material grinding, NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-045-30	Drying, rotary dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-045-31	Drying, spray dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-045-32	Drying, apron dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-045-33	Drying, vibrating grate dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-045-39	Drying, dryer NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-045-50	Product grinding	---	---	---	---	---	---	---	---	Tons Processed
3-05-045-51	Product screening/classification	---	---	---	---	---	---	---	---	Tons Processed
3-05-045-70	Product transfer	---	---	---	---	---	---	---	---	Tons Processed
3-05-045-71	Product storage	---	---	---	---	---	---	---	---	Tons Processed
3-05-045-72	Product packaging	---	---	---	---	---	---	---	---	Tons Processed
<i>Clay processing: Common clay and shale, NEC - multiple (See Appendix D)</i>										
3-05-046-01	Mining	---	---	---	---	---	---	---	---	Tons Processed



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Clay processing: Common clay and shale, NEC - multiple (See Appendix D)</i>										
3-05-046-02	Raw material storage	---	---	---	---	---	---	---	---	Tons Processed
3-05-046-03	Raw material transfer	---	---	---	---	---	---	---	---	Tons Processed
3-05-046-15	Raw material crushing, NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-046-19	Raw material grinding, NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-046-29	Screening, NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-046-30	Drying, rotary dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-046-31	Drying, spray dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-046-32	Drying, apron dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-046-33	Drying, vibrating grate dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-046-39	Drying, dryer NEC	---	---	---	---	---	---	---	---	Tons Processed
3-05-046-70	Product transfer	---	---	---	---	---	---	---	---	Tons Processed
3-05-046-71	Product storage	---	---	---	---	---	---	---	---	Tons Processed
3-05-046-72	Product packaging	---	---	---	---	---	---	---	---	Tons Processed
<i>Asphalt Processing (Blowing) - 1442</i>										
3-05-050-01	Asphalt Processing (Blowing)	---	---	---	---	---	---	---	---	Tons Processed
3-05-050-05	Asphalt Storage (Prior to Blowing)	---	---	---	---	---	---	---	---	Tons Processed
3-05-050-10	Asphalt Blowing Still	---	---	---	---	---	---	---	---	Tons Processed
3-05-050-20	Asphalt Heater: Natural Gas	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
3-05-050-21	Asphalt Heater: Residual Oil	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-05-050-22	Asphalt Heater: Distillate Oil	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-05-050-23	Asphalt Heater: LP Gas	---	---	---	---	---	---	---	---	1000 Gallons Burned
<i>Talc Processing - 1499, 3295</i>										
3-05-089-06	Storage of Raw Mined Talc Before Processing	---	---	---	---	---	---	---	---	1000 Pounds Stored
3-05-089-08	Conveyor Transfer of Raw Talc to Primary Crusher	---	---	---	---	---	---	---	---	1000 Pounds Conveyed
3-05-089-09	Natural Gas Fired Crude Ore Dryer	---	---	---	---	---	---	---	---	1000 Pounds Dried
3-05-089-10	Fuel Oil Fired Crude Ore Dryer	---	---	---	---	---	---	---	---	1000 Pounds Dried
3-05-089-11	Primary crusher	---	---	---	---	---	---	---	---	1000 Pounds Produced
3-05-089-12	Crushed Talc Railcar Loading	---	---	---	---	---	---	---	---	1000 Pounds Loaded
3-05-089-14	Crushed Talc Storage Bin Loading	---	---	---	---	---	---	---	---	1000 Pounds Loaded
3-05-089-17	Screening Oversize Ore to Return to Primary Crusher	---	---	---	---	---	---	---	---	1000 Pounds Screened
3-05-089-21	Natural Gas-fired Rotary Dryer	---	---	---	---	---	---	---	---	1000 Pounds Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Talc Processing - 1499, 3295</i></u>										
3-05-089-23	Fuel Oil-fired Rotary Dryer	---	---	---	---	---	---	---	---	1000 Pounds Produced
3-05-089-31	Natural Gas-fired Rotary Calciner	---	---	---	---	---	---	---	---	1000 Pounds Calcined
3-05-089-33	Fuel Oil-fired Rotary Calciner	---	---	---	---	---	---	---	---	1000 Pounds Calcined
3-05-089-41	Rotary Cooler Following Calciner	---	---	---	---	---	---	---	---	1000 Pounds Cooled
3-05-089-45	Grinding of Dried Talc	---	---	---	---	---	---	---	---	1000 Pounds Processed
3-05-089-47	Grinding/Drying of Talc with Heated Makeup Air	---	---	---	---	---	---	---	---	1000 Pounds Processed
3-05-089-49	Ground Talc Storage Bin Loading	---	---	---	---	---	---	---	---	1000 Pounds Loaded
3-05-089-50	Air Classifier - Size Classification of Ground Talc	---	---	---	---	---	---	---	---	1000 Pounds Processed
3-05-089-53	Pelletizer	---	---	---	---	---	---	---	---	1000 Pounds Processed
3-05-089-55	Pellet Dryer	---	---	---	---	---	---	---	---	1000 Pounds Processed
3-05-089-58	Pneumatic Conveyor Vents	---	---	---	---	---	---	---	---	1000 Pounds Conveyed
3-05-089-61	Concentration of Talc Fines Using Shaking Table	---	---	---	---	---	---	---	---	1000 Pounds Processed
3-05-089-71	Natural Gas-fired Flash Drying of Slurry after Flotation	---	---	---	---	---	---	---	---	1000 Pounds Produced
3-05-089-73	Fuel Oil-fired Flash Drying of Slurry after Flotation	---	---	---	---	---	---	---	---	1000 Pounds Produced
3-05-089-82	Custom Grinding - Additional Size Reduction	---	---	---	---	---	---	---	---	1000 Pounds Processed
3-05-089-85	Final Product Storage Bin Loading	---	---	---	---	---	---	---	---	1000 Pounds Loaded
3-05-089-88	Packaging	---	---	---	---	---	---	---	---	1000 Pounds Processed
<u><i>Mica - 1411, 1429</i></u>										
3-05-090-01	Rotary Dryer	---	---	---	---	---	---	---	---	Tons Processed
3-05-090-02	Fluid Energy Mill - Grinding	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Sandspar - 1400</i></u>										
3-05-091-01	Rotary Dryer	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Catalyst Manufacturing - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</i></u>										
3-05-092-01	Transferring and Handling	---	---	---	---	---	---	---	---	Tons Processed
3-05-092-02	Mixing and Blending	---	---	---	---	---	---	---	---	Tons Processed
3-05-092-03	Reacting	---	---	---	---	---	---	---	---	Tons Processed
3-05-092-04	Drying	---	---	---	---	---	---	---	---	Tons Processed
3-05-092-05	Storage	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Bulk Materials Elevators - 4491</i></u>										
3-05-100-01	Unloading	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Bulk Materials Elevators - 4491</u></i>										
3-05-100-02	Loading	---	---	---	---	---	---	---	---	Tons Processed
3-05-100-03	Removal from Bins	---	---	---	---	---	---	---	---	Tons Processed
3-05-100-04	Drying	---	---	---	---	---	---	---	---	Tons Processed
3-05-100-05	Cleaning	---	---	---	---	---	---	---	---	Tons Processed
3-05-100-06	Elevator Legs (Headhouse)	---	---	---	---	---	---	---	---	Tons Processed
3-05-100-07	Tripper (Gallery Belt)	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Bulk Materials Conveyors - 4491</u></i>										
3-05-101-01	Ammonium Sulfate	---	---	---	---	---	---	---	---	Tons Processed
3-05-101-02	Cement	---	---	---	---	---	---	---	---	Tons Processed
3-05-101-03	Coal	---	---	---	---	---	---	---	---	Tons Processed
3-05-101-04	Coke	---	---	---	---	---	---	---	---	Tons Processed
3-05-101-05	Limestone	---	---	---	---	---	---	---	---	Tons Processed
3-05-101-06	Phosphate Rock	---	---	---	---	---	---	---	---	Tons Processed
3-05-101-07	Scrap Metal	---	---	---	---	---	---	---	---	Tons Processed
3-05-101-08	Sulfur	---	---	---	---	---	---	---	---	Tons Processed
3-05-101-96	Chemical: Specify in Comments	---	---	---	---	---	---	---	---	Tons Processed
3-05-101-97	Fertilizer: Specify in Comments	---	---	---	---	---	---	---	---	Tons Processed
3-05-101-98	Mineral: Specify in Comments	---	---	---	---	---	---	---	---	Tons Processed
3-05-101-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Bulk Materials Storage Bins - 4491</u></i>										
3-05-102-01	Ammonium Sulfate	---	---	---	---	---	---	---	---	Tons Processed
3-05-102-02	Cement	---	---	---	---	---	---	---	---	Tons Processed
3-05-102-03	Coal	---	---	---	---	---	---	---	---	Tons Processed
3-05-102-04	Coke	---	---	---	---	---	---	---	---	Tons Processed
3-05-102-05	Limestone	---	---	---	---	---	---	---	---	Tons Processed
3-05-102-06	Phosphate Rock	---	---	---	---	---	---	---	---	Tons Processed
3-05-102-07	Scrap Metal	---	---	---	---	---	---	---	---	Tons Processed
3-05-102-08	Sulfur	---	---	---	---	---	---	---	---	Tons Processed
3-05-102-09	Sand	---	---	---	---	---	---	---	---	Tons Processed
3-05-102-96	Chemical: Specify in Comments	---	---	---	---	---	---	---	---	Tons Processed
3-05-102-97	Fertilizer: Specify in Comments	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Bulk Materials Storage Bins - 4491</u></i>										
3-05-102-98	Mineral: Specify in Comments	---	---	---	---	---	---	---	---	Tons Processed
3-05-102-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Bulk Materials Open Stockpiles - 4491</u></i>										
3-05-103-01	Ammonium Sulfate	---	---	---	---	---	---	---	---	Tons Processed
3-05-103-02	Cement	---	---	---	---	---	---	---	---	Tons Processed
3-05-103-03	Coal	---	---	---	---	---	---	---	---	Tons Processed
3-05-103-04	Coke	---	---	---	---	---	---	---	---	Tons Processed
3-05-103-05	Limestone	---	---	---	---	---	---	---	---	Tons Processed
3-05-103-06	Phosphate Rock	---	---	---	---	---	---	---	---	Tons Processed
3-05-103-07	Scrap Metal	---	---	---	---	---	---	---	---	Tons Processed
3-05-103-08	Sulfur	---	---	---	---	---	---	---	---	Tons Processed
3-05-103-09	Sand	---	---	---	---	---	---	---	---	Tons Processed
3-05-103-10	Fluxes	---	---	---	---	---	---	---	---	Tons Processed
3-05-103-96	Chemical: Specify in Comments	---	---	---	---	---	---	---	---	Tons Processed
3-05-103-97	Fertilizer: Specify in Comments	---	---	---	---	---	---	---	---	Tons Processed
3-05-103-98	Mineral: Specify in Comments	---	---	---	---	---	---	---	---	Tons Processed
3-05-103-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Bulk Materials Unloading Operation - 4491</u></i>										
3-05-104-01	Ammonium Sulfate	---	---	---	---	---	---	---	---	Tons Processed
3-05-104-02	Cement	---	---	---	---	---	---	---	---	Tons Processed
3-05-104-03	Coal	---	---	---	---	---	---	---	---	Tons Processed
3-05-104-04	Coke	---	---	---	---	---	---	---	---	Tons Processed
3-05-104-05	Limestone	---	---	---	---	---	---	---	---	Tons Processed
3-05-104-06	Phosphate Rock	---	---	---	---	---	---	---	---	Tons Processed
3-05-104-07	Scrap Metal	---	---	---	---	---	---	---	---	Tons Processed
3-05-104-08	Sulfur	---	---	---	---	---	---	---	---	Tons Processed
3-05-104-96	Chemical: Specify in Comments	---	---	---	---	---	---	---	---	Tons Processed
3-05-104-97	Fertilizer: Specify in Comments	---	---	---	---	---	---	---	---	Tons Processed
3-05-104-98	Mineral: Specify in Comments	---	---	---	---	---	---	---	---	Tons Processed
3-05-104-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Bulk Materials Loading Operation - 4491</i></u>										
3-05-105-01	Ammonium Sulfate	---	---	---	---	---	---	---	---	Tons Processed
3-05-105-02	Cement	---	---	---	---	---	---	---	---	Tons Processed
3-05-105-03	Coal	---	---	---	---	---	---	---	---	Tons Processed
3-05-105-04	Coke	---	---	---	---	---	---	---	---	Tons Processed
3-05-105-05	Limestone	---	---	---	---	---	---	---	---	Tons Processed
3-05-105-06	Phosphate Rock	---	---	---	---	---	---	---	---	Tons Processed
3-05-105-07	Scrap Metal	---	---	---	---	---	---	---	---	Tons Processed
3-05-105-08	Sulfur	---	---	---	---	---	---	---	---	Tons Processed
3-05-105-96	Chemical: Specify in Comments	---	---	---	---	---	---	---	---	Tons Processed
3-05-105-97	Fertilizer: Specify in Comments	---	---	---	---	---	---	---	---	Tons Processed
3-05-105-98	Mineral: Specify in Comments	---	---	---	---	---	---	---	---	Tons Processed
3-05-105-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Bulk Materials Screening/Size Classification - 1410, 1420, 1422, 1423, 1429, 1440, 1442, 1446</i></u>										
3-05-106-04	Coke	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Bulk Materials Separation: Cyclones - 1410, 1420, 1422, 1423, 1429, 1440, 1442, 1446</i></u>										
3-05-107-08	Sulfur	---	---	---	---	---	---	---	---	Tons Processed
3-05-107-09	Bauxite	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Bulk Materials: Grinding/Crushing - 1410, 1420, 1422, 1423, 1429, 1440, 1442, 1446</i></u>										
3-05-108-08	Sulfur	---	---	---	---	---	---	---	---	Tons Processed
3-05-108-09	Bauxite	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Calcining - 4491</i></u>										
3-05-150-01	Raw Material Handling	---	---	---	---	---	---	---	---	Tons Throughput
3-05-150-02	General	---	---	---	---	---	---	---	---	Tons Throughput
3-05-150-03	Grinding/Milling	---	---	---	---	---	---	---	---	Tons Throughput
3-05-150-04	Finished Product Handling	---	---	---	---	---	---	---	---	Tons Throughput
3-05-150-05	Mixing	---	---	---	---	---	---	---	---	Tons Throughput
<u><i>Coal Mining, Cleaning, and Material Handling (See 305010) - 4911</i></u>										
3-05-310-01	Fluidized Bed	26000	---	42	1400	160	98	---	---	1000 Tons Dried
3-05-310-02	Flash or Suspension	16000	---	---	520	---	---	---	---	Footnote 57
3-05-310-03	Multilouvered	3700	---	75	---	---	---	---	---	1000 Tons Dried

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Coal Mining, Cleaning, and Material Handling (See 305010) - 4911</i>										
3-05-310-04	Rotary	---	---	---	---	---	---	---	---	1000 Tons Dried
3-05-310-05	Cascade	---	---	---	---	---	---	---	---	1000 Tons Dried
3-05-310-06	Continuous Carrier	---	---	---	---	---	---	---	---	1000 Tons Dried
3-05-310-07	Screen	---	---	---	---	---	---	---	---	1000 Tons Dried
3-05-310-08	Unloading	---	---	---	---	---	---	---	---	1000 Tons Shipped
3-05-310-09	Raw Coal Storage	---	---	---	---	---	---	---	---	1000 Tons Shipped
3-05-310-10	Crushing	---	---	---	---	---	---	---	---	1000 Tons Shipped
3-05-310-11	Coal Transfer	---	---	---	---	---	---	---	---	1000 Tons Shipped
3-05-310-12	Screening	---	---	---	---	---	---	---	---	1000 Tons Shipped
3-05-310-13	Air Tables	---	---	---	---	---	---	---	---	1000 Tons Shipped
3-05-310-14	Cleaned Coal Storage	---	---	---	---	---	---	---	---	1000 Tons Shipped
3-05-310-15	Loading	---	---	---	---	---	---	---	---	1000 Tons Shipped
3-05-310-16	Loading: Clean Coal	---	---	---	---	---	---	---	---	1000 Tons Shipped
3-05-310-17	Secondary Crushing	---	---	---	---	---	---	---	---	1000 Tons Shipped
3-05-310-90	Haul Roads: General	---	---	---	---	---	---	---	---	1000 Tons Processed
3-05-310-99	Other Not Classified	---	---	---	---	---	---	---	---	1000 Tons Shipped
<i>Stone Quarrying - Processing (See also 305020 for diff. units) - 3255</i>										
3-05-320-01	Primary Crushing	---	---	---	---	---	---	---	---	1000 Tons Processed
3-05-320-02	Secondary Crushing/Screening	---	---	---	---	---	---	---	---	1000 Tons Processed
3-05-320-03	Tertiary Crushing/Screening	---	---	---	---	---	---	---	---	1000 Tons Processed
3-05-320-04	Recrushing/Screening	---	---	---	---	---	---	---	---	1000 Tons Processed
3-05-320-05	Fines Mill	---	---	---	---	---	---	---	---	1000 Tons Processed
3-05-320-06	Miscellaneous Operations: Screen/Convey/Handling	---	---	---	---	---	---	---	---	1000 Tons Processed
3-05-320-07	Open Storage	---	---	---	---	---	---	---	---	1000 Ton-Years Stored
3-05-320-08	Cut Stone: General	---	---	---	---	---	---	---	---	1000 Tons Processed
3-05-320-09	Blasting: General	---	---	---	---	---	---	---	---	1000 Tons Processed
3-05-320-10	Drilling	---	---	---	---	---	---	---	---	1000 Tons Processed
3-05-320-11	Hauling	---	---	---	---	---	---	---	---	1000 Miles Travelled
3-05-320-12	Drying	---	---	---	---	---	---	---	---	1000 Tons Dried
3-05-320-13	Bar Grizzlies	---	---	---	---	---	---	---	---	1000 Tons Processed
3-05-320-14	Shaker Screens	---	---	---	---	---	---	---	---	1000 Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Stone Quarrying - Processing (See also 305020 for diff. units) - 3255</u>										
3-05-320-15	Vibrating Screens	---	---	---	---	---	---	---	---	1000 Tons Processed
3-05-320-16	Revolving Screens	---	---	---	---	---	---	---	---	1000 Tons Processed
3-05-320-17	Pugmill	---	---	---	---	---	---	---	---	1000 Tons Processed
3-05-320-18	Drilling with Liquid Injection	---	---	---	---	---	---	---	---	1000 Feet Drilled
3-05-320-20	Drilling	---	---	---	---	---	---	---	---	1000 Feet Drilled
3-05-320-31	Truck Unloading	---	---	---	---	---	---	---	---	1000 Tons Processed
3-05-320-32	Truck Loading: Conveyor	---	---	---	---	---	---	---	---	1000 Tons Loaded
3-05-320-33	Truck Loading: Front End Loader	---	---	---	---	---	---	---	---	1000 Tons Loaded
3-05-320-90	Haul Roads - General	---	---	---	---	---	---	---	---	1000 Tons Transported
<u>Equipment Leaks - 1400</u>										
3-05-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Wastewater, Aggregate - 1400</u>										
3-05-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-05-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Wastewater, Points of Generation - 1400</u>										
3-05-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Fugitive Emissions - 1100, 1400, 2900, 4400</u>										
3-05-888-01	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-05-888-02	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-05-888-03	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-05-888-04	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-05-888-05	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
<u>Fuel Fired Equipment - 1100, 1400, 2900, 4400</u>										
3-05-900-01	Distillate Oil (No. 2): Process Heaters	---	---	---	143.68	20	0.2	---	---	1000 Gallons Burned
3-05-900-02	Residual Oil: Process Heaters	---	---	---	158.68	55	0.28	---	---	1000 Gallons Burned
3-05-900-03	Natural Gas: Process Heaters	---	---	---	0.6	140	2.8	---	---	Million Cubic Feet Burned
3-05-900-05	Liquified Petroleum Gas (LPG): Process Heaters	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-05-900-11	Distillate Oil (No. 2): Incinerators	---	---	---	---	---	0.4	---	---	1000 Gallons Burned
3-05-900-12	Residual Oil: Incinerators	---	---	---	---	---	0.56	---	---	1000 Gallons Burned
3-05-900-13	Natural Gas: Incinerators	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Fuel Fired Equipment - 1100, 1400, 2900, 4400</i></u>										
3-05-900-21	Distillate Oil (No. 2): Flares	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-05-900-23	Natural Gas: Flares	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
<u><i>Other Not Defined - 1100, 1400, 2900, 4400</i></u>										
3-05-999-99	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
<u><i>INDUSTRIAL PROCESSES -Petroleum Industry</i></u>										
<u><i>Process Heaters - 2911</i></u>										
3-06-001-01	Oil-fired	504S	---	---	6678S	2310	12.6	---	0.0000021	Footnote 58
3-06-001-02	Gas-fired	---	---	---	0.95S	0.14	---	0.03	---	1000 Cubic Feet Burned
3-06-001-03	Oil-fired	12S	7.4S	---	158.6S	55	0.3	5	---	1000 Gallons Burned
3-06-001-04	Gas-fired	1.9	3	5.7	---	100	5.5	84	---	Million Cubic Feet Burned
3-06-001-05	Natural Gas-fired	3	3	---	0.6	140	2.8	35	---	Million Cubic Feet Burned
3-06-001-06	Process Gas-fired	3	3	---	---	140	2.8	35	---	Million Cubic Feet Burned
3-06-001-07	LPG-fired	0.27	0.27	---	---	12.8	0.26	3.2	---	1000 Gallons Burned
3-06-001-08	Landfill Gas-fired	---	---	---	---	---	2.8	---	---	Million Cubic Feet Burned
3-06-001-11	Oil-fired (No. 6 Oil) > 100 Million Btu Capacity	13S	---	---	159.3S	67	---	5	---	1000 Gallons Burned
3-06-001-99	Other Not Classified	---	---	---	---	---	---	---	---	Gallons Heated
<u><i>Catalytic Cracking Units - 2911</i></u>										
3-06-002-01	Fluid Catalytic Cracking Unit	242	---	---	493	71	220	13700	---	1000 Barrels Processed
3-06-002-02	Catalyst Handling System	---	---	---	---	---	---	---	---	1000 Barrels Processed
<u><i>Catalytic Cracking Units - 2911</i></u>										
3-06-003-01	Thermal Catalytic Cracking Unit	17	11.9	---	60	5	87	3800	---	1000 Barrels Processed
<u><i>Blowdown Systems - 2911</i></u>										
3-06-004-01	Blowdown System with Vapor Recovery System with Flaring	---	---	---	26.9	18.9	0.8	4.3	---	1000 Barrels Processed
3-06-004-02	Blowdown System w/o Controls	---	---	---	---	---	580	---	---	1000 Barrel-Years Capacity
<u><i>Wastewater Treatment - 2911</i></u>										
3-06-005-03	Process Drains and Wastewater Separators	---	---	---	---	---	5	---	---	1000 Gallons Processed
3-06-005-04	Process Drains and Wastewater Separators	---	---	---	---	---	200	---	---	1000 Barrels Processed
3-06-005-05	Wastewater Treatment w/o Separator	---	---	---	---	---	0.03	---	---	1000 Gallons Processed



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Wastewater Treatment - 2911</u></i>										
3-06-005-06	Wastewater Treatment w/o Separator	---	---	---	---	---	0.7	---	---	1000 Barrels Processed
3-06-005-08	Oil/Water Separator	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-06-005-10	Liquid-Liquid Separator: Hydrocarbon/Amine	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-06-005-11	Sour Water Treating	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-06-005-14	Petroleum Refinery Wastewater System: Junction Box	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-06-005-15	Petroleum Refinery Wastewater System: Lift Station	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-06-005-16	Petroleum Refinery Wastewater System: Aerated Impoundment	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-06-005-17	Petroleum Refinery Wastewater System: Non-aerated Impoundment	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-06-005-18	Petroleum Refinery Wastewater System: Weir	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-06-005-19	Petroleum Refinery Wastewater System: Activated Sludge Impoundment	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-06-005-20	Petroleum Refinery Wastewater System: Clarifier	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-06-005-21	Petroleum Refinery Wastewater System: Open Trench	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-06-005-22	Petroleum Refinery Wastewater System: Auger Pumps	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Vacuum Distillate Column Condensers - 2911</u></i>										
3-06-006-02	Vacuum Distillation Column Condenser	---	---	---	---	---	50	---	---	1000 Barrels Processed
3-06-006-03	Vacuum Distillation Column Condenser	---	---	---	---	---	18	---	---	1000 Barrels Processed
<i><u>Cooling Towers - 2911</u></i>										
3-06-007-01	Cooling Towers	---	---	---	---	---	6	---	---	Million Gallons Circulated
3-06-007-02	Cooling Towers	---	---	---	---	---	10	---	---	1000 Barrels Processed
<i><u>Fugitive Emissions - 2911</u></i>										
3-06-008-01	Pipeline Valves and Flanges	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-06-008-02	Vessel Relief Valves	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-06-008-03	Pump Seals w/o Controls	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-06-008-04	Compressor Seals	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-06-008-05	Miscellaneous: Sampling/Non-Asphalt Blowing/Purging/etc.	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-06-008-06	Pump Seals with Controls	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-06-008-07	Blind Changing	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-06-008-11	Pipeline Valves: Gas Streams	---	---	---	---	---	516.8	---	---	Each-Year Operating

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Fugitive Emissions - 2911</i></u>										
3-06-008-12	Pipeline Valves: Light Liquid/Gas Streams	---	---	---	---	---	210.2	---	---	Each-Year Operating
3-06-008-13	Pipeline Valves: Heavy Liquid Streams	---	---	---	---	---	4.38	---	---	Each-Year Operating
3-06-008-14	Pipeline Valves: Hydrogen Streams	---	---	---	---	---	157.7	---	---	Each-Year Operating
3-06-008-15	Open-ended Valves: All Streams	---	---	---	---	---	43.8	---	---	Each-Year Operating
3-06-008-16	Flanges: All Streams	---	---	---	---	---	4.9	---	---	Each-Year Operating
3-06-008-17	Pump Seals: Light Liquid/Gas Streams	---	---	---	---	---	2190	---	---	Each-Year Operating
3-06-008-18	Pump Seals: Heavy Liquid Streams	---	---	---	---	---	403	---	---	Each-Year Operating
3-06-008-19	Compressor Seals: Gas Streams	---	---	---	---	---	12260	---	---	Each-Year Operating
3-06-008-20	Compressor Seals: Heavy Liquid Streams	---	---	---	---	---	963.6	---	---	Each-Year Operating
3-06-008-21	Drains: All Streams	---	---	---	---	---	613.2	---	---	Each-Year Operating
3-06-008-22	Vessel Relief Valves: All Streams	---	---	---	---	---	3154	---	---	Each-Year Operating
<u><i>Flares - 2900</i></u>										
3-06-009-01	Distillate Oil	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-06-009-02	Residual Oil	---	---	---	---	---	---	---	---	Million Gallons Burned
3-06-009-03	Natural Gas	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-06-009-04	Process Gas	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-06-009-05	Liquified Petroleum Gas	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-06-009-06	Hydrogen Sulfide	---	---	---	---	---	---	---	---	Tons Burned
3-06-009-99	Not Classified	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
<u><i>Sludge Converter - 2999</i></u>										
3-06-010-01	General	---	---	---	---	---	35.6	---	---	Tons Processed
3-06-010-11	Oil/Sludge Dewatering Unit: General	---	---	---	---	---	---	---	---	1000 Barrels Processed
<u><i>Asphalt Blowing - 2911</i></u>										
3-06-011-01	General	---	---	---	---	---	60	---	---	Tons Produced
<u><i>Fluid Coking Units - 2911</i></u>										
3-06-012-01	General	---	366	---	---	---	16	---	---	1000 Barrels Processed
<u><i>Coke Handling System - 2911</i></u>										
3-06-013-01	Storage and Transfer	---	---	---	---	---	---	---	---	Tons Handled
<u><i>Petroleum Coke Calcining - 2911</i></u>										
3-06-014-01	Coke Calciner	---	---	---	16	1.1	0.7	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Petroleum Coke Calcining - 2911</u>										
3-06-014-02	Delayed Coking	---	---	---	---	---	---	---	---	1000 Barrels Processed
<u>Bauxite Burning - 2911</u>										
3-06-015-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Used
<u>Catalytic Reforming Unit - 2911</u>										
3-06-016-01	General	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-06-016-02	Alkylation Feed Treater	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-06-016-03	Alkylation Unit: Hydrofluoric Acid	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-06-016-04	Alkylation Unit: Sulfuric Acid	---	---	---	---	---	---	---	---	1000 Barrels Processed
<u>Catalytic Hydrotreating Unit - 2911</u>										
3-06-017-01	General	---	---	---	---	---	---	---	---	1000 Barrels Processed
<u>Hydrogen Generation Unit - 2911</u>										
3-06-018-01	General	---	---	---	---	---	---	---	---	1000 Barrels Processed
<u>Merox Treating Unit - 2911</u>										
3-06-019-01	General	---	---	---	---	---	---	---	---	1000 Barrels Processed
<u>Crude Unit Atmospheric Distillation - 2911</u>										
3-06-020-01	General	---	---	---	---	---	---	---	---	1000 Barrels Processed
<u>Light Ends Fractionation Unit - 2911</u>										
3-06-021-01	General	---	---	---	---	---	---	---	---	1000 Barrels Processed
<u>Gasoline Blending Unit - 2911</u>										
3-06-022-01	General	---	---	---	---	---	---	---	---	1000 Barrels Processed
<u>Hydrocracking Unit - 2911</u>										
3-06-023-01	General	---	---	---	---	---	---	---	---	1000 Barrels Processed
<u>Reciprocating Engine Compressors - 2911</u>										
3-06-024-01	Natural Gas Fired	---	---	---	---	---	---	---	---	
<u>Sour Gas Treating Unit - 2911</u>										
3-06-032-01	General	---	---	---	---	---	---	---	---	1000 Barrels Processed
<u>Desulfurization - 1311, 2911</u>										
3-06-033-01	Sulfur Recovery Unit	---	---	---	---	---	---	---	---	Tons Recovered

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Incinerators - 2911</u></i>										
3-06-099-01	Distillate Oil (No. 2)	---	---	---	---	---	0.4	---	---	1000 Gallons Burned
3-06-099-02	Residual Oil	---	---	---	---	---	0.56	---	---	1000 Gallons Burned
3-06-099-03	Natural Gas	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-06-099-04	Process Gas	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-06-099-05	Liquified Petroleum Gas	---	---	---	---	---	---	---	---	1000 Gallons Burned
<i><u>Lube Oil Refining - 2922</u></i>										
3-06-100-01	General	---	---	---	---	---	---	---	---	1000 Barrels Processed
<i><u>Underground Storage Remediation and Other Remediation - 9711</u></i>										
3-06-220-01	Soil: General	---	---	---	---	---	---	---	---	Tons Processed
3-06-220-02	Soil: Residual Oil	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-06-220-03	Soil: Natural Gas	---	---	---	---	---	---	---	---	Cubic Feet Burned
3-06-220-04	Soil: Distillate Oil	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-06-220-05	Soil: LPG	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-06-220-06	Soil: Waste Oil	---	---	---	---	---	---	---	---	1000 Gallons Processed
<i><u>Underground Storage Remediation and Other Remediation - 9711</u></i>										
3-06-222-01	Vapor Extract: General	---	---	---	---	---	---	---	---	Cubic Feet Processed
3-06-222-02	Vapor Extract: Residual Oil	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-06-222-03	Vapor Extract: Natural Gas	---	---	---	---	---	---	---	---	Cubic Feet Processed
3-06-222-04	Vapor Extract: Distillate Oil	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-06-222-05	Vapor Extract: LPG	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-06-222-06	Vapor Extract: Waste Oil	---	---	---	---	---	---	---	---	1000 Gallons Processed
<i><u>Underground Storage Remediation and Other Remediation - 9711</u></i>										
3-06-224-01	Air Stripping: General	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-06-224-02	Air Stripping: Residual Oil	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-06-224-03	Air Stripping: Natural Gas	---	---	---	---	---	---	---	---	Cubic Feet Burned
3-06-224-04	Air Stripping: Distillate Oil	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-06-224-05	Air Stripping: LPG	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-06-224-06	Air Stripping: Waste Oil	---	---	---	---	---	---	---	---	1000 Gallons Processed
<i><u>Re-refining of Lube Oils and Greases - 2992, 4922, 7389</u></i>										
3-06-300-05	Waste Oil Still Vent	---	---	---	---	---	---	---	---	Gallons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Re-refining of Lube Oils and Greases - 2992, 4922, 7389</u>										
3-06-300-06	Waste Oil Storage Tank	---	---	---	---	---	---	---	---	Gallons Stored
3-06-300-07	Finished Product Storage Tank	---	---	---	---	---	---	---	---	Gallons Stored
<u>Fugitive Emissions - 2900</u>										
3-06-888-01	Specify in Comments Field	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-06-888-02	Specify in Comments Field	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-06-888-03	Specify in Comments Field	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-06-888-04	Specify in Comments Field	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-06-888-05	Specify in Comments Field	---	---	---	---	---	---	---	---	1000 Barrels Processed
<u>Petroleum Products - Not Classified - multiple (See Appendix D)</u>										
3-06-999-98	Not Classified	---	---	---	---	---	---	---	---	Tons Processed
3-06-999-99	Not Classified	---	---	---	---	---	---	---	---	Barrels Processed
<u>INDUSTRIAL PROCESSES -Pulp and Paper and Wood Products</u>										
<u>Sulfate (Kraft) Pulping - 2611, 2621, 2631</u>										
3-07-001-01	Digester Relief and Blow Tank	---	---	---	---	---	---	---	---	Tons Produced
3-07-001-02	Washer/Screens	---	---	---	0.01	---	0.2	---	---	Tons Produced
3-07-001-03	Multi-effect Evaporator	---	---	---	---	---	---	---	---	Tons Produced
3-07-001-04	Recovery Furnace/Direct Contact Evaporator	180	168	---	7	2	1.95	11	---	Tons Produced
3-07-001-05	Smelt Dissolving Tank	7	6.2	---	0.2	1	0.16	<sup>27</sup> 1.91	---	Footnote 59
3-07-001-06	Lime Kiln	56	9.4	---	0.3	2.8	0.25	0.1	0.0001088	Tons Produced
3-07-001-07	Turpentine Condenser	---	---	---	---	---	0.07	---	---	Tons Produced
3-07-001-08	Fluid Bed Calciner	---	50.4	---	0.3	2.8	0.25	---	---	Tons Produced
3-07-001-09	Liquor Oxidation Tower	---	---	---	0.02	---	0.45	---	---	Tons Produced
3-07-001-10	Recovery Furnace/Indirect Contact Evaporator	230	230	---	---	1.9	0.8	11	---	Tons Produced
3-07-001-11	Filtrate Tanks	---	---	---	---	---	---	---	---	Tons Produced
3-07-001-12	Lime Mud Washers	---	---	---	---	---	---	---	---	Tons Produced
3-07-001-13	Lime Mud Filter System	---	---	---	---	---	---	---	---	Tons Produced
3-07-001-14	Bleaching Reactors	---	---	---	---	---	---	---	---	Tons Produced
3-07-001-15	Chlorine Dioxide	---	---	---	---	---	---	---	---	Tons Produced
3-07-001-16	Turpentine Loading Facilities	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-07-001-17	Condensate Strippers	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Sulfate (Kraft) Pulping - 2611, 2621, 2631</u>										
3-07-001-18	Liquor Clarifiers	---	---	---	---	---	---	---	---	Tons Produced
3-07-001-19	Boiler Ash Handling	---	---	---	---	---	---	---	---	Tons Handled
3-07-001-20	Stock Washing/Screening	---	---	---	---	---	---	---	---	Tons Processed
3-07-001-21	Wastewater: General	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-07-001-22	Causticizing: General	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-07-001-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Sulfite Pulping - 2611, 2621, 2631</u>										
3-07-002-03	Digester/Blow Pit/Dump Tank: All Bases except Calcium	---	---	---	40	---	---	---	---	Tons Produced
3-07-002-11	Digester/Blow Pit/Dump Tank: Calcium	---	---	---	67	---	---	---	---	Tons Produced
3-07-002-12	Digester/Blow Pit/Dump Tank: MgO with Recovery System	---	---	---	---	---	---	---	---	Tons Produced
3-07-002-13	Digester/Blow Pit/Dump Tank: MgO with Process Change	---	---	---	0.2	---	---	---	---	Tons Produced
3-07-002-14	Digester/Blow Pit/Dump Tank: NH3 with Process Change	---	---	---	0.4	---	---	---	---	Tons Produced
3-07-002-15	Digester/Blow Pit/Dump Tank: Na with Process Change	---	---	---	2	---	---	---	---	Tons Produced
3-07-002-21	Recovery System: MgO	2	---	---	9	---	---	---	---	Tons Produced
3-07-002-22	Recovery System: NH3	0.7	---	---	7	---	---	---	---	Tons Produced
3-07-002-23	Recovery System: Na	4	---	---	2	---	---	---	---	Tons Produced
3-07-002-31	Acid Plant: NH3	---	---	---	0.3	---	3.5	---	---	Tons Produced
3-07-002-32	Acid Plant: Na	---	---	---	0.2	---	3.5	---	---	Tons Produced
3-07-002-33	Acid Plant: Ca	---	---	---	8	---	3.5	---	---	Tons Produced
3-07-002-34	Knotters/Washers/Screens/etc.	---	---	---	12	---	---	---	---	Tons Produced
3-07-002-99	See Comment	---	---	---	---	---	---	---	---	Tons Processed
<u>Neutral Sulfite Semichemical Pulping - 2611, 2621, 2631</u>										
3-07-003-01	Digester/Blow Pit/Dump Tank	---	---	---	4	---	---	---	---	Tons Produced
3-07-003-02	Evaporator	---	---	---	---	---	---	---	---	Tons Produced
3-07-003-03	Fluid Bed Reactor	---	282	---	---	1.6	0.25	---	---	Tons Produced
3-07-003-04	Sulfur Burner/Absorbers	---	---	---	20	---	---	---	---	Tons Produced
3-07-003-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Pulpboard Manufacture - 2611, 2621, 2631, 2493</u>										
3-07-004-01	Paperboard: General	---	---	---	---	---	0.2	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Pulpboard Manufacture - 2611, 2621, 2631, 2493</u></i>										
3-07-004-02	Fiberboard: General	0.6	0.35	---	---	---	2.5	---	---	Tons Produced
3-07-004-03	Raw Material Storage and Handling	---	---	---	---	---	---	---	---	Tons Processed
3-07-004-04	Stock Mixing/Blending	---	---	---	---	---	---	---	---	Tons Processed
3-07-004-05	Paper/Board Forming	---	---	---	---	---	---	---	---	Tons Processed
3-07-004-06	Multi-effect Evaporator/Dryer	---	---	---	---	---	---	---	---	Tons Processed
3-07-004-07	Coating Operations	---	---	---	---	---	---	---	---	Tons Processed
3-07-004-99	See Comment	---	---	---	---	---	---	---	---	Tons Produced
<i><u>Wood Pressure Treating - 2491</u></i>										
3-07-005-01	Creosote	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-05	Untreated wood storage	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-10	Full-cell process, creosote	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-11	Full-cell process, pentachlorophenol	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-12	Full-cell process, other oilborne preservative	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-13	Modified full-cell process, chromated copper arsenate	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-14	Modified full-cell process, other waterborne preservative	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-20	Full-cell process with artificial conditioning, creosote	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-21	Full-cell process with artificial conditioning, pentachlorophenol	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-22	Full-cell process with artificial conditioning, other oilborne preservative	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-23	Modified full-cell process with artif cond, chromated copper arsenate	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-24	Modified full-cell process with artif cond, other waterborne preservat	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-30	Empty-cell process, creosote	---	---	---	---	---	0.00074	---	---	Cubic Feet Treated
3-07-005-31	Empty-cell process, pentachlorophenol	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-32	Empty-cell process, other oilborne preservative	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-33	Empty-cell process, chromated copper arsenate	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-34	Empty-cell process, other waterborne preservative	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-40	Empty-cell process with artificial conditioning, creosote	---	---	---	---	---	0.0058	---	---	Cubic Feet Treated
3-07-005-41	Empty-cell process with artificial conditioning, pentachlorophenol	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-42	Empty-cell process with artificial conditioning, other oilborne preservatives	---	---	---	---	---	---	---	---	Tons Treated

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Wood Pressure Treating - 2491</i>										
3-07-005-43	Empty-cell process with artificial conditioning, chromated copper arsenate	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-44	Empty-cell process with artificial conditioning, other waterborne preservative	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-50	Empty-cell process with steam heating, creosote	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-51	Empty-cell process with steam heating, pentachlorophenol	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-52	Empty-cell process with steam heating, other oilborne preservative	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-53	Empty-cell process with steam heating, chromated copper arsenate	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-54	Empty-cell process with steam heating, other waterborne preservative	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-60	Empty-cell process with artif cond & stm heating, creosote	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-61	Empty-cell process with artif cond & stm heating, pentachlorophenol	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-62	Empty-cell process with artif cond & stm heating, other oilborne prese	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-63	Empty-cell process with artif cond & stm heating, chromated copper ars	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-64	Empty-cell process with artif cond & stm heating, other waterborne preservative	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-70	Quenching, creosote	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-71	Quenching, pentachlorophenol	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-72	Quenching, other oilborne preservative	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-73	Quenching, chromated copper arsenate	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-74	Quenching, other waterborne preservative	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-80	Retort unloading, creosote	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-81	Retort unloading, pentachlorophenol	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-82	Retort unloading, other oilborne preservative	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-83	Retort unloading, chromated copper arsenate	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-84	Retort unloading, other waterborne preservative	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-90	Treated wood storage, creosote	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-91	Treated wood storage, pentachlorophenol	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-92	Treated wood storage, other oilborne preservative	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-93	Treated wood storage, chromated copper arsenate	---	---	---	---	---	---	---	---	Tons Treated



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Wood Pressure Treating - 2491</u></i>										
3-07-005-94	Treated wood storage, other waterborne preservative	---	---	---	---	---	---	---	---	Tons Treated
3-07-005-97	Other Not Classified	---	---	---	---	---	---	---	---	1000 Cubic Feet Processed
3-07-005-98	Other Not Classified	---	---	---	---	---	---	---	---	1000 Board Feet Processed
3-07-005-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Treated
<i><u>Particleboard Manufacture - 2493, 3553</u></i>										
3-07-006-02	Direct Wood-fired Rotary Dryer, Unspecified Pines, <730F Inlet Air	3.9	0.69	0.3	<sup>21</sup> 0.002	1.1	0.95	1.6	---	Tons Produced
3-07-006-04	Direct Wood-fired Rotary Dryer, Unspecified Pines, >900F Inlet Air	3.9	0.69	0.3	<sup>21</sup> 0.002	1.1	8.2	1.6	---	Tons Produced
3-07-006-06	Direct Wood-fired Rotary Dryer, Southern Yellow Pine	8	0.9	0.43	<sup>21</sup> 0.002	1.1	1.1	1.6	---	Tons Produced
3-07-006-10	Direct Wood-fired Rotary Dryer, Hardwoods	2.5	---	0.13	<sup>21</sup> 0.002	1.1	0.35	1.6	---	Tons Produced
3-07-006-11	Direct Natural Gas-Fired Rotary Dryer, Unspecified Pines	1.3	---	---	---	0.031	0.9	0.12	---	Tons Produced
3-07-006-21	Direct Wood-fired Rotary Final Dryer, Unspecified Pines	---	---	---	---	---	---	0.75	---	Tons Produced
3-07-006-28	Direct Wood-fired Rotary Predryer, Douglas Fir	---	---	---	---	2.1	---	0.94	---	Tons Produced
3-07-006-29	Direct Wood-fired Tube Final Dryer, Douglas Fir	---	---	---	---	---	---	---	---	Tons Produced
3-07-006-51	Batch Hot Press, Urea Formaldehyde Resin	0.03	0.016	0.061	---	---	0.94	0.09	---	1000 Square Feet Produced
3-07-006-61	Particleboard Board Cooler, Urea-Formaldehyde Resin	0.014	0.0034	0.0092	---	---	0.27	---	---	1000 Square Feet Produced
<i><u>Plywood Operations - 2435, 2436, 2493</u></i>										
3-07-007-01	General: Not Classified	---	---	---	---	---	---	---	---	10,000 Square Feet Produced
3-07-007-02	Sanding Operations	---	---	---	---	---	---	---	---	Tons Processed
3-07-007-03	Particleboard Drying (See 3-07-006 For More Detailed Particleboard SCC)	0.6	0.35	---	---	---	---	---	---	Tons Processed
3-07-007-04	Waferboard Dryer (See 3-07-010 For More Detailed OSB SCCs)	---	---	---	1.71	11.4	40.9	---	---	1000 Pounds Dried
3-07-007-05	Hardboard: Coe Dryer	---	---	---	---	0.3	---	---	---	Tons Produced
3-07-007-06	Hardboard: Predryer	---	---	---	---	0.07	---	---	---	Tons Produced
3-07-007-07	Hardboard: Pressing	---	---	---	---	---	---	---	---	Tons Produced
3-07-007-08	Hardboard: Tempering	---	---	---	---	---	---	---	---	Tons Produced
3-07-007-09	Hardboard: Bake Oven	---	---	---	---	0.1	0.003	---	---	Tons Produced
3-07-007-10	Sawing	---	---	---	---	---	---	---	---	Tons Processed
3-07-007-11	Fir: Sapwood: Steam-fired Dryer	---	---	---	---	---	0.45	---	---	10,000 Square Feet Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Plywood Operations - 2435, 2436, 2493</i>										
3-07-007-12	Fir: Sapwood: Gas-fired Dryer	---	---	---	---	---	7.53	---	---	10,000 Square Feet Produced
3-07-007-13	Fir: Heartwood Plywood Veneer Dryer	---	---	---	---	---	1.3	---	---	10,000 Square Feet Produced
3-07-007-14	Larch Plywood Veneer Dryer	---	---	---	---	---	0.19	---	---	10,000 Square Feet Produced
3-07-007-15	Southern Pine Plywood Veneer Dryer	---	---	---	---	---	2.94	---	---	10,000 Square Feet Produced
3-07-007-16	Poplar Wood Fired Veneer Dryer	---	---	---	---	---	---	---	---	10,000 Square Feet Produced
3-07-007-17	Gas Veneer Dryer: Pines (use 3-07-007-50)	---	---	---	---	---	---	---	---	1000 Square Feet Produced
3-07-007-18	Steam Veneer Dryer: Pines (use 3-07-007-60)	---	---	---	---	---	---	---	---	1000 Square Feet Produced
3-07-007-20	Veneer Dryer: Steam Heated: Redry	---	---	---	---	---	---	---	---	1000 Square Feet Produced
3-07-007-25	Veneer Cutting	---	---	---	---	---	---	---	---	Tons Processed
3-07-007-27	Veneer Laying and Glue Spreading	---	---	---	---	---	---	---	---	Tons Processed
3-07-007-30	Wood Steaming	---	---	---	---	---	---	---	---	Tons Processed
3-07-007-40	Direct Wood-Fired Dryer: Non-specified Pine Species Veneer	---	---	---	<sup>21</sup> 0.058	0.24	3.3	5.1	---	1000 Square Feet Produced
3-07-007-44	Direct Wood-Fired Dryer: Hemlock Veneer	---	---	---	<sup>21</sup> 0.058	0.24	0.7	5.1	---	1000 Square Feet Produced
3-07-007-46	Direct Wood-Fired Dryer: Non-specified Fir Species Veneer	---	---	---	<sup>21</sup> 0.058	0.24	---	5.1	---	1000 Square Feet Produced
3-07-007-47	Direct Wood-Fired Dryer: Douglas Fir Veneer	---	---	---	---	---	<sup>27</sup> 0.5	---	---	1000 Square Feet of 3/8-inch Plywood Produced
3-07-007-50	Direct Natural Gas-Fired Dryer: Non-specified Pine Species Veneer	0.079	---	0.42	---	0.012	2.1	0.57	---	1000 Square Feet Produced
3-07-007-60	Indirect Heated Dryer: Non-specified Pine Species Veneer	0.35	---	1	---	---	2.7	---	---	1000 Square Feet Produced
3-07-007-66	Indirect Heated Dryer: Non-specified Fir Species Veneer	---	---	---	---	---	---	---	---	1000 Square Feet Produced
3-07-007-67	Indirect Heated Dryer: Douglas Fir Veneer	0.07	---	0.82	---	---	1.3	---	---	1000 Square Feet Produced
3-07-007-69	Indirect Heated Dryer: Poplar Veneer	---	---	---	---	---	0.033	---	---	1000 Square Feet Produced
3-07-007-70	Radio Frequency Heated Dryer: Non-specified Pine Species	0.005	---	0.006	---	---	0.22	---	---	1000 Square Feet Produced
3-07-007-80	Plywood Press: Phenol-formaldehyde Resin	0.12	---	0.083	---	---	0.33	---	---	1000 Square Feet Produced
3-07-007-81	Plywood Press: Urea-formaldehyde Resin	---	---	---	---	---	0.021	---	---	1000 Square Feet Produced
3-07-007-98	Other Not Classified	---	---	---	---	---	---	---	---	1000 Board Feet Processed
3-07-007-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Sawmill Operations - 2421, 2426, 2429, 2411</i></u>										
3-07-008-01	Log Debarking	0.02	0.011	---	---	---	---	---	---	Tons Processed
3-07-008-02	Log Sawing	0.35	0.2	---	---	---	---	---	---	Tons Processed
3-07-008-03	Sawdust Pile Handling	1	0.36	---	---	---	---	---	---	Tons Processed
3-07-008-04	Sawing: Cyclone Exhaust	---	---	---	---	---	---	---	---	SCFM-Year Processed
3-07-008-05	Planning/Trimming: Cyclone Exhaust	---	---	---	---	---	---	---	---	SCFM-Year Processed
3-07-008-06	Sanding: Cyclone Exhaust	---	---	---	---	---	---	---	---	SCFM-Year Processed
3-07-008-07	Sanderdust: Cyclone Exhaust	---	---	---	---	---	---	---	---	Hour Operated
3-07-008-08	Other Cyclones: Exhaust	---	---	---	---	---	---	---	---	Hour Operated
3-07-008-20	Chipping and Screening	---	---	---	---	---	---	---	---	Tons Processed
3-07-008-21	Chip Storage Piles	---	---	---	---	---	---	---	---	Tons Processed
3-07-008-22	Chip Transfer/Conveying	---	---	---	---	---	---	---	---	Tons Processed
3-07-008-95	Log Storage	---	---	---	---	---	---	---	---	Tons Stored
3-07-008-96	Other Not Classified	---	---	---	---	---	---	---	---	1000 Cubic Feet Processed
3-07-008-97	Other Not Classified	---	---	---	---	---	---	---	---	Gallons Processed
3-07-008-98	Other Not Classified	---	---	---	---	---	---	---	---	1000 Board Feet Processed
3-07-008-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Medium Density Fiberboard (MDF) Manufacture - 2493</i></u>										
3-07-009-21	Direct Wood-fired Tube Dryer, Unspecified Pines	10	1.6	0.59	---	---	6.6	4	---	Tons Produced
3-07-009-25	Direct Wood-fired Tube Dryer, Hardwoods	---	---	---	---	---	6.5	4	---	Tons Produced
3-07-009-31	Indirect-heated Tube Dryer, Unspecified Pines	1.4	---	---	---	---	---	---	---	Tons Produced
3-07-009-35	Indirect-heated Tube Dryer, Hardwoods	---	---	---	---	---	4.7	---	---	Tons Produced
3-07-009-39	Indirect-heated Tube Dryer, 50% Softwood, 50% Hardwood	1.5	0.28	0.73	---	---	2.2	---	---	Tons Produced
3-07-009-50	Continuous Hot Press, UF Resin	0.17	---	0.14	---	---	1.4	---	---	1000 Square Feet Produced
3-07-009-60	Batch Hot Press, UF Resin	0.18	0.075	0.26	---	0.03	0.69	0.034	---	1000 Square Feet Produced
3-07-009-71	MDF Board Cooler, UF Resin	0.054	0.0038	---	---	---	0.2	---	---	1000 Square Feet Produced
<u><i>Oriented Strandboard (OSB) Manufacture - 2493</i></u>										
3-07-010-01	Direct Wood-fired Rotary Dryer, Unspecified Pines	3.9	---	1.9	<sup>27</sup> 0.014	0.65	8.6	5.8	---	Tons Produced
3-07-010-08	Direct Wood-fired Rotary Dryer, Aspen	---	---	---	<sup>27</sup> 0.014	0.65	2.2	5.8	---	Tons Produced
3-07-010-10	Direct Wood-fired Rotary Dryer, Hardwoods	<sup>27</sup> 0.036	---	1.9	<sup>27</sup> 0.014	0.65	1.6	5.8	---	Tons Produced
3-07-010-20	Direct Natural Gas-fired Rotary Dryer, Hardwoods	---	---	---	---	0.68	---	0.72	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Oriented Strandboard (OSB) Manufacture - 2493</u>										
3-07-010-53	Hot Press, Phenol-Formaldehyde Resin	0.12	0.1	0.25	<sup>21</sup> 0.037	0.038	0.52	0.11	---	1000 Square Feet Produced
3-07-010-55	Hot Press, Methylene Diphenyl Diisocyanate Resin	0.16	---	0.046	<sup>21</sup> 0.037	0.038	0.45	0.11	---	1000 Square Feet Produced
3-07-010-57	Hot Press, PF Resin (surface layers) / MDI Resin (core layers)	0.37	0.11	0.14	<sup>21</sup> 0.037	0.038	0.56	0.11	---	1000 Square Feet Produced
<u>Paper Coating and Glazing - 2671, 2672</u>										
3-07-011-99	Extrusion Coating Line with Solvent Free Resin/Wax	---	---	---	---	---	---	---	---	Tons Consumed
<u>Miscellaneous Paper Processes - 2611, 2653, 2656, 2731, 2754, 3053, 3569</u>										
3-07-012-01	Cyclones	---	---	---	---	---	---	---	---	Tons Produced
3-07-012-20	Thermomechanical Process	---	---	---	---	---	---	---	---	Tons Produced
<u>Miscellaneous Paper Products - 2679</u>										
3-07-013-01	Shredding Newspaper for Insulation Manufacturing	---	---	---	---	---	---	---	---	Tons Processed
3-07-013-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Furniture Manufacture - 2500</u>										
3-07-020-01	Rough-end	---	---	---	---	---	---	---	---	1000 Board Feet Processed
3-07-020-02	Machine Room	---	---	---	---	---	---	---	---	1000 Board Feet Processed
3-07-020-03	Sanding	---	---	---	---	---	---	---	---	1000 Board Feet Processed
3-07-020-04	Wood Hog	---	---	---	---	---	---	---	---	Tons Processed
3-07-020-21	Veneer Hot Press, Urea Formaldehyde Resin	---	---	---	---	---	---	---	---	1000 Square Feet Processed
3-07-020-98	Other Not Classified	---	---	---	---	---	---	---	---	1000 Board Feet Processed
3-07-020-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Miscellaneous Wood Working Operations - 2420, 2430</u>										
3-07-030-01	Wood Waste Storage Bin Vent	1	0.58	---	---	---	---	---	---	Tons Processed
3-07-030-02	Wood Waste Storage Bin Loadout	2	1.2	---	---	---	---	---	---	Tons Processed
3-07-030-96	Sanding/Planning Operations: Specify	---	---	---	---	---	---	---	---	1000 Square Feet Processed
3-07-030-97	Sanding/Planning Operations: Specify	---	---	---	---	---	---	---	---	Each Processed
3-07-030-98	Sanding/Planning Operations: Specify	---	---	---	---	---	---	---	---	1000 Board Feet Processed
3-07-030-99	Sanding/Planning Operations: Specify	---	---	---	---	---	---	---	---	Tons Processed
<u>Bulk Handling and Storage - Wood/Bark - 2435</u>										
3-07-040-01	Storage Bins	---	---	---	---	---	---	---	---	Tons Processed
3-07-040-02	Stockpiles	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Bulk Handling and Storage - Wood/Bark - 2435</i></u>										
3-07-040-03	Unloading	---	---	---	---	---	---	---	---	Tons Processed
3-07-040-04	Loading	---	---	---	---	---	---	---	---	Tons Processed
3-07-040-05	Conveyors	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Fugitive Emissions - 2400, 2500, 2600, 2700</i></u>										
3-07-888-01	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-07-888-02	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-07-888-03	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-07-888-04	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-07-888-05	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-07-888-98	Specify in Comments Field	---	---	---	---	---	---	---	---	1000 Board Feet Processed
<u><i>Fuel Fired Equipment - 2400, 2500, 2600, 2700</i></u>										
3-07-900-01	Distillate Oil (No. 2): Process Heaters	---	---	---	143.68	20	0.2	---	---	1000 Gallons Burned
3-07-900-02	Residual Oil: Process Heaters	---	---	---	158.68	55	0.28	---	---	1000 Gallons Burned
3-07-900-03	Natural Gas: Process Heaters	---	---	---	0.6	140	2.8	---	---	Million Cubic Feet Burned
3-07-900-11	Distillate Oil (No. 2): Incinerators	---	---	---	---	---	0.4	---	---	1000 Gallons Burned
3-07-900-12	Residual Oil: Incinerators	---	---	---	---	---	0.56	---	---	1000 Gallons Burned
3-07-900-13	Natural Gas: Incinerators	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-07-900-14	Process Gas: Incinerators	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
3-07-900-21	Distillate Oil (No. 2): Flares	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-07-900-22	Residual Oil: Flares	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-07-900-23	Natural Gas: Flares	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-07-900-24	Process Gas: Flares	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
<u><i>Other Not Classified - 2400, 2500, 2600, 2700</i></u>										
3-07-999-01	Battery Separators	---	---	---	---	---	---	---	---	Tons Produced
3-07-999-98	Other Not Classified	---	---	---	---	---	---	---	---	1000 Board Feet Produced
3-07-999-99	See Comment	---	---	---	---	---	---	---	---	Tons Processed
<u><i>INDUSTRIAL PROCESSES -Rubber and Miscellaneous Plastics Products</i></u>										
<u><i>Tire Manufacture - 3011</i></u>										
3-08-001-01	Undertread and Sidewall Cementing	---	---	---	---	---	229.5	---	---	1000 Each Produced
3-08-001-02	Bead Dipping	---	---	---	---	---	13.3	---	---	1000 Each Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Tire Manufacture - 3011</u></i>										
3-08-001-03	Bead Swabbing	---	---	---	---	---	18.3	---	---	1000 Each Produced
3-08-001-04	Tire Building	---	---	---	---	---	72.6	---	---	1000 Each Produced
3-08-001-05	Tread End Cementing	---	---	---	---	---	33.2	---	---	1000 Each Produced
3-08-001-06	Green Tire Spraying	---	---	---	---	---	301.8	---	---	1000 Each Produced
3-08-001-07	Tire Curing	---	---	---	---	---	4.4	---	---	1000 Each Produced
3-08-001-08	Solvent Mixing	---	---	---	---	---	10.8	---	---	Tons Used
3-08-001-09	Solvent Storage (Use 4-07-004-01 thru 4-07-999-98 if possible)	---	---	---	---	---	---	---	---	Tons Used
3-08-001-10	Solvent Storage (Use 4-07-004-01 thru 4-07-999-98 if possible)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-08-001-11	Compounding	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-12	Milling	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-13	Tread Extruder	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-14	Sidewall Extruder	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-15	Calendering	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-16	Latex Dipping	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-17	Finishing	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-20	Undertread and Sidewall Cementing	---	---	---	---	---	1800	---	---	Tons Used
3-08-001-21	Tread End Cementing	---	---	---	---	---	1800	---	---	Tons Used
3-08-001-22	Bead Dipping	---	---	---	---	---	1800	---	---	Tons Used
3-08-001-23	Green Tire Spraying	---	---	---	---	---	1840	---	---	Tons Used
3-08-001-24	Bead Swabbing	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-25	Tire Building	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-26	Tire Curing	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-27	Compounding	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-28	Milling	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-29	Tread Extruder	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-30	Sidewall Extruder	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-31	Calendering	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-32	Latex Dipping	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-33	Finishing	---	---	---	---	---	---	---	---	1000 Each Produced
3-08-001-97	Other Not Classified	---	---	---	---	---	---	---	---	Each Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Tire Manufacture - 3011</u>										
3-08-001-98	Other Not Classified	---	---	---	---	---	---	---	---	Gallons Processed
3-08-001-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Tire Retreading - 7534</u>										
3-08-005-01	Tire Buffing Machines	---	---	---	---	---	600	---	---	1000 Each Processed
<u>Other Fabricated Plastics - 3021, 3052, 3061, 3069</u>										
3-08-006-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Fiberglass Resin Products - 3080</u>										
3-08-007-01	Plastics Machining: Drilling/Sanding/Sawing/etc.	---	---	---	---	---	13	---	---	Tons Processed
3-08-007-02	Mould Release	---	---	---	---	---	---	---	---	Tons Produced
3-08-007-03	Solvent Consumption	---	---	---	---	---	649	---	---	Tons Used
3-08-007-04	Adhesive Consumption	---	---	---	---	---	649	---	---	Tons Applied
3-08-007-05	Wax Burnout Oven	---	---	---	---	---	---	---	---	Tons Burned
3-08-007-20	General	---	---	---	---	---	---	---	---	Tons Produced
3-08-007-21	Gel Coat: Roll On	---	---	---	---	---	---	---	---	Tons Applied
3-08-007-22	Gel Coat: Spray On	---	---	---	---	---	---	---	---	Tons Applied
3-08-007-23	Resin: General: Roll On	---	---	---	---	---	---	---	---	Tons Applied
3-08-007-24	Resin: General: Spray On (use 3-08-007-30)	---	---	---	---	---	---	---	---	Tons Applied
3-08-007-30	Resin Spray Layup (non-vapor-suppressed)	---	---	---	---	---	---	---	---	1000 Pounds Applied
3-08-007-31	Resin Spray Layup (vapor-suppressed)	---	---	---	---	---	---	---	---	1000 Pounds Applied
3-08-007-32	Resin Spray Layup (vacuum bagging)	---	---	---	---	---	---	---	---	1000 Pounds Applied
3-08-007-36	Resin Closed Molding	---	---	---	---	---	---	---	---	1000 Pounds Applied
3-08-007-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Plastic Foam Products - 3000</u>										
3-08-008-01	Expansion Process via Steam	---	---	---	---	---	---	---	---	Tons Produced
3-08-008-02	Molding	---	---	---	---	---	---	---	---	Tons Produced
3-08-008-03	Bead Storage	---	---	---	---	---	---	---	---	Tons Stored
<u>Plastic Miscellaneous Products - 3080</u>										
3-08-009-01	Polystyrene: General	---	---	---	---	---	---	---	---	Tons Consumed
<u>Plastic Products Manufacturing - multiple (See Appendix D)</u>										
3-08-010-01	Adhesives Production: General Process	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Plastic Products Manufacturing - multiple (See Appendix D)</i>										
3-08-010-02	Extruder	---	---	---	---	---	---	---	---	Tons Produced
3-08-010-03	Film Production, Die (Flat/Circular)	---	---	---	---	---	---	---	---	Tons Produced
3-08-010-04	Sheet Production, Polymerizer	---	---	---	---	---	---	---	---	Tons Produced
3-08-010-05	Foam Production - General Process	---	---	---	---	---	---	---	---	Tons Produced
3-08-010-06	Lamination, Kettles/Oven	---	---	---	---	---	---	---	---	Tons Produced
3-08-010-07	Molding Machine	---	---	---	---	---	---	---	---	Tons Produced
3-08-010-08	Sheet Production, Calendaring	---	---	---	---	---	---	---	---	Tons Produced
<i>Vinyl Floor Tile Manufacturing - 3000, 3080, 3083</i>										
3-08-050-01	Tile Chip Bin Tipper	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-02	Tile Chip Receiving Hopper	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-03	Tile Chip Belt Conveyors	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-04	Scrap Hopper	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-05	Weigh Scales	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-06	Mixer	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-07	Mill	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-08	Blender	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-09	Conveyors	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-10	Scrap Chopper	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-11	Adhesive Applicator	---	---	---	---	---	---	---	---	Gallons Applied
3-08-050-12	Limestone Purge	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-13	Scrap Discharging	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-14	PVC Unloading	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-15	PVC Storage	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-16	PVC Surge Bins	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-17	Limestone Storage	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-18	Limestone Elevators	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-19	Unloading Operation, Limestone	---	---	---	---	---	---	---	---	Tons Processed
3-08-050-99	Unspecified	---	---	---	---	---	---	---	---	Tons Processed
<i>Equipment Leaks - 3000, 3080</i>										
3-08-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Wastewater, Aggregate - 3000</u>										
3-08-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-08-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Wastewater, Points of Generation - 3000</u>										
3-08-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Fuel Fired Equipment - 3000, 7500</u>										
3-08-900-01	Distillate Oil (No. 2): Process Heaters	---	---	---	143.6S	20	0.2	---	---	1000 Gallons Burned
3-08-900-02	Residual Oil: Process Heaters	---	---	---	158.6S	55	0.28	---	---	1000 Gallons Burned
3-08-900-03	Natural Gas: Process Heaters	---	---	---	0.6	140	2.8	---	---	Million Cubic Feet Burned
3-08-900-04	Liquified Petroleum Gas (LPG): Process Heaters	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-08-900-11	Distillate Oil (No. 2): Incinerators	---	---	---	---	---	0.4	---	---	1000 Gallons Burned
3-08-900-12	Residual Oil: Incinerators	---	---	---	---	---	0.56	---	---	1000 Gallons Burned
3-08-900-13	Natural Gas: Incinerators	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-08-900-21	Distillate Oil (No. 2): Flares	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-08-900-22	Residual Oil: Flares	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-08-900-23	Natural Gas: Flares	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
<u>Other Not Specified - 3000, 7500</u>										
3-08-999-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>INDUSTRIAL PROCESSES -Fabricated Metal Products</u>										
<u>General Processes - 3400</u>										
3-09-001-98	Other Not Classified	---	---	---	---	---	---	---	---	Gallons Processed
3-09-001-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Abrasive Blasting of Metal Parts - 3400</u>										
3-09-002-01	General	---	---	---	---	---	---	---	---	Tons Consumed
3-09-002-02	Sand Abrasive	---	---	---	---	---	---	---	---	Tons Consumed
3-09-002-03	Slag Abrasive	---	---	---	---	---	---	---	---	Tons Consumed
3-09-002-04	Garnet Abrasive	---	---	---	---	---	---	---	---	Tons Consumed
3-09-002-05	Steel Grit Abrasive	---	---	---	---	---	---	---	---	Tons Consumed
3-09-002-06	Walnut Shell Abrasive	---	---	---	---	---	---	---	---	Tons Consumed
3-09-002-07	Shotblast with Air	---	---	---	---	---	---	---	---	Tons Consumed
3-09-002-08	Shotblast w/o Air	---	---	---	---	---	---	---	---	Tons Consumed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Abrasive Blasting of Metal Parts - 3400</i></u>										
3-09-002-98	General	---	---	---	---	---	---	---	---	Feet Processed
3-09-002-99	General	---	---	---	---	---	---	---	---	Each Processed
<u><i>Abrasive Cleaning of Metal Parts - 3400</i></u>										
3-09-003-01	Brush Cleaning	---	---	---	---	---	---	---	---	Tons Consumed
3-09-003-02	Tumble Cleaning	---	---	---	---	---	---	---	---	Tons Consumed
3-09-003-03	Polishing	---	---	---	---	---	---	---	---	Tons Consumed
3-09-003-04	Buffing	---	---	---	---	---	---	---	---	Tons Consumed
<u><i>Welding - 2892, 3264, 3423, 3429, 3442, 3612, 3999, 7389, 92</i></u>										
3-09-005-00	General	---	---	---	---	---	---	---	---	Pounds Used
3-09-005-01	Arc Welding: General (See 3-09-050)	---	---	---	---	---	---	---	---	Pounds Consumed
3-09-005-02	Oxyfuel Welding: General (See 3-09-044)	---	---	---	---	---	---	---	---	1000 Cubic Feet Burned
<u><i>Electroplating Operations - 3471</i></u>										
3-09-010-01	Entire Process: General	---	---	---	---	0.009	0.026	---	---	Square Feet Plated
3-09-010-02	Entire Process: General	---	---	---	---	---	---	---	---	Ampere-Hours Applied
3-09-010-03	Entire Process: Nickel	---	---	---	---	---	---	---	---	Square Feet-Years Existing
3-09-010-04	Entire Process: Copper	---	---	---	---	---	---	---	---	Square Feet-Years Existing
3-09-010-05	Entire Process: Zinc	---	---	---	---	---	---	---	---	Ampere-Hours Applied
3-09-010-06	Entire Process: Chrome	---	---	---	---	---	---	---	---	Ampere-Hours Applied
3-09-010-07	Entire Process: Cadmium	---	---	---	---	---	---	---	---	Ampere-Hours Applied
3-09-010-14	Chromium (all types) - Alkaline Cleaning	---	---	---	---	---	---	---	---	1000 Square Feet Treated
3-09-010-15	Chromium (all types) - Acid Dip	---	---	---	---	---	---	---	---	1000 Square Feet Treated
3-09-010-16	Hard Chromium - Chromic Acid Anodic Treatment	---	---	---	---	---	---	---	---	1000 Square Feet Treated
3-09-010-18	Hard Chromium - Electroplating Tank	---	---	---	---	---	---	---	---	1000 Ampere-Hours Applied
3-09-010-28	Decorative Chromium - Electroplating Tank	---	---	---	---	---	---	---	---	1000 Ampere-Hours Applied
3-09-010-38	Chromic Acid Anodizing - Anodizing Tank	---	---	---	---	---	---	---	---	1000 Square Feet-Hours Operated
3-09-010-42	Copper (cyanide, including strike) - Electroplating Tank	---	---	---	---	---	---	---	---	1000 Ampere-Hours Applied
3-09-010-45	Copper (sulfate) - Electroplating Tank	---	---	---	---	---	---	---	---	1000 Ampere-Hours Applied

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Electroplating Operations - 3471</u></i>										
3-09-010-48	Copper (general) - Electroplating Tank 1000 amp-hr current applied	---	---	---	---	---	---	---	---	1000 Ampere-Hours Applied
3-09-010-52	Cadmium (cyanide) - Electroplating Tank 1000 amp-hr current applied	---	---	---	---	---	---	---	---	1000 Ampere-Hours Applied
3-09-010-54	Cadmium (acid fluoborate) - Electroplating Tank 1000 amp-hr current	---	---	---	---	---	---	---	---	1000 Ampere-Hours Applied
3-09-010-58	Cadmium (general) - Electroplating Tank 1000 amp-hr current applied	---	---	---	---	---	---	---	---	1000 Ampere-Hours Applied
3-09-010-61	Nickel (all chloride) - Electroplating Tank 1000 amp-hr current appli	---	---	---	---	---	---	---	---	1000 Ampere-Hours Applied
3-09-010-63	Nickel (chloride sulfate) - Electroplating Tank 1000 amp-hr current	---	---	---	---	---	---	---	---	1000 Ampere-Hours Applied
3-09-010-65	Nickel (sulfamate or watts) - Electroplating Tank 1000 amp-hr current	---	---	---	---	---	---	---	---	1000 Ampere-Hours Applied
3-09-010-67	Nickel (non-chloride) - Electroplating Tank 1000 amp-hr current appli	---	---	---	---	---	---	---	---	1000 Ampere-Hours Applied
3-09-010-68	Nickel (general) - Electroplating Tank	---	---	---	---	---	---	---	---	1000 Ampere-Hours Applied
3-09-010-78	Zinc (general) - Electroplating Tank	---	---	---	---	---	---	---	---	1000 Ampere-Hours Applied
3-09-010-97	Other Not Classified	---	---	---	---	---	---	---	---	Tons Used
3-09-010-98	Other Not Classified	---	---	---	---	---	---	---	---	Gallons Processed
3-09-010-99	See Comment	---	---	---	---	---	---	---	---	Tons Plated
<i><u>Conversion Coating of Metal Products - 3471</u></i>										
3-09-011-01	Alkaline Cleaning Bath	---	---	---	---	---	---	---	---	Tons Processed
3-09-011-02	Acid Cleaning Bath (Pickling)	---	---	---	---	---	---	---	---	Tons Processed
3-09-011-03	Anodizing Kettle	---	---	---	---	---	---	---	---	Tons Processed
3-09-011-04	Rinsing/Finishing	---	---	---	---	---	---	---	---	Tons Processed
3-09-011-99	Other Not Classified	---	---	---	---	---	---	---	---	Gallons Processed
<i><u>Precious Metals Recovery - 3341, 3339</u></i>										
3-09-012-01	Reclamation Furnace	---	---	---	---	---	---	---	---	Tons Produced
3-09-012-02	Crucible Furnace	---	---	---	---	---	---	---	---	Tons Produced
3-09-012-03	Size Reduction	---	---	---	---	---	---	---	---	Tons Produced
3-09-012-04	Reactor	---	---	---	---	---	---	---	---	Tons Produced
3-09-012-05	Drying	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Chemical Milling of Metal Products - 3471</u>										
3-09-015-01	Milling Tank	---	---	---	---	---	---	---	---	Tons Processed
<u>Metal Pipe Coating of Metal Parts - 3479</u>										
3-09-016-01	Asphalt Dipping	---	---	---	---	---	1000	---	---	Tons Processed
3-09-016-02	Pipe Spinning	---	---	---	---	---	---	---	---	Tons Processed
3-09-016-03	Pipe Wrapping	---	---	---	---	---	---	---	---	Tons Processed
3-09-016-04	Coal Tar/Asphalt Melting Kettle	---	---	---	---	---	---	---	---	Tons Melted
3-09-016-05	Asphalt Dipping	---	---	---	---	---	23.3	---	---	1000 Square Feet Processed
3-09-016-06	Pipe Spinning	---	---	---	---	---	23.3	---	---	1000 Square Feet Processed
3-09-016-07	Pipe Wrapping	---	---	---	---	---	23.3	---	---	1000 Square Feet Processed
3-09-016-10	Raw Material Storage: Asphalt	---	---	---	---	---	---	---	---	Tons Stored
3-09-016-11	Raw Material Storage: Coal Tar	---	---	---	---	---	---	---	---	Tons Stored
3-09-016-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Other Not Classified - 3291, 3411, 3471,</u>										
3-09-020-99	See Comment	---	---	---	---	---	---	---	---	Tons Produced
<u>Drum Cleaning/Reclamation - 5085</u>										
3-09-025-01	Drum Burning Furnace	0.035	0.02	---	---	0.002	---	---	---	Each Burned
<u>Machining Operations - 3400, 5000</u>										
3-09-030-04	Specify Material	---	---	---	---	---	---	---	---	Tons Processed
3-09-030-05	Sawing: Specify Material in Comments	---	---	---	---	---	---	---	---	Tons Processed
3-09-030-06	Honing: Specify Material in Comments	---	---	---	---	---	---	---	---	Tons Processed
3-09-030-07	Lubrication: Specify Material	---	---	---	---	---	---	---	---	Gallons Consumed
3-09-030-08	Plasma Torch	---	---	---	---	---	---	---	---	Tons Processed
3-09-030-10	Stamping and Drawing (Auto Body Parts)	---	---	---	---	---	---	---	---	Tons Used
3-09-030-99	See Comment	---	---	---	---	---	---	---	---	Tons Processed
<u>Powder Metallurgy Part Manufacturing (NAICS 332117) - 3499</u>										
3-09-039-01	Electric Sinter Oven Vents	---	---	---	---	---	---	---	---	
3-09-039-02	Electric Sinter Oven Gas Burners	---	---	---	---	---	---	---	---	
3-09-039-51	Application of Coatings to Sintered Parts	---	---	---	---	---	---	---	---	
<u>Metal Deposition Processes - 3400, 5000</u>										
3-09-040-01	Metallizing: Wire Atomization and Spraying	---	---	---	---	---	---	---	0.5	Tons Consumed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Metal Deposition Processes - 3400, 5000</i></u>										
3-09-040-10	Thermal Spraying of Powdered Metal	---	---	---	---	---	---	---	---	Tons Consumed
3-09-040-20	Plasma Arc Spraying of Powdered Metal	---	---	---	---	---	---	---	---	Tons Consumed
3-09-040-30	Tinning: Batch Process	---	---	---	---	---	---	---	---	Tons Consumed
<u><i>Resistance Welding - 3548</i></u>										
3-09-041-00	General	---	---	---	---	---	---	---	---	1000 Pounds Consumed
<u><i>Brazing - 3398, 3548</i></u>										
3-09-042-00	General	---	---	---	---	---	---	---	---	1000 Pounds Consumed
<u><i>Soldering - 3423</i></u>										
3-09-043-00	General	---	---	---	---	---	---	---	---	1000 Pounds Consumed
<u><i>Oxyfuel Welding - 3761</i></u>										
3-09-044-00	General	---	---	---	---	---	---	---	---	1000 Pounds Consumed
<u><i>Thermal Spraying - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</i></u>										
3-09-045-00	General	---	---	---	---	---	---	---	---	1000 Pounds Consumed
<u><i>Oxyfuel Cutting - 3743</i></u>										
3-09-046-00	General	---	---	---	---	---	---	---	---	1000 Pounds Consumed
<u><i>Arc Cutting - 3324, 3561, 3761</i></u>										
3-09-047-00	General	---	---	---	---	---	---	---	---	1000 Pounds Consumed
<u><i>Arc Welding: General: Consummable and Non-consummable Electrode - 4961</i></u>										
3-09-050-00	Consumable and Non-consumable Electrode	---	---	---	---	---	---	---	---	1000 Pounds Consumed
<u><i>Shielded Metal Arc Welding (SMAW) - 3699</i></u>										
3-09-051-00	General	---	---	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-04	14Mn-4Cr Electrode	---	81.6	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-08	E11018 Electrode	---	16.4	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-12	E308 Electrode	---	10.8	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-16	E310 Electrode	---	15.1	---	---	---	---	---	0.024	1000 Pounds Consumed
3-09-051-20	E316 Electrode	---	10	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-24	E410 Electrode	---	13.2	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-28	E6010 Electrode	---	25.6	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-32	E6011 Electrode	---	38.4	---	---	---	---	---	---	1000 Pounds Consumed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Shielded Metal Arc Welding (SMAW) - 3699</u>										
3-09-051-36	E6012 Electrode	---	8	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-40	E6013 Electrode	---	19.7	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-44	E7018 Electrode	---	18.4	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-48	E7024 Electrode	---	9.2	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-52	E7028 Electrode	---	18	---	---	---	---	---	0.162	1000 Pounds Consumed
3-09-051-56	E8018 Electrode	---	17.1	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-60	E9015 Electrode	---	17	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-64	E9018 Electrode	---	16.9	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-68	ECoCr-A Electrode	---	27.9	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-72	ENi-CI Electrode	---	18.2	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-76	ENiCrMo Electrode	---	11.7	---	---	---	---	---	---	1000 Pounds Consumed
3-09-051-80	ENi-Cu Electrode	---	10.1	---	---	---	---	---	---	1000 Pounds Consumed
<u>Gas Metal Arc Welding (GMAW) - 3496</u>										
3-09-052-00	General	---	---	---	---	---	---	---	---	1000 Pounds Consumed
3-09-052-10	ER1260 Electrode	---	20.5	---	---	---	---	---	---	1000 Pounds Consumed
3-09-052-12	E308I Electrode	---	5.4	---	---	---	---	---	---	1000 Pounds Consumed
3-09-052-20	ER316 Electrode	---	3.2	---	---	---	---	---	---	1000 Pounds Consumed
3-09-052-26	ER5154 Electrode	---	24.1	---	---	---	---	---	---	1000 Pounds Consumed
3-09-052-54	E70S Electrode	---	5.2	---	---	---	---	---	---	1000 Pounds Consumed
3-09-052-76	ERNiCrMo Electrode	---	3.9	---	---	---	---	---	---	1000 Pounds Consumed
3-09-052-80	ERNiCu Electrode	---	2	---	---	---	---	---	---	1000 Pounds Consumed
<u>Flux Cored Arc Welding (FCAW) - 3561</u>										
3-09-053-00	General	---	---	---	---	---	---	---	---	1000 Pounds Consumed
3-09-053-06	E110 T5-K3 Electrode	---	20.8	---	---	---	---	---	---	1000 Pounds Consumed
3-09-053-08	E11018 Electrode	---	57	---	---	---	---	---	---	1000 Pounds Consumed
3-09-053-12	E308LT Electrode	---	9.1	---	---	---	---	---	---	1000 Pounds Consumed
3-09-053-20	E316LT Electrode	---	8.5	---	---	---	---	---	---	1000 Pounds Consumed
3-09-053-54	E70T Electrode	---	15.1	---	---	---	---	---	---	1000 Pounds Consumed
3-09-053-55	E71T Electrode	---	12.2	---	---	---	---	---	---	1000 Pounds Consumed
<u>Submerged Arc Welding (SAW) - 3699</u>										
3-09-054-00	General	---	---	---	---	---	---	---	---	1000 Pounds Consumed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Submerged Arc Welding (SAW) - 3699</u>										
3-09-054-10	EM12K Electrode	---	0.05	---	---	---	---	---	---	1000 Pounds Consumed
<u>Electrogas Welding (EGW) - 4961</u>										
3-09-055-00	General	---	---	---	---	---	---	---	---	1000 Pounds Consumed
<u>Electroslag Welding (ESW) - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</u>										
3-09-056-00	General	---	---	---	---	---	---	---	---	1000 Pounds Consumed
<u>Gas Tungsten Arc Welding (GTAW) - 3496</u>										
3-09-058-00	General	---	---	---	---	---	---	---	---	1000 Pounds Consumed
<u>Plasma Arc Welding (PAW) - 3496</u>										
3-09-059-00	General	---	---	---	---	---	---	---	---	1000 Pounds Consumed
<u>Porcelain Enamel/Ceramic Glaze Spraying - 3431</u>										
3-09-060-01	Spray Booth	---	---	---	---	---	---	---	---	Gallons Sprayed
3-09-060-02	Ceramic Glaze: Material Handling	---	---	---	---	---	---	---	---	Tons Processed
3-09-060-03	Ceramic Glaze: Solution Preparation	---	---	---	---	---	---	---	---	Tons Processed
3-09-060-04	Ceramic Glaze: Surface Preparation	---	---	---	---	---	---	---	---	Tons Processed
3-09-060-05	Ceramic Glaze: Plating	---	---	---	---	---	---	---	---	Tons Processed
3-09-060-06	Ceramic Glaze: Storage	---	---	---	---	---	---	---	---	Tons Processed
3-09-060-07	Ceramic Glaze: Drying	---	---	---	---	---	---	---	---	Tons Processed
3-09-060-99	Spray Booth	---	---	---	---	---	---	---	---	Tons Processed
<u>Equipment Leaks - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</u>										
3-09-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Wastewater, Aggregate - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</u>										
3-09-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-09-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Wastewater, Points of Generation - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</u>										
3-09-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Fugitive Emissions - 3400, 5000</u>										
3-09-888-01	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-09-888-02	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-09-888-03	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Fugitive Emissions - 3400, 5000</i></u>										
3-09-888-04	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-09-888-05	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
3-09-888-06	Other Not Classified	---	---	---	---	---	---	---	---	Each Processed
<u><i>Fuel Fired Equipment - 3400, 5000</i></u>										
3-09-900-01	Distillate Oil (No. 2): Process Heaters	---	---	---	143.6S	20	0.2	---	---	1000 Gallons Burned
3-09-900-02	Residual Oil: Process Heaters	---	---	---	158.6S	55	0.28	---	---	1000 Gallons Burned
3-09-900-03	Natural Gas: Process Heaters	---	---	---	0.6	140	2.8	---	---	Million Cubic Feet Burned
3-09-900-11	Distillate Oil (No. 2): Incinerators	---	---	---	---	---	0.4	---	---	1000 Gallons Burned
3-09-900-12	Residual Oil: Incinerators	---	---	---	---	---	0.56	---	---	1000 Gallons Burned
3-09-900-13	Natural Gas: Incinerators	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-09-900-23	Natural Gas: Flares	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
<u><i>Other Not Classified - 3400, 5000</i></u>										
3-09-999-97	Other Not Classified	---	---	---	---	---	---	---	---	1000 Each Processed
3-09-999-98	Other Not Classified	---	---	---	---	---	---	---	---	Million Each Processed
3-09-999-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u><i>INDUSTRIAL PROCESSES -Oil and Gas Production</i></u>										
<u><i>Crude Oil Production - 1311</i></u>										
3-10-001-01	Complete Well: Fugitive Emissions	---	---	---	---	---	396	---	---	Each-Year Operating
3-10-001-02	Miscellaneous Well: General	---	---	---	---	---	280	---	---	Each-Year Operating
3-10-001-03	Wells: Rod Pumps	---	---	---	---	---	456	---	---	Each-Year Operating
3-10-001-04	Crude Oil Sumps	---	---	---	---	---	9	---	---	Square Feet-Years Operating
3-10-001-05	Crude Oil Pits	---	---	---	---	---	9	---	---	Square Feet-Years Operating
3-10-001-06	Enhanced Wells, Water Reinjection	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-10-001-07	Oil/Gas/Water/Separation	---	---	---	---	---	---	---	---	1000 Gallons Transferred
3-10-001-08	Evaporation from Liquid Leaks into Oil Well Cellars	---	---	---	---	---	---	---	---	Square Feet-Years Existing
3-10-001-21	Site Preparation	---	---	---	---	---	---	---	---	100 Acres Prepared
3-10-001-22	Drilling and Well Completion	---	---	---	---	---	---	---	---	Each Drilled
3-10-001-23	Well Casing Vents	---	---	---	---	---	---	---	---	Each-Year Operating
3-10-001-24	Valves: General	---	---	---	---	---	---	---	---	1000 Barrels Processed



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Crude Oil Production - 1311</u></i>										
3-10-001-25	Relief Valves	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-10-001-26	Pump Seals	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-10-001-27	Ranges and Connections	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-10-001-28	Oil Heating	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-10-001-29	Gas/Liquid Separation	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-10-001-30	Fugitives: Compressor Seals	---	---	---	---	---	---	---	---	Each-Year Operating
3-10-001-31	Fugitives: Drains	---	---	---	---	---	---	---	---	Each-Year Operating
3-10-001-32	Atmospheric Wash Tank (2nd Stage of Gas-Oil Separation): Flashing Loss	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-10-001-40	Waste Sumps: Primary Light Crude	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-10-001-41	Waste Sumps: Primary Heavy Crude	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-10-001-42	Waste Sumps: Secondary Light Crude	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-10-001-43	Waste Sumps: Secondary Heavy Crude	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-10-001-44	Waste Sumps: Tertiary Light Crude	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-10-001-45	Waste Sumps: Tertiary Heavy Crude	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-10-001-46	Gathering Lines	---	---	---	---	---	---	---	---	1000 Mile-Years Existing
3-10-001-60	Flares	---	---	---	---	---	---	---	---	1000 Barrels Processed
3-10-001-99	Processing Operations: Not Classified	---	---	---	---	---	---	---	---	1000 Barrels Produced
<i><u>Natural Gas Production - 1311</u></i>										
3-10-002-01	Gas Sweetening: Amine Process	---	---	---	1685S	---	---	---	---	Million Cubic Feet Processed
3-10-002-02	Gas Stripping Operations	---	---	---	312.2	---	---	---	---	Million Cubic Feet Produced
3-10-002-03	Compressors	---	---	---	---	---	6	---	---	Million Cubic Feet Produced
3-10-002-04	Wells	---	---	---	---	---	35.3	---	---	Million Cubic Feet Produced
3-10-002-05	Flares	---	---	---	---	---	5.6	---	---	Million Cubic Feet Produced
3-10-002-06	Gas Lift	---	---	---	---	---	6	---	---	Million Cubic Feet Produced
3-10-002-07	Valves: Fugitive Emissions	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-002-08	Sulfur Recovery Unit	---	---	---	---	---	---	---	---	Tons Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Natural Gas Production - 1311</u></i>										
3-10-002-09	Incinerators Burning Waste Gas or Augmented Waste Gas	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
3-10-002-11	Pipeline Pigging (releases during pig removal)	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-002-15	Flares Combusting Gases >1000 BTU/scf	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
3-10-002-16	Flares Combusting Gases <1000 BTU/scf	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
3-10-002-20	All Equip Leak Fugitives (Valves, Flanges, Connections, Seals, Drains	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-002-21	Site Preparation	---	---	---	---	---	---	---	---	100 Acres Prepared
3-10-002-22	Drilling and Well Completion	---	---	---	---	---	---	---	---	Each Drilled
3-10-002-23	Relief Valves	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-002-24	Pump Seals	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-002-25	Compressor Seals	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-002-26	Flanges and Connections	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-002-27	Glycol Dehydrator Reboiler Still Stack	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-002-28	Glycol Dehydrator Reboiler Burner	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-002-29	Gathering Lines	---	---	---	---	---	---	---	---	1000 Mile-Years Existing
3-10-002-30	Hydrocarbon Skimmer	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-002-31	Fugitives: Drains	---	---	---	---	---	---	---	---	Each-Year Operating
3-10-002-99	Other Not Classified	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
<i><u>Natural Gas Processing Facilities - 1311, 1321, 1389, 4911, 4922, 4923</u></i>										
3-10-003-01	Glycol Dehydrators: Reboiler Still Vent: Triethylene Glycol	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-003-02	Glycol Dehydrators: Reboiler Burner Stack: Triethylene Glycol	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-003-03	Glycol Dehydrators: Phase Separator Vent: Triethylene Glycol	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-003-04	Glycol Dehydrators: Ethylene Glycol: General	---	---	---	---	---	---	---	---	Million Cubic Feet Produced

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Natural Gas Processing Facilities - 1311, 1321, 1389, 4911, 4922, 4923</u>										
3-10-003-05	Gas Sweetening: Amine Process	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-003-06	Process Valves	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-003-07	Relief Valves	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-003-08	Open-ended Lines	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-003-09	Compressor Seals	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-003-10	Pump Seals	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-003-11	Flanges and Connections	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
3-10-003-21	Glycol Dehydrators: Niagaran Formation (Mich.)	---	---	---	---	---	---	---	---	Gallon Per Minute-Year Circulated
3-10-003-22	Glycol Dehydrators: Prairie du Chien Formation (Mich.)	---	---	---	---	---	---	---	---	Gallon Per Minute-Year Circulated
3-10-003-23	Glycol Dehydrators: Antrim Formation (Mich.)	---	---	---	---	---	---	---	---	Gallon Per Minute-Year Circulated
<u>Process Heaters - 1300</u>										
3-10-004-01	Distillate Oil (No. 2)	2	1	---	143.6S	20	0.2	5	---	1000 Gallons Burned
3-10-004-02	Residual Oil	12S	10.3S	---	158.6S	55	0.28	5	0.00224	1000 Gallons Burned
3-10-004-03	Crude Oil	12S	10.3S	---	158.6S	55	0.28	5	---	1000 Gallons Burned
3-10-004-04	Natural Gas	3	3	---	0.6	140	2.8	35	---	Million Cubic Feet Burned
3-10-004-05	Process Gas	3	3	---	950S	140	2.8	35	---	Million Cubic Feet Burned
3-10-004-06	Propane/Butane	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-10-004-11	Distillate Oil (No. 2): Steam Generators	2	1	---	143.6S	20	0.2	5	---	1000 Gallons Burned
3-10-004-12	Residual Oil: Steam Generators	12S	10.3S	---	158.6S	55	0.28	5	---	1000 Gallons Burned
3-10-004-13	Crude Oil: Steam Generators	12S	10.3S	---	158.6S	55	0.28	5	<sup>27</sup> 0.00000194	Footnote 60
3-10-004-14	Natural Gas: Steam Generators	3	3	---	0.6	140	2.8	35	---	Million Cubic Feet Burned
3-10-004-15	Process Gas: Steam Generators	3	3	---	---	140	2.8	35	---	Million Cubic Feet Burned
<u>Liquid Waste Treatment - 1311, 5171</u>										
3-10-005-01	Floatation Units	---	---	---	---	---	---	---	---	Barrels Processed
3-10-005-02	Liquid - Liquid Separator	---	---	---	---	---	---	---	---	Barrels Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Liquid Waste Treatment - 1311, 5171</u>										
3-10-005-03	Oil-Water Separator	---	---	---	---	---	---	---	---	Barrels Processed
3-10-005-04	Oil-Sludge-Waste Water Pit	---	---	---	---	---	---	---	---	Barrels Processed
3-10-005-05	Sand Filter Operation	---	---	---	---	---	---	---	---	Barrels Processed
3-10-005-06	Oil-Water Separation Wastewater Holding Tanks	---	---	---	---	---	---	---	---	Square Feet-Years Existing
<u>Fugitive Emissions - 1300</u>										
3-10-888-01	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
3-10-888-02	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
3-10-888-03	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
3-10-888-04	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
3-10-888-05	Specify in Comments Field	---	---	---	---	---	---	---	---	100 Barrels Prepared
3-10-888-11	Fugitive Emissions	---	---	---	---	---	---	---	---	Million Cubic Feet Produced
<u>INDUSTRIAL PROCESSES -Building Construction</u>										
<u>Construction: Building Contractors - 1521, 1522</u>										
3-11-001-01	Site Preparation: Topsoil Removal	---	---	---	---	---	---	---	---	Miles Travelled
3-11-001-02	Site Preparation: Earth Moving (Cut and Fill)	---	---	---	---	---	---	---	---	Miles Travelled
3-11-001-03	Site Preparation: Aggregate Hauling (On Dirt)	---	---	---	---	---	---	---	---	Miles Travelled
3-11-001-99	Other Not Classified	---	---	---	---	---	---	---	---	Acres Processed
<u>Demolitions/Special Trade Contracts - 1521, 1522</u>										
3-11-002-01	Mechanical or Explosive Dismemberment	---	---	---	---	---	---	---	---	Square Feet Demolished
3-11-002-02	Mechanical or Explosive Dismemberment	---	---	---	---	---	---	---	---	Tons Processed
3-11-002-03	Debris Loading	---	---	---	---	---	---	---	---	Square Feet Demolished
3-11-002-04	Debris Loading	---	---	---	---	---	---	---	---	Tons Processed
3-11-002-05	On-site Truck Traffic	---	---	---	---	---	---	---	---	Square Feet Demolished
3-11-002-06	On-site Truck Traffic	---	---	---	---	---	---	---	---	Miles Travelled
3-11-002-99	Other Not Classified: Construction/Demolition	---	---	---	---	---	---	---	---	Acres Processed
<u>INDUSTRIAL PROCESSES -Machinery, Miscellaneous</u>										
<u>Miscellaneous Machinery - 3500</u>										
3-12-999-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<b><i>INDUSTRIAL PROCESSES -Electrical Equipment</i></b>										
<b><i>Electrical Switch Manufacture - 3600, 3613, 3625</i></b>										
3-13-005-00	Electrical Switch Manufacture: Overall Process	---	---	---	---	---	---	---	---	Tons Used
<b><i>Light Bulb Manufacture - 3641</i></b>										
3-13-010-01	Light Bulb Glass to Socket Base Lubrication with SO <sub>2</sub>	---	---	---	---	---	---	---	---	Pounds Used
<b><i>Fluorescent Lamp Manufacture - 3645, 3646, 3648</i></b>										
3-13-011-00	Fluorescent Lamp Manufacture: Overall Process	---	---	---	---	---	---	---	---	Tons Used
<b><i>Fluorescent Lamp Recycling - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</i></b>										
3-13-012-00	Fluorescent Lamp Recycling: Lamp Crusher	---	---	---	---	---	---	---	---	Each Crushed
<b><i>Mercury Oxide Battery Manufacture - 2819</i></b>										
3-13-020-00	Mercury Oxide Battery Manufacture: Overall Process	---	---	---	---	---	---	---	---	Tons Used
<b><i>Manufacturing - General - 3651, 3661, 3663, 3671, 3679</i></b>										
3-13-030-01	Circuit Board Manufacturing	---	---	---	---	---	---	---	---	Each Produced
3-13-030-61	Circuit Board Etching: Acid	---	---	---	---	---	---	---	---	1000 Each Produced
3-13-030-62	Circuit Board Etching: Alkaline	---	---	---	---	---	---	---	---	1000 Each Produced
3-13-030-63	Circuit Board Etching: Plasma	---	---	---	---	---	---	---	---	1000 Each Produced
<b><i>Manufacturing - General Processes - 2899, 3299, 3643, 3651, 3661, 3663, 3671, 3714</i></b>										
3-13-035-01	Soldering	---	---	---	---	---	---	---	---	Pounds Used
3-13-035-02	Cleaning	---	---	---	---	---	---	---	---	Pounds Used
<b><i>Semiconductor Manufacturing - 3299, 3661, 3671, 3674, 3714</i></b>										
3-13-065-00	Integrated Circuit Manufacturing: General	---	---	---	---	---	---	---	---	1000 Each Produced
3-13-065-01	Cleaning Processes: Wet Chemical: Specify Aqueous Solution	---	---	---	---	---	---	---	---	Gallons Consumed
3-13-065-02	Cleaning Process: Plasma Process: Specify Gas Used	---	---	---	---	---	---	---	---	1000 Cubic Feet Used
3-13-065-05	Photoresist Operations: General	---	---	---	---	---	---	---	---	Tons Processed
3-13-065-10	Chemical Vapor Deposition: General: Specify Gas Used	---	---	---	---	---	---	---	---	1000 Cubic Feet Used
3-13-065-20	Diffusion Process: Deposition Operation: Specify Gas Used	---	---	---	---	---	---	---	---	1000 Cubic Feet Used
3-13-065-30	Etching Process: Wet Chemical: Specify Aqueous Solution	---	---	---	---	---	---	---	---	Gallons Consumed
3-13-065-31	Etching Process: Plasma/Reactive Ion: Specify Gas Used	---	---	---	---	---	---	---	---	1000 Cubic Feet Used

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Semiconductor Manufacturing - 3299, 3661, 3671, 3674, 3714</u>										
3-13-065-99	Miscellaneous Operations: General: Specify Material	---	---	---	---	---	---	---	---	Pounds Processed
<u>Electrical Windings Reclamation - 7694</u>										
3-13-070-01	Single Chamber Incinerator/Oven	---	---	---	2.5	---	---	---	---	Tons Charged
3-13-070-02	Multiple Chamber Incinerator/Oven	---	---	---	2.5	---	---	---	---	Tons Charged
<u>Equipment Leaks - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</u>										
3-13-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Wastewater, Aggregate - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</u>										
3-13-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-13-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Wastewater, Points of Generation - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</u>										
3-13-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Process Heaters - 7600</u>										
3-13-900-01	Distillate Oil (No. 2)	---	---	---	143.68	20	0.2	---	---	1000 Gallons Burned
3-13-900-02	Residual Oil	---	---	---	158.68	55	0.28	---	---	1000 Gallons Burned
3-13-900-03	Natural Gas	---	---	---	0.6	140	2.8	---	---	Million Cubic Feet Burned
<u>Other Not Classified - 7600</u>										
3-13-999-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>INDUSTRIAL PROCESSES -Transportation Equipment</u>										
<u>Automobiles/Truck Assembly Operations - 3731, 3713</u>										
3-14-009-01	Solder Joint Grinding	---	---	---	---	---	---	---	---	Each Processed
3-14-009-02	Soldering Machine	---	---	---	---	---	---	---	---	Each Processed
3-14-009-03	Stamping	---	---	---	---	---	---	---	---	Each Processed
<u>Brake Shoe Debonding - 7539</u>										
3-14-010-01	Single Chamber Incinerator	---	---	---	2.5	---	---	---	---	Tons Charged
3-14-010-02	Multiple Chamber Incinerator	---	---	---	2.5	---	---	---	---	Tons Charged
<u>Auto Body Shredding - 5093</u>										
3-14-011-01	Primary Metal Recovery Line	---	---	---	---	---	---	---	---	Tons Processed
3-14-011-02	Secondary Metal Recovery Line	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Welding/Soldering Automotive Repair - 7530, 7532, 7533, 7537, 7539</u></i>										
3-14-012-01	Soldering	---	---	---	---	---	---	---	---	Pounds Processed
<i><u>Boat Manufacturing - 3732</u></i>										
3-14-015-01	General	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-03	Resin Storage	---	---	---	---	---	---	---	---	Tons Stored
3-14-015-04	Resin Transfer	---	---	---	---	---	---	---	---	Tons Transferred
3-14-015-10	Molding and Lamination Operations	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-11	Open Contact Molding: Gel Coat Application, Hand Layup	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-12	Open Contact Molding: Gel Coat Application, Spray Layup	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-13	Open Contact Molding: Gel Coat Curing	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-14	Open Contact Molding: Resin/Laminate Application, Machine Layup	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-15	Open Contact Molding: Resin/Laminate Application, Hand Layup, Spraying	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-16	Open Contact Molding: Resin/Laminate Application, Hand Layup, Brushing	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-17	Open Contact Molding: Resin/Laminate Application, Spray Layup	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-18	Open Contact Molding: Resin/Laminate Curing	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-25	Resin Transfer Molding	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-30	Bag Molding: Resin/Lamination, Hand Layup	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-31	Bag Molding: Resin/Lamination, Spray Layup	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-40	Lamination: Preparation of Resin/Laminate	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-41	Lamination: Polyurethane Foams	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-50	Assembly Area	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-51	Assembly Area: Sanding/Trimming of Laminated Parts	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-52	Assembly Area: Paint Spraying	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-53	Assembly Area: Carpet Glues	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-60	Cleanup	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-61	Cleanup: Tools (Other than Spray Guns)	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-62	Cleanup: Spray Guns	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-63	Cleanup: Molds	---	---	---	---	---	---	---	---	Each Manufactured
3-14-015-70	Waste Disposal: Used Cleanup Solvents	---	---	---	---	---	---	---	---	1000 Gallons Disposed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Boat Manufacturing - 3732</i></u>										
3-14-015-71	Waste Disposal: Stills	---	---	---	---	---	---	---	---	1000 Gallons Disposed
<u><i>Equipment Leaks - 9711</i></u>										
3-14-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u><i>Wastewater, Aggregate - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</i></u>										
3-14-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-14-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u><i>Wastewater, Point of Generation - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</i></u>										
3-14-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u><i>Other Not Classified - 3700, 5000, 7500</i></u>										
3-14-999-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u><i>INDUSTRIAL PROCESSES -Photographic Equipment/Health Care/Laboratories</i></u>										
<u><i>Photocopying Equipment Manufacturing - 3861</i></u>										
3-15-010-01	Resin Transfer/Storage	---	---	---	---	---	---	---	---	1000 Pounds Processed
3-15-010-02	Toner Classification	---	---	---	---	---	630	---	---	1000 Pounds Processed
3-15-010-03	Toner (Carbon Black) Grinding	---	---	---	---	---	---	---	---	1000 Pounds Processed
<u><i>Health Care - Hospitals - 8062</i></u>										
3-15-020-01	Sterilization with Ethylene Oxide	---	---	---	---	---	2000	---	---	Tons Consumed
3-15-020-02	Sterilization with Freon	---	---	---	---	---	---	---	---	Tons Consumed
3-15-020-03	Sterilization with Formaldehyde	---	---	---	---	---	---	---	---	Tons Consumed
3-15-020-04	Sterilization - Steam Autoclaving	---	---	---	---	---	---	---	---	
3-15-020-21	Shredding Medical Waste	---	---	---	---	---	---	---	---	
3-15-020-88	Laboratory Fugitive Emissions	---	---	---	---	---	---	---	---	Gallons Consumed
3-15-020-89	Miscellaneous Fugitive Emissions	---	---	---	---	---	---	---	---	Gallons Consumed
<u><i>Health Care - Crematoriums - 3860, 7260, 8000</i></u>										
3-15-021-01	Crematory Stack	0.0000559	---	---	---	---	---	---	0.0000662	Each Burned
3-15-021-02	Crematory Stack - Human and Animal Crematories	---	---	---	---	---	---	---	---	Tons Burned
<u><i>Dental Alloy (Mercury Amalgams) Production - 3843, 3860, 8000, 8072</i></u>										
3-15-025-00	Dental Alloy (Mercury Amalgams) Production: Overall Process	---	---	---	---	---	---	---	---	Tons Used



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Thermometer Manufacture - 3820, 3829, 3840, 3860, 8000</u>										
3-15-027-00	Thermometer Manufacture: Overall Process	---	---	---	---	---	---	---	---	Tons Used
<u>Laboratories - 3821, 3860, 8000, 8070, 8071, 8072, 8090</u>										
3-15-030-01	Bench Scale Reagents: Research	---	---	---	---	---	---	---	---	Pounds Processed
3-15-030-02	Bench Scale Reagents: Testing	---	---	---	---	---	---	---	---	Pounds Processed
3-15-030-03	Bench Scale Reagents: Medical	---	---	---	---	---	---	---	---	Pounds Processed
<u>X-rays - 3844, 3860, 8000, 8070, 8071, 8072, 8090</u>										
3-15-031-01	Medical: General	---	---	---	---	---	---	---	---	Each Taken
3-15-031-02	Structural: General	---	---	---	---	---	---	---	---	Each Taken
<u>Commercial Swimming Pools - Chlorination-Chloroform - 3860, 8000, 8070, 8071, 8072, 8090</u>										
3-15-040-01	Chlorination: Chloroform	---	---	---	---	---	---	---	---	Pounds Used
<u>Air-conditioning/Refrigeration - Freons - 3860, 7623, 8000, 8070, 8071, 8072, 8090</u>										
3-15-050-01	Cooling Fluid: Miscellaneous: Freons	---	---	---	---	---	---	---	---	Tons Consumed
3-15-050-02	Cooling Fluid: Miscellaneous: Ammonia	---	---	---	---	---	---	---	---	Tons Consumed
3-15-050-03	Cooling Fluid: Miscellaneous: Specify Fluid	---	---	---	---	---	---	---	---	Tons Consumed
<u>INDUSTRIAL PROCESSES -Photographic Film Manufacturing</u>										
<u>Product Manufacturing - Substrate Preparation - 3861</u>										
3-16-030-01	Extrusion Operations	---	---	---	---	---	---	---	---	
3-16-030-02	Film Support Operations	---	---	---	---	---	---	---	---	
<u>Product Manufacturing - Chemical Preparation - 3861</u>										
3-16-040-01	Chemical Manufacturing	---	---	---	---	---	---	---	---	
3-16-040-02	Emulsion Making Operations	---	---	---	---	---	---	---	---	
3-16-040-03	Chemical Mixing Operations	---	---	---	---	---	---	---	---	
<u>Product Manufacturing - Surface Treatments - 3861</u>										
3-16-050-01	Surface Coating Operations	---	---	---	---	---	---	---	---	
3-16-050-02	Grid Ionizers	---	---	---	---	---	---	---	---	
3-16-050-03	Corona Discharge Treatment	---	---	---	---	---	---	---	---	
3-16-050-04	Photographic Drying Operations	---	---	---	---	---	---	---	---	
<u>Product Manufacturing - Finishing Operations - 3861</u>										
3-16-060-01	General Film Manufacturing	---	---	---	---	---	---	---	---	

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Product Manufacturing - Finishing Operations - 3861</u>										
3-16-060-02	Cutting/Slitting Operations	---	---	---	---	---	---	---	---	
<u>Support Activities - Cleaning Operations - 3861</u>										
3-16-120-01	Tank Cleaning Operations	---	---	---	---	---	---	---	---	
3-16-120-02	General Cleaning Operations	---	---	---	---	---	---	---	---	
3-16-120-03	Parts Cleaning Operations	---	---	---	---	---	---	---	---	
<u>Support Activities - Storage Operations - 3861</u>										
3-16-130-01	Solvent Storage Operations	---	---	---	---	---	---	---	---	
3-16-130-02	General Storage Operations	---	---	---	---	---	---	---	---	
3-16-130-03	Storage Silos	---	---	---	---	---	---	---	---	
3-16-130-04	Waste Storage Operations	---	---	---	---	---	---	---	---	
<u>Support Activities - Material Transfer Operations - 3861</u>										
3-16-140-01	Filling Operations (non petroleum)	---	---	---	---	---	---	---	---	
3-16-140-02	Transfer of Chemicals	---	---	---	---	---	---	---	---	
<u>Support Activities - Separation Processes - 3861</u>										
3-16-150-01	Recovery Operations	---	---	---	---	---	---	---	---	
3-16-150-02	Regeneration Operations	---	---	---	---	---	---	---	---	
3-16-150-03	Distillation Operations	---	---	---	---	---	---	---	---	
3-16-150-04	Filtration Operations	---	---	---	---	---	---	---	---	
<u>Support Activities - Other Operations - 3861</u>										
3-16-160-01	General Ventillation - Manufacturing Areas	---	---	---	---	---	---	---	---	
3-16-160-02	General Process Tank Operations	---	---	---	---	---	---	---	---	
3-16-160-03	Miscellaneous Manufacturing Operations	---	---	---	---	---	---	---	---	
3-16-160-04	Paint Spraying Operations	---	---	---	---	---	---	---	---	
3-16-160-05	General Maintenance Operations	---	---	---	---	---	---	---	---	
3-16-160-06	Chemical Weighing Operations	---	---	---	---	---	---	---	---	
<u>INDUSTRIAL PROCESSES -Leather and Leather Products</u>										
<u>Other Not Classified - 3100</u>										
3-20-999-97	Other Not Classified	---	---	---	---	---	---	---	---	1000 Square Feet Processed
3-20-999-98	Other Not Classified	---	---	---	---	---	19	---	---	Gallons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Other Not Classified - 3100</u>										
3-20-999-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>INDUSTRIAL PROCESSES -Textile Products</u>										
<u>Miscellaneous - 2261, 2262, 2280, 2290</u>										
3-30-001-01	Yarn Preparation/Bleaching	---	---	---	---	---	---	---	---	Tons Processed
3-30-001-02	Printing	---	---	---	---	---	284	---	---	Tons Processed
3-30-001-03	Polyester Thread Production	---	---	---	---	---	---	---	---	Tons Processed
3-30-001-04	Tenter Frames: Heat Setting	---	---	---	---	---	0.47	---	---	Tons Processed
3-30-001-05	Carding	---	---	---	---	---	---	---	---	Tons Processed
3-30-001-06	Drying	---	---	---	---	---	---	---	---	Tons Processed
3-30-001-98	Other Not Classified	---	---	---	---	---	---	---	---	1000 Feet Processed
3-30-001-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Rubberized Fabrics - 3069, 2241</u>										
3-30-002-01	General	---	---	---	---	---	---	---	---	Tons Processed
3-30-002-02	Wet Coating: General	---	---	---	---	---	---	---	---	Tons Processed
3-30-002-03	Hot Melt Coating: General	---	---	---	---	---	---	---	---	Tons Processed
3-30-002-11	Impregnation	---	---	---	---	---	---	---	---	Tons Applied
3-30-002-12	Wet Coating	---	---	---	---	---	1200	---	---	Tons Applied
3-30-002-13	Hot Melt Coating	---	---	---	---	---	---	---	---	Tons Applied
3-30-002-14	Wet Coating Mixing	---	---	---	---	---	120	---	---	Tons Mixed
3-30-002-97	Other Not Classified	---	---	---	---	---	---	---	---	Tons Consumed
3-30-002-98	Other Not Classified	---	---	---	---	---	---	---	---	Gallons Processed
3-30-002-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u>Carpet Operations - 2273</u>										
3-30-003-01	Preparation/Processing	---	---	---	---	---	---	---	---	Tons Processed
3-30-003-02	Printing/Dyeing	---	---	---	---	---	---	---	---	Gallons Processed
3-30-003-03	Basic Material Mixing	---	---	---	---	---	---	---	---	Tons Processed
3-30-003-04	Shearing	---	---	---	---	---	---	---	---	Tons Processed
3-30-003-05	Pile Erector	---	---	---	---	---	---	---	---	Tons Processed
3-30-003-06	Heat Treating	---	---	---	---	---	---	---	---	Tons Processed
3-30-003-07	Drying	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Carpet Operations - 2273</i></u>										
3-30-003-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Fabric Finishing - 2261, 2262, 2269</i></u>										
3-30-004-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Processed
<u><i>Fabric Finishing - 2261, 2262, 2269</i></u>										
3-30-005-99	Other Not Classified	---	---	---	---	---	---	---	---	Each Produced
<u><i>Fugitive Emissions - 2200, 3000</i></u>										
3-30-888-01	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
3-30-888-02	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
3-30-888-03	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
3-30-888-04	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
3-30-888-05	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
<u><i>INDUSTRIAL PROCESSES -Printing and Publishing</i></u>										
<u><i>Typesetting (Lead Remelting) - 2791</i></u>										
3-60-001-01	Remelting (Lead Emissions Only)	0.7	0.18	---	---	---	---	---	0.25	Tons Melted
<u><i>INDUSTRIAL PROCESSES -Cooling Tower</i></u>										
<u><i>Process Cooling - multiple (See Appendix D)</i></u>										
3-85-001-01	Mechanical Draft	---	19	---	---	---	---	---	---	Million Gallons Throughput
3-85-001-02	Natural Draft	---	---	---	---	---	---	---	---	Million Gallons Throughput
3-85-001-10	Other Not Specified	---	---	---	---	---	---	---	---	Million Gallons Throughput
<u><i>INDUSTRIAL PROCESSES -In-process Fuel Use</i></u>										
<u><i>Anthracite Coal - multiple (See Appendix D)</i></u>										
3-90-001-89	General	10A	2.3A	---	39S	18	0.07	0.6	---	Tons Burned
3-90-001-99	General	---	---	---	---	---	---	---	---	Tons Burned
<u><i>Bituminous Coal - multiple (See Appendix D)</i></u>										
3-90-002-01	Cement Kiln/Dryer (Bituminous Coal)	---	---	---	---	---	---	---	---	Tons Burned
3-90-002-03	Lime Kiln (Bituminous)	---	---	---	---	---	---	---	---	Tons Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Bituminous Coal - multiple (See Appendix D)</i>										
3-90-002-88	General (Subbituminous)	7A	1.6A	---	39S	34	0.07	0.6	---	Tons Burned
3-90-002-89	General (Bituminous)	7A	1.4A	---	39S	34	0.07	0.6	---	Tons Burned
3-90-002-99	General (Bituminous)	---	---	---	---	---	---	---	---	Tons Burned
<i>Lignite - 2297</i>										
3-90-003-89	General	6.3A	1.3A	---	30S	14	0.07	0.6	---	Tons Burned
3-90-003-99	General	---	---	---	---	---	---	---	---	Tons Burned
<i>Residual Oil - multiple (See Appendix D)</i>										
3-90-004-02	Cement Kiln/Dryer	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-90-004-03	Lime Kiln	---	---	---	79.5S	---	---	---	---	1000 Gallons Burned
3-90-004-89	General	12S	10.3S	---	158.6S	55	0.28	5	---	1000 Gallons Burned
3-90-004-99	General	---	---	---	---	---	---	---	---	1000 Gallons Burned
<i>Distillate Oil - multiple (See Appendix D)</i>										
3-90-005-01	Asphalt Dryer	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-90-005-02	Cement Kiln/Dryer	---	---	---	98S	---	---	---	---	1000 Gallons Burned
3-90-005-03	Lime Kiln	---	---	---	72S	---	---	---	---	1000 Gallons Burned
3-90-005-89	General	2	1	---	143.6S	20	0.2	5	---	1000 Gallons Burned
3-90-005-98	Grade 4 Oil: General	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-90-005-99	General	---	---	---	---	---	---	---	---	1000 Gallons Burned
<i>Natural Gas - multiple (See Appendix D)</i>										
3-90-006-02	Cement Kiln/Dryer	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
3-90-006-03	Lime Kiln	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
3-90-006-05	Metal Melting	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
3-90-006-89	General	3	3	---	0.6	---	---	---	---	Million Cubic Feet Burned
3-90-006-99	General	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
<i>Process Gas - multiple (See Appendix D)</i>										
3-90-007-01	Coke Oven or Blast Furnace	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
3-90-007-02	Coke Oven Gas	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
3-90-007-88	General	---	3	---	---	---	---	---	---	Million Cubic Feet Burned
3-90-007-89	Coke Oven Gas	---	4.3	---	---	---	---	---	---	Million Cubic Feet Burned
3-90-007-97	General	---	---	---	---	---	---	---	---	Million Cubic Feet Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Process Gas - multiple (See Appendix D)</i>										
3-90-007-98	General	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
3-90-007-99	General	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
<i>Coke - multiple (See Appendix D)</i>										
3-90-008-01	Mineral Wool Fuel	---	---	---	---	---	---	---	---	Tons Burned
3-90-008-89	General	---	---	---	---	---	---	---	---	Tons Burned
3-90-008-99	General: Coke	---	---	---	---	---	---	---	---	Tons Burned
<i>Wood - multiple (See Appendix D)</i>										
3-90-009-89	General	---	6.5	---	---	---	---	---	---	Tons Burned
3-90-009-99	General: Wood	---	---	---	---	---	---	---	---	Tons Burned
<i>Liquified Petroleum Gas - multiple (See Appendix D)</i>										
3-90-010-89	General	0.4	0.4	---	---	14	0.5	1.9	---	1000 Gallons Burned
3-90-010-99	General	---	---	---	---	---	---	---	---	1000 Gallons Burned
<i>Solid Waste - multiple (See Appendix D)</i>										
3-90-012-89	Solid Waste: General	---	---	---	---	---	---	---	---	Tons Burned
3-90-012-99	General	---	---	---	---	---	---	---	---	Tons Burned
<i>Liquid Waste - multiple (See Appendix D)</i>										
3-90-013-85	Recovered Solvent: General	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-90-013-89	General	19	16.3	---	---	---	---	---	---	1000 Gallons Burned
3-90-013-99	General	---	---	---	---	---	---	---	---	1000 Gallons Burned
<i>Fuel Storage - Fixed Roof Tanks - 2851</i>										
3-90-900-01	Residual Oil: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-90-900-02	Residual Oil: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-90-900-03	Distillate Oil (No. 2): Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-90-900-04	Distillate Oil (No. 2): Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-90-900-05	Oil No. 6: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-90-900-06	Oil No. 6: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-90-900-07	Methanol: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-90-900-08	Methanol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Fuel Storage - Fixed Roof Tanks - 2851</u></i>										
3-90-900-09	Residual Oil/Crude Oil: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-90-900-10	Residual Oil/Crude Oil: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-90-900-11	Dual Fuel (Gas/Oil): Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-90-900-12	Dual Fuel (Gas/Oil): Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fuel Storage - Floating Roof Tanks - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</u></i>										
3-90-910-01	Residual Oil: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-90-910-02	Residual Oil: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-90-910-03	Distillate Oil (No. 2): Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-90-910-04	Distillate Oil (No. 2): Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-90-910-05	Oil No. 6: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-90-910-06	Oil No. 6: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-90-910-07	Methanol: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-90-910-08	Methanol: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-90-910-09	Residual Oil/Crude Oil: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-90-910-10	Residual Oil/Crude Oil: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-90-910-11	Dual Fuel (Gas/Oil): Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
3-90-910-12	Dual Fuel (Gas/Oil): Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fuel Storage - Pressure Tanks - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</u></i>										
3-90-920-50	Natural Gas: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-90-920-51	LPG: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-90-920-52	Landfill Gas: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-90-920-53	Refinery Gas: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-90-920-54	Digester Gas: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-90-920-55	Process Gas: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
3-90-920-56	Dual Fuel (Gas/Oil): Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>INDUSTRIAL PROCESSES -Miscellaneous Manufacturing Industries</u></i>										
<i><u>Process Heater/Furnace - 2911</u></i>										
3-99-005-01	Distillate Oil	---	---	---	---	---	---	---	---	1000 Gallons Burned
<i><u>Process Heater/Furnace - 2891, 2899, 3411, 3423, 3471, 3493, 3523, 3531, 35</u></i>										
3-99-006-01	Natural Gas	---	---	---	---	---	---	---	---	1000 Cubic Feet Burned
<i><u>Process Heater/Furnace - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</u></i>										
3-99-007-01	Process Gas	---	---	---	---	---	---	---	---	1000 Cubic Feet Burned
3-99-007-11	Refinery Gas	---	---	---	---	---	---	---	---	1000 Cubic Feet Burned
3-99-007-21	Digester Gas	---	---	---	---	---	---	---	---	1000 Cubic Feet Burned
<i><u>Process Heater/Furnace - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</u></i>										
3-99-008-01	Landfill Gas	---	---	---	---	---	---	---	---	1000 Cubic Feet Burned
<i><u>Process Heater/Furnace - 3356</u></i>										
3-99-010-01	LPG	---	---	---	---	---	---	---	---	1000 Gallons Burned
<i><u>Process Heater/Furnace - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</u></i>										
3-99-016-01	Methanol	---	---	---	---	---	---	---	---	1000 Gallons Burned
<i><u>Process Heater/Furnace - 2641, 2671, 2800, 2810, 2821, 2851, 2899, 3299</u></i>										
3-99-017-01	Gasoline	---	---	---	---	---	---	---	---	1000 Gallons Burned
<i><u>Miscellaneous Manufacturing Industries - 3900</u></i>										
3-99-900-01	Distillate Oil (No. 2): Process Heaters	---	---	---	143.6S	20	0.2	---	---	1000 Gallons Burned
3-99-900-02	Residual Oil: Process Heaters	---	---	---	158.6S	55	0.28	---	---	1000 Gallons Burned
3-99-900-03	Natural Gas: Process Heaters	---	---	---	0.6	140	2.8	---	---	Million Cubic Feet Burned
3-99-900-04	Process Gas: Process Heaters	---	---	---	950S	140	2.8	---	---	Million Cubic Feet Burned
3-99-900-11	Distillate Oil (No. 2): Incinerators	---	---	---	---	---	0.4	---	---	1000 Gallons Burned
3-99-900-12	Residual Oil: Incinerators	---	---	---	---	---	0.56	---	---	1000 Gallons Burned
3-99-900-13	Natural Gas: Incinerators	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-99-900-14	Process Gas: Incinerators	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-99-900-21	Distillate Oil (No. 2 Oil): Flares	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-99-900-22	Residual Oil: Flares	---	---	---	---	---	---	---	---	1000 Gallons Burned
3-99-900-23	Natural Gas: Flares	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
3-99-900-24	Process Gas: Flares	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Miscellaneous Industrial Processes - 3900</i>										
3-99-999-89	Other Not Classified	---	---	---	---	---	---	---	---	Kilograms Processed
3-99-999-91	Other Not Classified	---	---	---	---	---	---	---	---	Kilowatt-Hour Used
3-99-999-92	Other Not Classified	---	---	---	---	---	---	---	---	Hour Operated
3-99-999-93	Other Not Classified	---	---	---	---	---	---	---	---	Each Processed
3-99-999-94	Other Not Classified	---	---	---	---	---	---	---	---	Pounds Processed
3-99-999-95	Other Not Classified	---	---	---	---	---	---	---	---	Gallons Processed
3-99-999-96	Other Not Classified	---	---	---	---	---	---	---	---	1000 Gallons Processed
3-99-999-97	Other Not Classified	---	---	---	---	---	---	---	---	Each Processed
3-99-999-98	Other Not Classified	---	---	---	---	---	---	---	---	1000 Each Produced
3-99-999-99	See Comment	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
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## **PETROLEUM AND SOLVENT EVAPORATION**

### **PETROLEUM AND SOLVENT EVAPORATION -Organic Solvent Evaporation**

#### **Dry Cleaning - 7215, 7216, 7218**

4-01-001-01	Perchloroethylene	---	---	---	---	---	550	---	---	Tons Cleaned
4-01-001-02	Stoddard (Petroleum Solvent) (Use 4-10-001-01 or 4-10-002-01)	---	---	---	---	---	560	---	---	Tons Cleaned
4-01-001-03	Perchloroethylene	---	---	---	---	---	2000	---	---	Tons Consumed
4-01-001-04	Stoddard (Petroleum Solvent) (Use 4-10-001-02 or 4-10-002-02)	---	---	---	---	---	2000	---	---	Tons Consumed
4-01-001-05	Trichlorotrifluoroethane (Freon)	---	---	---	---	---	---	---	---	Tons Consumed
4-01-001-06	Trichlorotrifluoroethane (Freon)	---	---	---	---	---	---	---	---	Tons Cleaned
4-01-001-07	Ethylene Oxide: General	---	---	---	---	---	---	---	---	Tons Consumed
4-01-001-13	Perchloroethylene	---	---	---	---	---	---	---	---	Gallons Consumed
4-01-001-46	Stoddard:Filtr Disp/Cooked Muck(Drained) (Use 4-10-001-61 or 002-61)	---	---	---	---	---	---	---	---	Tons Cleaned
4-01-001-47	Stoddard:Filtr Disp/Cooked Muck (Centrif) (Use 4-10-001-62 or 002-62)	---	---	---	---	---	---	---	---	Tons Cleaned
4-01-001-60	Trichlorofluoroethane: Washer/Dryer/Still	---	---	---	---	---	---	---	---	Tons Cleaned
4-01-001-61	Trichlorofluoroethane: Cartridge Filter Disposal	---	---	---	---	---	---	---	---	Tons Cleaned
4-01-001-62	Trichlorofluoroethane: Still Residue Disposal	---	---	---	---	---	---	---	---	Tons Cleaned
4-01-001-63	Trichlorofluoroethane: Miscellaneous Fugitive	---	---	---	---	---	---	---	---	Tons Cleaned
4-01-001-98	Other Not Classified	---	---	---	---	---	---	---	---	Tons Consumed
4-01-001-99	See Comment	---	---	---	---	---	---	---	---	Tons Cleaned

#### **Degreasing - 2500, 3300, 3900, 7500**

4-01-002-01	Stoddard (Petroleum Solvent): Open-top Vapor Degreasing	---	---	---	---	---	2000	---	---	Tons Used
4-01-002-02	1,1,1-Trichloroethane (Methyl Chloroform): Open-top Vapor Degreasing	---	---	---	---	---	---	---	---	Tons Used
4-01-002-03	Perchloroethylene: Open-top Vapor Degreasing	---	---	---	---	---	2000	---	---	Tons Used
4-01-002-04	Methylene Chloride: Open-top Vapor Degreasing	---	---	---	---	---	---	---	---	Tons Used
4-01-002-05	Trichloroethylene: Open-top Vapor Degreasing	---	---	---	---	---	2000	---	---	Tons Used
4-01-002-06	Toluene: Open-top Vapor Degreasing	---	---	---	---	---	2000	---	---	Tons Used
4-01-002-07	Trichlorotrifluoroethane (Freon): Open-top Vapor Degreasing	---	---	---	---	---	---	---	---	Tons Used

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Degreasing - 2500, 3300, 3900, 7500</u>										
4-01-002-08	Chlorosolve: Open-top Vapor Degreasing	---	---	---	---	---	2000	---	---	Tons Used
4-01-002-09	Butyl Acetate	---	---	---	---	---	2000	---	---	Tons Used
4-01-002-15	Entire Unit: Open-top Vapor Degreasing	---	---	---	---	---	21000	---	---	Each-Year Operating
4-01-002-16	Degreaser: Entire Unit	---	---	---	---	---	150	---	---	1000 Square Feet Degreased
4-01-002-17	Entire Unit	---	---	---	---	---	0.15	---	---	Square Feet-Hours Operated
4-01-002-21	Stoddard (Petroleum Solvent): Conveyorized Vapor Degreasing	---	---	---	---	---	2000	---	---	Tons Used
4-01-002-22	1,1,1-Trichloroethane (Methyl Chloroform):Conveyorized Vapor Degreaser	---	---	---	---	---	1031	---	---	Tons Used
4-01-002-23	Perchloroethylene: Conveyorized Vapor Degreasing	---	---	---	---	---	2000	---	---	Tons Used
4-01-002-24	Methylene Chloride: Conveyorized Vapor Degreasing	---	---	---	---	---	---	---	---	Tons Used
4-01-002-25	Trichloroethylene: Conveyorized Vapor Degreasing	---	---	---	---	---	2000	---	---	Tons Used
4-01-002-35	Entire Unit: with Vaporized Solvent: Conveyorized Vapor Degreasing	---	---	---	---	---	52000	---	---	Each-Year Operating
4-01-002-36	Entire Unit: with Non-boiling Solvent: Conveyorized Vapor Degreasing	---	---	---	---	---	104000	---	---	Each-Year Operating
4-01-002-51	Stoddard (Petroleum Solvent): General Degreasing Units	---	---	---	---	---	7	---	---	Gallons Consumed
4-01-002-52	1,1,1-Trichloroethane (Methyl Chloroform): General Degreasing Units	---	---	---	---	---	---	---	---	Gallons Consumed
4-01-002-53	Perchloroethylene: General Degreasing Units	---	---	---	---	---	13.6	---	---	Gallons Consumed
4-01-002-54	Methylene Chloride: General Degreasing Units	---	---	---	---	---	---	---	---	Gallons Consumed
4-01-002-55	Trichloroethylene: General Degreasing Units	---	---	---	---	---	12.2	---	---	Gallons Consumed
4-01-002-56	Toluene: General Degreasing Units	---	---	---	---	---	7.2	---	---	Gallons Consumed
4-01-002-57	Trichlorotrifluoroethane (Freon): General Degreasing Units	---	---	---	---	---	---	---	---	Gallons Consumed
4-01-002-58	Trichlorofluoromethane: General Degreasing Units	---	---	---	---	---	---	---	---	Gallons Consumed
4-01-002-59	1,1,1-Trichloroethane (Methyl Chloroform): General Degreasing Units	---	---	---	---	---	---	---	---	Gallons Consumed
4-01-002-95	Other Not Classified: General Degreasing Units	---	---	---	---	---	---	---	---	Gallons Consumed
4-01-002-96	Other Not Classified: General Degreasing Units	---	---	---	---	---	---	---	---	Gallons Consumed
4-01-002-97	Other Not Classified: Open-top Vapor Degreasing	---	---	---	---	---	---	---	---	Gallons Consumed
4-01-002-98	Other Not Classified: Conveyorized Vapor Degreasing	---	---	---	---	---	2000	---	---	Tons Used
4-01-002-99	Other Not Classified: Open-top Vapor Degreasing	---	---	---	---	---	---	---	---	Tons Used

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Cold Solvent Cleaning/Stripping - 2500, 3300, 3900, 7500</u></i>										
4-01-003-01	Methanol	---	---	---	---	---	2000	---	---	Tons Consumed
4-01-003-02	Methylene Chloride	---	---	---	---	---	---	---	---	Tons Consumed
4-01-003-03	Stoddard (Petroleum Solvent)	---	---	---	---	---	2000	---	---	Tons Consumed
4-01-003-04	Perchloroethylene	---	---	---	---	---	2000	---	---	Tons Consumed
4-01-003-05	1,1,1-Trichloroethane (Methyl Chloroform)	---	---	---	---	---	---	---	---	Tons Consumed
4-01-003-06	Trichloroethylene	---	---	---	---	---	2000	---	---	Tons Consumed
4-01-003-07	Isopropyl Alcohol	---	---	---	---	---	2000	---	---	Tons Consumed
4-01-003-08	Methyl Ethyl Ketone	---	---	---	---	---	2000	---	---	Tons Consumed
4-01-003-09	Freon	---	---	---	---	---	---	---	---	Tons Consumed
4-01-003-10	Acetone	---	---	---	---	---	2000	---	---	Tons Consumed
4-01-003-11	Glycol Ethers	---	---	---	---	---	---	---	---	Tons Consumed
4-01-003-35	Entire Unit	---	---	---	---	---	660	---	---	Each-Year Operating
4-01-003-36	Degreaser: Entire Unit	---	---	---	---	---	80	---	---	1000 Square Feet Degreased
4-01-003-98	Other Not Classified	---	---	---	---	---	---	---	---	Gallons Consumed
4-01-003-99	Other Not Classified	---	---	---	---	---	2000	---	---	Tons Consumed
<i><u>Knit Fabric Scouring with Chlorinated Solvent - 2200</u></i>										
4-01-004-01	Perchloroethylene	---	---	---	---	---	2000	---	---	Tons Consumed
4-01-004-99	Other Not Classified	---	---	---	---	---	2000	---	---	Tons Consumed
<i><u>Solvent Storage - 3861</u></i>										
4-01-005-01	General Processes: Spent Solvent Storage	---	---	---	---	---	---	---	---	Gallons Stored
4-01-005-50	General Processes: Drum Storage - Pure Organic Chemicals	---	---	---	---	---	---	---	---	Gallons Stored
<i><u>Fugitive Emissions - 2500, 3300, 3900, 7500</u></i>										
4-01-888-01	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
4-01-888-02	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
4-01-888-03	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
4-01-888-04	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
4-01-888-05	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
4-01-888-98	Specify in Comments Field	---	---	---	---	---	---	---	---	Gallons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>PETROLEUM AND SOLVENT EVAPORATION -Surface Coating Operations</u>										
<u>Surface Coating Application - General - multiple (See Appendix D)</u>										
4-02-001-01	Paint: Solvent-base	---	---	---	---	---	1120	---	---	Tons Applied
4-02-001-10	Paint: Solvent-base	---	---	---	---	---	5.6	---	---	Gallons Processed
<u>Surface Coating Application - General - multiple (See Appendix D)</u>										
4-02-002-01	Paint: Water-base	---	---	---	---	---	246	---	---	Tons Applied
4-02-002-10	Paint: Water-base	---	---	---	---	---	1.3	---	---	Gallons Processed
<u>Surface Coating Application - General - multiple (See Appendix D)</u>										
4-02-003-01	Varnish/Shellac	---	---	---	---	---	1000	---	---	Tons Applied
4-02-003-10	Varnish/Shellac	---	---	---	---	---	3.3	---	---	Gallons Processed
<u>Surface Coating Application - General - multiple (See Appendix D)</u>										
4-02-004-01	Lacquer	---	---	---	---	---	1540	---	---	Tons Applied
4-02-004-10	Lacquer	---	---	---	---	---	6.1	---	---	Gallons Processed
<u>Surface Coating Application - General - multiple (See Appendix D)</u>										
4-02-005-01	Enamel	---	---	---	---	---	840	---	---	Tons Applied
4-02-005-10	Enamel	---	---	---	---	---	3.5	---	---	Gallons Processed
<u>Surface Coating Application - General - multiple (See Appendix D)</u>										
4-02-006-01	Primer	---	---	---	---	---	1320	---	---	Tons Applied
4-02-006-10	Primer	---	---	---	---	---	6.6	---	---	Gallons Processed
<u>Surface Coating Application - General - multiple (See Appendix D)</u>										
4-02-007-01	Adhesive Application	---	---	---	---	---	1270	---	---	Tons Applied
4-02-007-06	Adhesive: Solvent Mixing	---	---	---	---	---	---	---	---	Tons Mixed
4-02-007-07	Adhesive: Solvent Storage	---	---	---	---	---	---	---	---	Tons Stored
4-02-007-10	Adhesive: General	---	---	---	---	---	4.4	---	---	Gallons Processed
4-02-007-11	Adhesive: Spray	---	---	---	---	---	---	---	---	Gallons Applied
4-02-007-12	Adhesive: Roll-on	---	---	---	---	---	---	---	---	Gallons Applied
<u>Coating Oven - General - multiple (See Appendix D)</u>										
4-02-008-01	General	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-02	Dried < 175F	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-03	Baked > 175F	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Coating Oven - General - multiple (See Appendix D)</i>										
4-02-008-10	General	---	---	---	---	---	---	---	---	Gallons Processed
4-02-008-20	Prime/Base Coat Oven	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-30	Topcoat Oven	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-40	Two Piece Can Curing Ovens: General (Includes Codes 41, 42, and 43)	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-41	Two Piece Can Base Coat Oven	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-42	Two Piece Can Over Varnish Oven	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-43	Two Piece Can Interior Body Coat Oven	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-45	Three Piece Can Curing Ovens (Includes Codes 46, 47, 48, and 49)	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-46	Three Piece Can Sheet Base Coat (Interior) Oven	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-47	Three Piece Can Sheet Base Coat (Exterior) Oven	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-48	Three Piece Can Sheet Lithographic Coating Oven	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-49	Three Piece Can Interior Body Coat Oven	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-55	Filler Oven	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-56	Sealer Oven	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-61	Single Coat Application: Oven	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-70	Color Coat Oven	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-71	Topcoat/Texture Coat Oven	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-72	EMI/RFI Shielding Coat Oven	---	---	---	---	---	---	---	---	Tons Processed
4-02-008-98	General	---	---	---	---	---	---	---	---	1000 Feet Processed
4-02-008-99	See Comment	---	---	---	---	---	---	---	---	Tons Processed
<i>Thinning Solvents - General - multiple (See Appendix D)</i>										
4-02-009-01	General: Specify in Comments	---	---	---	---	---	---	---	---	Tons Used
4-02-009-02	Acetone	---	---	---	---	---	---	---	---	Tons Used
4-02-009-03	Butyl Acetate	---	---	---	---	---	---	---	---	Tons Used
4-02-009-04	Butyl Alcohol	---	---	---	---	---	---	---	---	Tons Used
4-02-009-05	Carbitol	---	---	---	---	---	---	---	---	Tons Used
4-02-009-06	Cellosolve	---	---	---	---	---	---	---	---	Tons Used
4-02-009-07	Cellosolve Acetate	---	---	---	---	---	---	---	---	Tons Used
4-02-009-08	Dimethyl Formamide	---	---	---	---	---	---	---	---	Tons Used
4-02-009-09	Ethyl Acetate	---	---	---	---	---	---	---	---	Tons Used

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Thinning Solvents - General - multiple (See Appendix D)</i>										
4-02-009-10	Ethyl Alcohol	---	---	---	---	---	---	---	---	Tons Used
4-02-009-11	Gasoline	---	---	---	---	---	---	---	---	Tons Used
4-02-009-12	Isopropyl Alcohol	---	---	---	---	---	---	---	---	Tons Used
4-02-009-13	Isopropyl Acetate	---	---	---	---	---	---	---	---	Tons Used
4-02-009-14	Kerosene	---	---	---	---	---	---	---	---	Tons Used
4-02-009-15	Lactol Spirits	---	---	---	---	---	---	---	---	Tons Used
4-02-009-16	Methyl Acetate	---	---	---	---	---	---	---	---	Tons Used
4-02-009-17	Methyl Alcohol	---	---	---	---	---	---	---	---	Tons Used
4-02-009-18	Methyl Ethyl Ketone	---	---	---	---	---	---	---	---	Tons Used
4-02-009-19	Methyl Isobutyl Ketone	---	---	---	---	---	---	---	---	Tons Used
4-02-009-20	Mineral Spirits	---	---	---	---	---	---	---	---	Tons Used
4-02-009-21	Naphtha	---	---	---	---	---	---	---	---	Tons Used
4-02-009-22	Toluene	---	---	---	---	---	---	---	---	Tons Used
4-02-009-23	Varsol	---	---	---	---	---	---	---	---	Tons Used
4-02-009-24	Xylene	---	---	---	---	---	---	---	---	Tons Used
4-02-009-25	Benzene	---	---	---	---	---	---	---	---	Tons Used
4-02-009-26	Turpentine	---	---	---	---	---	---	---	---	Tons Used
4-02-009-27	Hexylene Glycol	---	---	---	---	---	---	---	---	Tons Used
4-02-009-28	Ethylene Oxide	---	---	---	---	---	---	---	---	Tons Used
4-02-009-29	1,1,1-Trichloroethane (Methyl Chloroform)	---	---	---	---	---	---	---	---	Tons Used
4-02-009-30	Methylene Chloride	---	---	---	---	---	---	---	---	Tons Used
4-02-009-31	Perchloroethylene	---	---	---	---	---	2000	---	---	Tons Used
4-02-009-98	General: Specify in Comments	---	---	---	---	---	---	---	---	Gallons Used
<i>Coating Oven Heater - multiple (See Appendix D)</i>										
4-02-010-01	Natural Gas	3	3	---	0.6	---	---	---	---	Million Cubic Feet Burned
4-02-010-02	Distillate Oil	2	---	---	143.65S	---	---	---	---	1000 Gallons Burned
4-02-010-03	Residual Oil	12	---	---	158.6S	---	---	---	---	1000 Gallons Burned
4-02-010-04	Liquified Petroleum Gas (LPG)	0.28	---	---	0.09s	---	---	---	---	1000 Gallons Burned
<i>Fabric Coating/Printing - 2295, 2261, 2262, 2269</i>										
4-02-011-01	Coating Operation (Also See Specific Coating Method Codes 4-02-04X)	---	---	---	---	---	1600	---	---	Tons Used

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Fabric Coating/Printing - 2295, 2261, 2262, 2269</u></i>										
4-02-011-03	Coating Mixing (Also See Specific Coating Method Codes 4-02-04X)	---	---	---	---	---	200	---	---	Tons Used
4-02-011-04	Coating Storage (Also See Specific Coating Method Codes 4-02-04X)	---	---	---	---	---	---	---	---	Tons Used
4-02-011-05	Equipment Cleanup:Fabric Coating(Also Spec Coat Method Codes 4-02-04X)	---	---	---	---	---	200	---	---	Tons Used
4-02-011-11	Fabric Printing: Roller (Also See New Codes Under 4-02-040-XX)	---	---	---	---	---	284	---	---	Tons Processed
4-02-011-12	Fabric Printing: Roller (Also See New Codes Under 4-02-040-XX)	---	---	---	---	---	278000	---	---	Each-Year Operating
4-02-011-13	Fabric Printing: Rotary Screen (Also See New Codes Under 4-02-040-XX)	---	---	---	---	---	46	---	---	Tons Processed
4-02-011-14	Fabric Printing: Rotary Screen (Also See New Codes Under 4-02-040-XX)	---	---	---	---	---	62000	---	---	Each-Year Operating
4-02-011-15	Fabric Printing: Flat Screen (Also See New Codes Under 4-02-040-XX)	---	---	---	---	---	158	---	---	Tons Processed
4-02-011-16	Fabric Printing: Flat Screen (Also See New Codes Under 4-02-040-XX)	---	---	---	---	---	62000	---	---	Each-Year Operating
4-02-011-21	Fabric Print:Dryer: Steam Coil (Also See New Codes Under 4-02-040-XX)	---	---	---	---	---	---	---	---	Tons Processed
4-02-011-22	Fabric Print:Dryer: Fuel-fired (Also See New Codes Under 4-02-040- XX)	---	---	---	---	---	---	---	---	Tons Processed
4-02-011-97	Misc. Fugitives: Specify in Comments (Also New Codes 4-02-040-XX)	---	---	---	---	---	---	---	---	Tons Used
4-02-011-98	Misc. Fugitives: Specify in Comments (Also New Codes 4-02-040-XX)	---	---	---	---	---	---	---	---	Tons Coated
4-02-011-99	Other Not Classified (Also See New Codes Under 4-02-040-XX)	---	---	---	---	---	2000	---	---	Tons Used
<i><u>Fabric Dyeing - 2200</u></i>										
4-02-012-01	Dye Application: General (Also See New Codes Under 4-02-060-XX)	---	---	---	---	---	---	---	---	Tons Consumed
4-02-012-10	Dye Application: General (Also See New Codes Under 4-02-060-XX)	---	---	---	---	---	---	---	---	Gallons Consumed
<i><u>Paper Coating - 2671, 2672</u></i>										
4-02-013-01	Coating Operation	---	---	---	---	---	1400	---	---	Tons Used
4-02-013-03	Coating Mixing	---	---	---	---	---	300	---	---	Tons Used
4-02-013-04	Coating Storage	---	---	---	---	---	---	---	---	Tons Used
4-02-013-05	Equipment Cleanup	---	---	---	---	---	300	---	---	Tons Used



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Paper Coating - 2671, 2672</u></i>										
4-02-013-10	Coating Application: Knife Coater	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-013-20	Coating Application: Reverse Roll Coater	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-013-30	Coating Application: Rotogravure Printer	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-013-99	Other Not Classified	---	---	---	---	---	2000	---	---	Tons Used
<i><u>Large Appliances - 3630, 3650, 3430, 3580</u></i>										
4-02-014-01	Prime Coating Operation	---	---	---	---	---	900	---	---	Tons Used
4-02-014-02	Cleaning/Pretreatment	---	---	---	---	---	---	---	---	Tons Used
4-02-014-03	Coating Mixing	---	---	---	---	---	200	---	---	Tons Used
4-02-014-04	Coating Storage	---	---	---	---	---	---	---	---	Tons Used
4-02-014-05	Equipment Cleanup	---	---	---	---	---	200	---	---	Tons Used
4-02-014-06	Topcoat Spray	---	---	---	---	---	700	---	---	Tons Used
4-02-014-10	Prime Coat Flashoff	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-014-11	Topcoat Flashoff	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-014-31	Coating Line: General	---	---	---	---	---	0.9	---	---	Each Produced
4-02-014-32	Prime Air Spray	---	---	---	---	---	3.1	---	---	1000 Square Feet Coated
4-02-014-33	Prime Electrostatic Spray	---	---	---	---	---	1.79	---	---	1000 Square Feet Coated
4-02-014-34	Prime Flow Coat	---	---	---	---	---	1.65	---	---	1000 Square Feet Coated
4-02-014-35	Prime Dip Coat	---	---	---	---	---	1.65	---	---	1000 Square Feet Coated
4-02-014-36	Prime Electro-deposition	---	---	---	---	---	1.5	---	---	1000 Square Feet Coated
4-02-014-37	Top Air Spray	---	---	---	---	---	6.3	---	---	1000 Square Feet Coated
4-02-014-38	Top Electrostatic Spray	---	---	---	---	---	3.2	---	---	1000 Square Feet Coated
4-02-014-99	Other Not Classified	---	---	---	---	---	2000	---	---	Tons Used
<i><u>Magnet Wire Surface Coating - 3357, 3351</u></i>										
4-02-015-01	Coating/Application/Curing	---	---	---	---	---	1600	---	---	Tons Used
4-02-015-02	Cleaning/Pretreatment	---	---	---	---	---	---	---	---	Tons Used
4-02-015-03	Coating Mixing	---	---	---	---	---	200	---	---	Tons Used
4-02-015-04	Coating Storage	---	---	---	---	---	---	---	---	Tons Used
4-02-015-05	Equipment Cleanup	---	---	---	---	---	200	---	---	Tons Used
4-02-015-31	Coating Line: General	---	---	---	---	---	186000	---	---	Each-Year Operating
4-02-015-99	Other Not Classified	---	---	---	---	---	2000	---	---	Tons Used

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Automobiles and Light Trucks - 3771, 3713, 3711</u>										
4-02-016-01	Prime Application/Electro-deposition/Dip/Spray	9.68	4.52	---	---	---	500	---	---	Tons Used
4-02-016-02	Cleaning/Pretreatment	---	---	---	---	---	---	---	---	Tons Used
4-02-016-03	Coating Mixing	---	---	---	---	---	200	---	---	Tons Used
4-02-016-04	Coating Storage	---	---	---	---	---	---	---	---	Tons Used
4-02-016-05	Equipment Cleanup	---	---	---	---	---	200	---	---	Tons Used
4-02-016-06	Topcoat Operation	---	---	---	---	---	800	---	---	Tons Used
4-02-016-07	Sealers	---	---	---	---	---	---	---	---	Gallons Used
4-02-016-08	Deadeners	---	---	---	---	---	---	---	---	Gallons Used
4-02-016-09	Anti-corrosion Priming	---	---	---	---	---	---	---	---	Gallons Used
4-02-016-19	Prime Surfacing Operation	---	---	---	---	---	100	---	---	Tons Used
4-02-016-20	Repair Topcoat Application Area	---	---	---	---	---	200	---	---	Tons Used
4-02-016-21	Prime Coating: Solvent-borne - Automobiles	---	---	---	---	---	14.54	---	---	Each Produced
4-02-016-22	Prime Coating: Electro-deposition - Automobiles	---	---	---	---	---	0.45	---	---	Each Produced
4-02-016-23	Guide Coating: Solvent-borne - Automobiles	---	---	---	---	---	4.16	---	---	Each Produced
4-02-016-24	Guide Coating: Water-borne - Automobiles	---	---	---	---	---	1.5	---	---	Each Produced
4-02-016-25	Topcoat: Solvent-borne - Automobiles	---	---	---	---	---	27.3	---	---	Each Produced
4-02-016-26	Topcoat: Water-borne - Automobiles	---	---	---	---	---	4.95	---	---	Each Produced
4-02-016-27	Prime Coating: Solvent-borne - Light Trucks	---	---	---	---	---	42.39	---	---	Each Produced
4-02-016-28	Prime Coating: Electro-deposition - Light Trucks	---	---	---	---	---	0.58	---	---	Each Produced
4-02-016-29	Guide Coating: Solvent-borne - Light Trucks	---	---	---	---	---	14.04	---	---	Each Produced
4-02-016-30	Guide Coating: Water-borne - Light Trucks	---	---	---	---	---	5.06	---	---	Each Produced
4-02-016-31	Topcoat: Solvent-borne - Light Trucks	---	---	---	---	---	40.3	---	---	Each Produced
4-02-016-32	Topcoat: Water-borne - Light Trucks	---	---	---	---	---	15.47	---	---	Each Produced
4-02-016-99	Other Not Classified	---	---	---	---	---	2000	---	---	Tons Used
<u>Metal Can Coating - 3411</u>										
4-02-017-02	Cleaning/Pretreatment	---	---	---	---	---	---	---	---	Tons Used
4-02-017-03	Coating Mixing	---	---	---	---	---	200	---	---	Tons Used
4-02-017-04	Coating Storage	---	---	---	---	---	---	---	---	Tons Used
4-02-017-05	Equipment Cleanup	---	---	---	---	---	200	---	---	Tons Used
4-02-017-06	Solvent Storage	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-02-017-21	Two Piece Exterior Base Coating	---	---	---	---	---	900	---	---	Tons Used

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Metal Can Coating - 3411</i></u>										
4-02-017-22	Interior Spray Coating	---	---	---	---	---	400	---	---	Tons Used
4-02-017-23	Sheet Base Coating (Interior)	---	---	---	---	---	---	---	---	Tons Used
4-02-017-24	Sheet Base Coating (Exterior)	---	---	---	---	---	700	---	---	Tons Used
4-02-017-25	Side Seam Spray Coating	---	---	---	---	---	100	---	---	Tons Used
4-02-017-26	End Sealing Compound (Also See 4-02-017-36 & -37)	---	---	---	---	---	100	---	---	Tons Used
4-02-017-27	Lithography	---	---	---	---	---	400	---	---	Tons Used
4-02-017-28	Over Varnish	---	---	---	---	---	200	---	---	Tons Used
4-02-017-29	Exterior End Coating	---	---	---	---	---	---	---	---	Each-Year Operating
4-02-017-31	Three-piece Can Sheet Base Coating	---	---	---	---	---	352000	---	---	Each-Year Operating
4-02-017-32	Three-piece Can Sheet Lithographic Coating Line	---	---	---	---	---	110000	---	---	Each-Year Operating
4-02-017-33	Three-piece Can-side Seam Spray Coating	---	---	---	---	---	40000	---	---	Each-Year Operating
4-02-017-34	Three-piece Can Interior Body Spray Coat	---	---	---	---	---	176000	---	---	Each-Year Operating
4-02-017-35	Two-piece Can Coating Line	---	---	---	---	---	574000	---	---	Each-Year Operating
4-02-017-36	Two-piece Can End Sealing Compound	---	---	---	---	---	30000	---	---	Each-Year Operating
4-02-017-37	Three Piece Can End Sealing Compound	---	---	---	---	---	---	---	---	Each-Year Operating
4-02-017-38	Two Piece Can Lithographic Coating Line	---	---	---	---	---	---	---	---	Each-Year Operating
4-02-017-39	Three Piece Can Coating Line (All Coating Solvent Emission Points)	---	---	---	---	---	---	---	---	Each-Year Operating
4-02-017-99	Other Not Classified	---	---	---	---	---	2000	---	---	Tons Used
<u><i>Metal Coil Coating - 3353, 3354</i></u>										
4-02-018-01	Prime Coating Application	---	---	---	---	---	800	---	---	Tons Used
4-02-018-02	Cleaning/Pretreatment	---	---	---	---	---	---	---	---	Tons Used
4-02-018-03	Solvent Mixing	---	---	---	---	---	200	---	---	Tons Used
4-02-018-04	Solvent Storage (Use 4-07-004-01 thru 4-07-999-98 if possible)	---	---	---	---	---	---	---	---	Tons Used
4-02-018-05	Equipment Cleanup	---	---	---	---	---	200	---	---	Tons Used
4-02-018-06	Finish Coating	---	---	---	---	---	800	---	---	Tons Used
4-02-018-07	Coating Storage	---	---	---	---	---	---	---	---	Tons Used
4-02-018-99	Other Not Classified	---	---	---	---	---	2000	---	---	Tons Used
<u><i>Wood Furniture Surface Coating - 2511, 2512, 2517, 2521</i></u>										
4-02-019-01	Coating Operation	---	---	---	---	---	1600	---	---	Tons Used
4-02-019-03	Coating Mixing	---	---	---	---	---	200	---	---	Tons Used

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Wood Furniture Surface Coating - 2511, 2512, 2517, 2521</i>										
4-02-019-04	Coating Storage	---	---	---	---	---	---	---	---	Tons Used
4-02-019-99	Other Not Classified	---	---	---	---	---	2000	---	---	Tons Used
<i>Metal Furniture Operations - 2514, 2522</i>										
4-02-020-01	Coating Operation	---	---	---	---	---	1600	---	---	Tons Used
4-02-020-02	Cleaning/Pretreatment	---	---	---	---	---	---	---	---	Tons Used
4-02-020-03	Coating Mixing	---	---	---	---	---	200	---	---	Tons Used
4-02-020-04	Coating Storage	---	---	---	---	---	---	---	---	Tons Used
4-02-020-05	Equipment Cleanup	---	---	---	---	---	200	---	---	Tons Used
4-02-020-10	Prime Coat Application	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-11	Prime Coat Application: Spray, High Solids	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-12	Prime Coat Application: Spray, Water-borne	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-13	Prime Coat Application: Dip	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-14	Prime Coat Application: Flow Coat	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-15	Prime Coat Application: Flashoff	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-20	Topcoat Application	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-21	Topcoat Application: Spray, High Solids	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-22	Topcoat Application: Spray, Water-borne	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-23	Topcoat Application: Dip	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-24	Topcoat Application: Flow Coat	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-25	Topcoat Application: Flashoff	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-31	Single Spray Line: General	---	---	---	---	---	22.9	---	---	1000 Square Feet Coated
4-02-020-32	Spray Dip Line: General (Use 4-02-020-37)	---	---	---	---	---	15.3	---	---	1000 Square Feet Coated
4-02-020-33	Spray High Solids Coating (Use 4-02-020-35)	---	---	---	---	---	6.8	---	---	1000 Square Feet Coated
4-02-020-34	Spray Water-borne Coating (Use 4-02-020-36)	---	---	---	---	---	4.3	---	---	1000 Square Feet Coated
4-02-020-35	Single Coat Application: Spray, High Solids	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-36	Single Coat Application: Spray, Water-borne	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-37	Single Coat Application: Dip	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-38	Single Coat Application: Flow Coat	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-39	Single Coat Application: Flashoff	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-020-99	Other Not Classified	---	---	---	---	---	2000	---	---	Tons Used

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Flatwood Products - 2435, 2492, 2499</i>										
4-02-021-01	Base Coat	---	---	---	---	---	800	---	---	Tons Used
4-02-021-03	Coating Mixing	---	---	---	---	---	200	---	---	Tons Used
4-02-021-04	Coating Storage	---	---	---	---	---	---	---	---	Tons Used
4-02-021-05	Equipment Cleanup	---	---	---	---	---	200	---	---	Tons Used
4-02-021-06	Topcoat	---	---	---	---	---	800	---	---	Tons Used
4-02-021-07	Filler	---	---	---	---	---	2000	---	---	Tons Used
4-02-021-08	Sealer	---	---	---	---	---	2000	---	---	Tons Used
4-02-021-09	Inks	---	---	---	---	---	2000	---	---	Tons Used
4-02-021-10	Grove Coat Application	---	---	---	---	---	---	---	---	Tons Used
4-02-021-11	Stain Application	---	---	---	---	---	---	---	---	Tons Used
4-02-021-17	Filler Sander	---	---	---	---	---	---	---	---	1000 Square Feet Produced
4-02-021-18	Sealer Sander	---	---	---	---	---	---	---	---	1000 Square Feet Produced
4-02-021-31	Water-borne Coating	---	---	---	---	---	2.5	---	---	1000 Square Feet Coated
4-02-021-32	Solvent-borne Coating	---	---	---	---	---	16.5	---	---	1000 Square Feet Coated
4-02-021-33	Ultraviolet Coating	---	---	---	---	---	0.8	---	---	1000 Square Feet Coated
4-02-021-40	Surface Preparation (Includes Tempering, Sanding, Brushing, Grove Cut)	---	---	---	---	---	---	---	---	1000 Square Feet Produced
4-02-021-99	Other Not Classified	---	---	---	---	---	2000	---	---	Tons Used
<i>Plastic Parts - 3079</i>										
4-02-022-01	Coating Operation	---	---	---	---	---	1600	---	---	Tons Used
4-02-022-02	Cleaning/Pretreatment	---	---	---	---	---	---	---	---	Tons Used
4-02-022-03	Coating Mixing	---	---	---	---	---	200	---	---	Tons Used
4-02-022-04	Coating Storage	---	---	---	---	---	---	---	---	Tons Used
4-02-022-05	Equipment Cleanup	---	---	---	---	---	200	---	---	Tons Used
4-02-022-06	Business: Baseline Coating Mix	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-07	Business: Low Solids Solvent-borne Coating	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-08	Business: Medium Solids Solvent-borne Coating	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-09	Business: High Solids Coating (25% Efficiency)	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-10	Business: High Solids Solvent-borne Coating (40% Efficiency)	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-11	Business: Water-borne Coating	---	---	---	---	---	---	---	---	Square Feet Coated

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Plastic Parts - 3079</u></i>										
4-02-022-12	Business: Low Solids Solvent-borne EMI/RFI Shielding Coating	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-13	Business: Higher Solids Solvent-borne EMI/RFI Shielding Coating	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-14	Business: Water-borne EMI/RFI Shielding Coating	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-15	Business: Zinc Arc Spray	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-20	Prime Coat Application	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-29	Prime Coat Flashoff	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-30	Color Coat Application	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-39	Color Coat Flashoff	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-40	Topcoat/Texture Coat Application	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-49	Topcoat/Texture Coat Flashoff	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-50	EMI/RFI Shielding Coat Application	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-59	EMI/RFI Shielding Coat Flashoff	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-70	Sanding/Grit Blasting Prior to EMI/RFI Shielding Coat Application	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-80	Maskant Application	---	---	---	---	---	---	---	---	Square Feet Coated
4-02-022-99	Other Not Classified	---	---	---	---	---	2000	---	---	Tons Used
<i><u>Large Ships - 3731</u></i>										
4-02-023-01	Prime Coating Operation	---	---	---	---	---	800	---	---	Tons Used
4-02-023-02	Cleaning/Pretreatment	---	---	---	---	---	---	---	---	Tons Used
4-02-023-03	Coating Mixing	---	---	---	---	---	200	---	---	Tons Used
4-02-023-04	Coating Storage	---	---	---	---	---	---	---	---	Tons Used
4-02-023-05	Equipment Cleanup	---	---	---	---	---	200	---	---	Tons Used
4-02-023-06	Topcoat Operation	---	---	---	---	---	800	---	---	Tons Used
4-02-023-99	Other Not Classified	---	---	---	---	---	2000	---	---	Tons Used
<i><u>Large Aircraft - 3721</u></i>										
4-02-024-01	Prime Coating Operation	---	---	---	---	---	800	---	---	Tons Used
4-02-024-02	Cleaning/Pretreatment	---	---	---	---	---	---	---	---	Tons Used
4-02-024-03	Coating Mixing	---	---	---	---	---	200	---	---	Tons Used
4-02-024-04	Coating Storage	---	---	---	---	---	---	---	---	Tons Used
4-02-024-05	Equipment Cleanup	---	---	---	---	---	200	---	---	Tons Used

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Large Aircraft - 3721</i>										
4-02-024-06	Topcoat Operation	---	---	---	---	---	800	---	---	Tons Used
4-02-024-99	Other Not Classified	---	---	---	---	---	2000	---	---	Tons Used
<i>Miscellaneous Metal Parts - multiple (See Appendix D)</i>										
4-02-025-01	Coating Operation	---	---	---	---	---	1600	---	---	Tons Used
4-02-025-02	Cleaning/Pretreatment	---	---	---	---	---	---	---	---	Tons Used
4-02-025-03	Coating Mixing	---	---	---	---	---	200	---	---	Tons Used
4-02-025-04	Coating Storage	---	---	---	---	---	---	---	---	Tons Used
4-02-025-05	Equipment Cleanup	---	---	---	---	---	200	---	---	Tons Used
4-02-025-10	Prime Coat Application	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-025-11	Prime Coat Application: Spray, High Solids	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-025-12	Prime Coat Application: Spray, Water-borne	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-025-15	Prime Coat Application: Flashoff	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-025-20	Topcoat Application	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-025-21	Topcoat Application: Spray, High Solids	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-025-22	Topcoat Application: Spray, Water-borne	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-025-23	Topcoat Application: Dip	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-025-24	Topcoat Application: Flow Coat	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-025-25	Topcoat Application: Flashoff	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-025-31	Conveyor Single Flow	---	---	---	---	---	15.3	---	---	1000 Square Feet Coated
4-02-025-32	Conveyor Single Dip	---	---	---	---	---	15.3	---	---	1000 Square Feet Coated
4-02-025-33	Conveyor Single Spray	---	---	---	---	---	27.5	---	---	1000 Square Feet Coated
4-02-025-34	Conveyor Two Coat, Flow and Spray	---	---	---	---	---	42.8	---	---	1000 Square Feet Coated
4-02-025-35	Conveyor Two Coat, Dip and Spray	---	---	---	---	---	42.8	---	---	1000 Square Feet Coated
4-02-025-36	Conveyor Two Coat, Spray	---	---	---	---	---	55	---	---	1000 Square Feet Coated
4-02-025-37	Manual Two Coat, Spray and Air Dry	---	---	---	---	---	54.8	---	---	1000 Square Feet Coated
4-02-025-42	Single Coat Application: Spray, High Solids	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-025-43	Single Coat Application: Spray, Water-borne	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-025-44	Single Coat Application: Dip	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-025-45	Single Coat Application: Flow Coat	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-025-46	Single Coat Application: Flashoff	---	---	---	---	---	---	---	---	1000 Square Feet Coated
4-02-025-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Used

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Steel Drums - 3412</u>										
4-02-026-01	Coating Operation	---	---	---	---	---	4.3	---	---	Gallons Consumed
4-02-026-02	Cleaning/Pretreatment	---	---	---	---	---	---	---	---	Gallons Consumed
4-02-026-03	Coating Mixing	---	---	---	---	---	0.5	---	---	Gallons Consumed
4-02-026-04	Coating Storage	---	---	---	---	---	---	---	---	Gallons Consumed
4-02-026-05	Equipment Cleanup	---	---	---	---	---	0.5	---	---	Gallons Consumed
4-02-026-06	Interior Coating	---	---	---	---	---	2.2	---	---	Gallons Consumed
4-02-026-07	Exterior Coating	---	---	---	---	---	2.2	---	---	Gallons Consumed
4-02-026-99	Specify in Comments Field	---	---	---	---	---	---	---	---	Gallons Consumed
<u>Glass Mirrors - 3559, 3231</u>										
4-02-027-01	Mirror Backing: Coating Operation	---	---	---	---	---	---	---	---	Tons Applied
4-02-027-10	Mirror Backing: Coating Operation	---	---	---	---	---	---	---	---	Gallons Applied
<u>Semiconductors - 3674</u>										
4-02-030-01	Specify Solvent	---	---	---	---	---	---	---	---	Tons Used
<u>Fabric Printing - multiple (See Appendix D)</u>										
4-02-040-01	Roller: Print Paste	---	---	---	---	---	---	---	---	Tons Processed
4-02-040-02	Roller: Application	---	---	---	---	---	---	---	---	Tons Processed
4-02-040-03	Roller: Transfer	---	---	---	---	---	---	---	---	Tons Processed
4-02-040-04	Roller: Steam Cans/Drying	---	---	---	---	---	---	---	---	Tons Processed
4-02-040-10	Rotary Screen: Print Paste	---	---	---	---	---	---	---	---	Tons Processed
4-02-040-11	Rotary Screen: Application	---	---	---	---	---	---	---	---	Tons Processed
4-02-040-12	Rotary Screen: Transfer	---	---	---	---	---	---	---	---	Tons Processed
4-02-040-13	Rotary Screen: Drying/Curing	---	---	---	---	---	---	---	---	Tons Processed
4-02-040-20	Flat Screen: Print Paste	---	---	---	---	---	---	---	---	Tons Processed
4-02-040-21	Flat Screen: Application	---	---	---	---	---	---	---	---	Tons Processed
4-02-040-22	Flat Screen: Transfer	---	---	---	---	---	---	---	---	Tons Processed
4-02-040-23	Flat Screen: Drying/Curing	---	---	---	---	---	---	---	---	Tons Processed
<u>Fabric Coating, Knife Coating - multiple (See Appendix D)</u>										
4-02-041-21	Mixing Tanks	---	---	---	---	---	---	---	---	Tons Coated
4-02-041-30	Coating Application	---	---	---	---	---	---	---	---	Tons Coated
4-02-041-40	Drying/Curing	---	---	---	---	---	---	---	---	Tons Coated



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Fabric Coating, Knife Coating - multiple (See Appendix D)</i>										
4-02-041-50	Cleanup	---	---	---	---	---	---	---	---	Tons Coated
4-02-041-51	Cleanup: Coating Application Equipment	---	---	---	---	---	---	---	---	Tons Coated
4-02-041-52	Cleanup: Empty Coating Drums	---	---	---	---	---	---	---	---	Tons Coated
4-02-041-60	Waste	---	---	---	---	---	---	---	---	Tons Coated
4-02-041-61	Waste: Cleaning Rags	---	---	---	---	---	---	---	---	Tons Coated
4-02-041-62	Waste: Waste Ink Disposal	---	---	---	---	---	---	---	---	Tons Coated
<i>Fabric Coating, Roller Coating - multiple (See Appendix D)</i>										
4-02-042-21	Mixing Tanks	---	---	---	---	---	---	---	---	Tons Coated
4-02-042-30	Coating Application	---	---	---	---	---	---	---	---	Tons Coated
4-02-042-40	Drying/Curing	---	---	---	---	---	---	---	---	Tons Coated
4-02-042-50	Cleanup	---	---	---	---	---	---	---	---	Tons Coated
4-02-042-51	Cleanup: Coating Application Equipment	---	---	---	---	---	---	---	---	Tons Coated
4-02-042-52	Cleanup: Empty Coating Drums	---	---	---	---	---	---	---	---	Tons Coated
4-02-042-60	Waste	---	---	---	---	---	---	---	---	Tons Coated
4-02-042-61	Waste: Cleaning Rags	---	---	---	---	---	---	---	---	Tons Coated
4-02-042-62	Waste: Waste Ink Disposal	---	---	---	---	---	---	---	---	Tons Coated
<i>Fabric Coating, Dip Coating - multiple (See Appendix D)</i>										
4-02-043-21	Mixing Tanks	---	---	---	---	---	---	---	---	Tons Coated
4-02-043-30	Coating Application	---	---	---	---	---	---	---	---	Tons Coated
4-02-043-40	Drying/Curing	---	---	---	---	---	---	---	---	Tons Coated
4-02-043-50	Cleanup	---	---	---	---	---	---	---	---	Tons Coated
4-02-043-51	Cleanup: Coating Application Equipment	---	---	---	---	---	---	---	---	Tons Coated
4-02-043-52	Cleanup: Empty Coating Drums	---	---	---	---	---	---	---	---	Tons Coated
4-02-043-60	Waste	---	---	---	---	---	---	---	---	Tons Coated
4-02-043-61	Waste: Cleaning Rags	---	---	---	---	---	---	---	---	Tons Coated
4-02-043-62	Waste: Waste Ink Disposal	---	---	---	---	---	---	---	---	Tons Coated
<i>Fabric Coating, Transfer Coating - multiple (See Appendix D)</i>										
4-02-044-21	Mixing Tanks	---	---	---	---	---	---	---	---	Tons Coated
4-02-044-30	Coating Application	---	---	---	---	---	---	---	---	Tons Coated
4-02-044-31	Coating Application: First Roll Applicator	---	---	---	---	---	---	---	---	Tons Coated
4-02-044-32	Coating Application: Second Roll Applicator	---	---	---	---	---	---	---	---	Tons Coated

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Fabric Coating, Transfer Coating - multiple (See Appendix D)</i>										
4-02-044-35	Lamination: Laminating Device	---	---	---	---	---	---	---	---	Tons Coated
4-02-044-40	Drying/Curing	---	---	---	---	---	---	---	---	Tons Coated
4-02-044-41	Drying/Curing: First Predrier	---	---	---	---	---	---	---	---	Tons Coated
4-02-044-42	Drying/Curing: Second Predrier	---	---	---	---	---	---	---	---	Tons Coated
4-02-044-43	Drying/Curing: Main Drying Tunnel	---	---	---	---	---	---	---	---	Tons Coated
4-02-044-50	Cooler	---	---	---	---	---	---	---	---	Tons Coated
4-02-044-55	Winding	---	---	---	---	---	---	---	---	Tons Coated
4-02-044-60	Cleanup	---	---	---	---	---	---	---	---	Tons Coated
4-02-044-61	Cleanup: Coating Application Equipment	---	---	---	---	---	---	---	---	Tons Coated
4-02-044-62	Cleanup: Empty Coating Drums	---	---	---	---	---	---	---	---	Tons Coated
4-02-044-70	Waste	---	---	---	---	---	---	---	---	Tons Coated
4-02-044-71	Waste: Cleaning Rags	---	---	---	---	---	---	---	---	Tons Coated
4-02-044-72	Waste: Waste Ink Disposal	---	---	---	---	---	---	---	---	Tons Coated
<i>Fabric Coating, Extrusion Coating - multiple (See Appendix D)</i>										
4-02-045-21	Mixing Tanks	---	---	---	---	---	---	---	---	Tons Coated
4-02-045-30	Coating Application	---	---	---	---	---	---	---	---	Tons Coated
4-02-045-31	Coating Application: Extruder	---	---	---	---	---	---	---	---	Tons Coated
4-02-045-32	Coating Application: Coating Die	---	---	---	---	---	---	---	---	Tons Coated
4-02-045-50	Cooling Cylinder	---	---	---	---	---	---	---	---	Tons Coated
4-02-045-55	Winding	---	---	---	---	---	---	---	---	Tons Coated
4-02-045-60	Cleanup	---	---	---	---	---	---	---	---	Tons Coated
4-02-045-61	Cleanup: Coating Application Equipment	---	---	---	---	---	---	---	---	Tons Coated
4-02-045-62	Cleanup: Empty Coating Drums	---	---	---	---	---	---	---	---	Tons Coated
4-02-045-70	Waste	---	---	---	---	---	---	---	---	Tons Coated
4-02-045-71	Waste: Cleaning Rags	---	---	---	---	---	---	---	---	Tons Coated
4-02-045-72	Waste: Waste Ink Disposal	---	---	---	---	---	---	---	---	Tons Coated
<i>Fabric Coating, Melt Roll Coating - multiple (See Appendix D)</i>										
4-02-046-21	Mixing Tanks	---	---	---	---	---	---	---	---	Tons Coated
4-02-046-30	Coating Application	---	---	---	---	---	---	---	---	Tons Coated
4-02-046-31	Coating Application: Calendar Rolls	---	---	---	---	---	---	---	---	Tons Coated
4-02-046-32	Coating Application: Pick Up Roll	---	---	---	---	---	---	---	---	Tons Coated

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Fabric Coating, Melt Roll Coating - multiple (See Appendix D)</i>										
4-02-046-50	Cooling Rolls	---	---	---	---	---	---	---	---	Tons Coated
4-02-046-55	Winding	---	---	---	---	---	---	---	---	Tons Coated
4-02-046-60	Cleanup	---	---	---	---	---	---	---	---	Tons Coated
4-02-046-61	Cleanup: Coating Application Equipment	---	---	---	---	---	---	---	---	Tons Coated
4-02-046-62	Cleanup: Empty Coating Drums	---	---	---	---	---	---	---	---	Tons Coated
4-02-046-70	Waste	---	---	---	---	---	---	---	---	Tons Coated
4-02-046-71	Waste: Cleaning Rags	---	---	---	---	---	---	---	---	Tons Coated
4-02-046-72	Waste: Waste Ink Disposal	---	---	---	---	---	---	---	---	Tons Coated
<i>Fabric Coating, Coagulation Coating - multiple (See Appendix D)</i>										
4-02-047-21	Mixing Tanks	---	---	---	---	---	---	---	---	Tons Coated
4-02-047-30	Coating Application	---	---	---	---	---	---	---	---	Tons Coated
4-02-047-35	Coagulation Baths and Solvent Separation	---	---	---	---	---	---	---	---	Tons Coated
4-02-047-40	Solvent Recovery	---	---	---	---	---	---	---	---	Tons Coated
4-02-047-50	Drying	---	---	---	---	---	---	---	---	Tons Coated
4-02-047-55	Winding	---	---	---	---	---	---	---	---	Tons Coated
4-02-047-60	Cleanup	---	---	---	---	---	---	---	---	Tons Coated
4-02-047-61	Cleanup: Coating Application Equipment	---	---	---	---	---	---	---	---	Tons Coated
4-02-047-62	Cleanup: Empty Coating Drums	---	---	---	---	---	---	---	---	Tons Coated
4-02-047-70	Waste	---	---	---	---	---	---	---	---	Tons Coated
4-02-047-71	Waste: Cleaning Rags	---	---	---	---	---	---	---	---	Tons Coated
4-02-047-72	Waste: Waste Ink Disposal	---	---	---	---	---	---	---	---	Tons Coated
<i>Fabric Dyeing - multiple (See Appendix D)</i>										
4-02-060-10	Dye Preparation	---	---	---	---	---	---	---	---	Tons Dyed
4-02-060-30	Dye Application	---	---	---	---	---	---	---	---	Tons Dyed
4-02-060-31	Dye Application: Beam	---	---	---	---	---	---	---	---	Tons Dyed
4-02-060-32	Dye Application: Beck	---	---	---	---	---	---	---	---	Tons Dyed
4-02-060-33	Dye Application: Jig	---	---	---	---	---	---	---	---	Tons Dyed
4-02-060-34	Dye Application: Jet	---	---	---	---	---	---	---	---	Tons Dyed
4-02-060-35	Dye Application: Continuous	---	---	---	---	---	---	---	---	Tons Dyed
4-02-060-50	Waste	---	---	---	---	---	---	---	---	Tons Dyed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Equipment Leaks - 2800</u>										
4-02-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Wastewater, Aggregate - 2800</u>										
4-02-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-02-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Wastewater, Points of Generation - 2800</u>										
4-02-825-01	Printing Blanket, Rotary Screen	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-02-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Fugitive Emissions - multiple (See Appendix D)</u>										
4-02-888-01	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
4-02-888-02	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
4-02-888-03	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
4-02-888-04	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
4-02-888-05	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Produced
4-02-888-21	Basecoat	---	---	---	---	---	---	---	---	Tons Produced
4-02-888-22	Coating	---	---	---	---	---	---	---	---	Tons Produced
4-02-888-23	Cleartop Coat	---	---	---	---	---	---	---	---	Tons Produced
4-02-888-24	Clean-up	---	---	---	---	---	---	---	---	Tons Produced
<u>Fuel Fired Equipment - multiple (See Appendix D)</u>										
4-02-900-11	Distillate Oil: Incinerator/Afterburner	---	---	---	---	---	---	---	---	1000 Gallons Burned
4-02-900-12	Residual Oil: Incinerator/Afterburner	---	---	---	---	---	---	---	---	1000 Gallons Burned
4-02-900-13	Natural Gas: Incinerator/Afterburner	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
4-02-900-23	Natural Gas: Flares	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
<u>Miscellaneous - multiple (See Appendix D)</u>										
4-02-999-95	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Used
4-02-999-96	Specify in Comments Field	---	---	---	---	---	---	---	---	Tons Used
4-02-999-97	Specify in Comments Field	---	---	---	---	---	---	---	---	1000 Each Produced
4-02-999-98	Specify in Comments Field	---	---	---	---	---	---	---	---	Gallons Processed
4-02-999-99	See Comment	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>PETROLEUM AND SOLVENT EVAPORATION -Petroleum Product Storage at Refineries</i>										
<i>Deleted - Do Not Use (See 4-03-010 and 4-07) - multiple (See Appendix D)</i>										
4-03-001-01	Gasoline	---	---	---	---	---	30.5	---	---	1000 Gallon-Years Storage Capacity
4-03-001-02	Crude	---	---	---	---	---	23.4	---	---	1000 Gallon-Years Storage Capacity
4-03-001-03	Gasoline	---	---	---	---	---	16.5	---	---	1000 Gallons Throughput
4-03-001-04	Crude	---	---	---	---	---	2.47	---	---	1000 Gallons Throughput
4-03-001-05	Jet Fuel	---	---	---	---	---	8.8	---	---	1000 Gallon-Years Storage Capacity
4-03-001-06	Kerosene	---	---	---	---	---	0.45	---	---	1000 Gallon-Years Storage Capacity
4-03-001-07	Dist Fuel	---	---	---	---	---	0.39	---	---	1000 Gallon-Years Storage Capacity
4-03-001-08	Benzene	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-001-09	Cyclohexane	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-001-10	Cyclopentane	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-001-11	Heptane	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-001-12	Hexane	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-001-13	Isooctane	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-001-14	Isopentane	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-001-15	Pentane	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-001-16	Toluene	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-001-50	Jet Fuel	---	---	---	---	---	2.5	---	---	1000 Gallons Throughput
4-03-001-51	Kerosene	---	---	---	---	---	0.03	---	---	1000 Gallons Throughput
4-03-001-52	Dist Fuel	---	---	---	---	---	0.02	---	---	1000 Gallons Throughput
4-03-001-53	Benzene	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-001-54	Cyclohexane	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-001-55	Cyclopentane	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Deleted - Do Not Use (See 4-03-010 and 4-07) - multiple (See Appendix D)</i>										
4-03-001-56	Heptane	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-001-57	Hexane	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-001-58	Isooctane	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-001-59	Isopentane	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-001-60	Pentane	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-001-61	Toluene	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-001-98	See Comment	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-001-99	See Comment	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i>Deleted - Do Not Use (See 4-03-011 and 4-07) - multiple (See Appendix D)</i>										
4-03-002-01	Gasoline	---	---	---	---	---	13.4	---	---	1000 Gallon-Years Storage Capacity
4-03-002-02	Product	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-002-03	Crude	---	---	---	---	---	1.76	---	---	1000 Gallon-Years Storage Capacity
4-03-002-04	Crude	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-002-05	Jet Fuel	---	---	---	---	---	3.5	---	---	1000 Gallon-Years Storage Capacity
4-03-002-07	Dist Fuel	---	---	---	---	---	0.02	---	---	1000 Gallon-Years Storage Capacity
4-03-002-08	Benzene	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-002-09	Cyclohexane	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-002-10	Cyclopentane	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-002-11	Heptane	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-002-12	Hexane	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-002-13	Isooctane	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-002-14	Isopentane	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-002-15	Pentane	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Deleted - Do Not Use (See 4-03-011 and 4-07) - multiple (See Appendix D)</i>										
4-03-002-16	Toluene	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-002-99	Specify Liquid	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
<i>Deleted - Do Not Use (See 4-03-011 and 4-07) - 2911, 5171, 9711</i>										
4-03-003-02	Gasoline	---	---	---	---	---	7.7	---	---	1000 Gallons Throughput
<i>Fixed Roof Tanks (Varying Sizes) - 2911, 2992, 1311, 1321</i>										
4-03-010-01	Gasoline RVP 13: Breathing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	30.5	---	---	1000 Gallon-Years Storage Capacity
4-03-010-02	Gasoline RVP 10: Breathing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	23.4	---	---	1000 Gallon-Years Storage Capacity
4-03-010-03	Gasoline RVP 7: Breathing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	16.5	---	---	1000 Gallon-Years Storage Capacity
4-03-010-04	Gasoline RVP 13: Breathing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	22	---	---	1000 Gallon-Years Storage Capacity
4-03-010-05	Gasoline RVP 10: Breathing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	16.9	---	---	1000 Gallon-Years Storage Capacity
4-03-010-06	Gasoline RVP 7: Breathing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	11.9	---	---	1000 Gallon-Years Storage Capacity
4-03-010-07	Gasoline RVP 13: Working Loss (Tank Diameter Independent)	---	---	---	---	---	10	---	---	1000 Gallons Throughput
4-03-010-08	Gasoline RVP 10: Working Loss (Tank Diameter Independent)	---	---	---	---	---	8.2	---	---	1000 Gallons Throughput
4-03-010-09	Gasoline RVP 7: Working Loss (Tank Diameter Independent)	---	---	---	---	---	5.7	---	---	1000 Gallons Throughput
4-03-010-10	Crude Oil RVP 5: Breathing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	6.5	---	---	1000 Gallon-Years Storage Capacity
4-03-010-11	Crude Oil RVP 5: Breathing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	4.69	---	---	1000 Gallon-Years Storage Capacity
4-03-010-12	Crude Oil RVP 5: Working Loss (Tank Diameter Independent)	---	---	---	---	---	2.8	---	---	1000 Gallons Throughput
4-03-010-13	Jet Naphtha (JP-4): Breathing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	8.8	---	---	1000 Gallon-Years Storage Capacity
4-03-010-14	Jet Naphtha (JP-4): Breathing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	6.3	---	---	1000 Gallon-Years Storage Capacity
4-03-010-15	Jet Naphtha (JP-4): Working Loss (Tank Diameter Independent)	---	---	---	---	---	2.5	---	---	1000 Gallons Throughput
4-03-010-16	Jet Kerosene: Breathing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	0.44	---	---	1000 Gallon-Years Storage Capacity

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Fixed Roof Tanks (Varying Sizes) - 2911, 2992, 1311, 1321</i>										
4-03-010-17	Jet Kerosene: Breathing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	0.3	---	---	1000 Gallon-Years Storage Capacity
4-03-010-18	Jet Kerosene: Working Loss (Tank Diameter Independent)	---	---	---	---	---	0.03	---	---	1000 Gallons Throughput
4-03-010-19	Distillate Fuel #2: Breathing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	0.4	---	---	1000 Gallon-Years Storage Capacity
4-03-010-20	Distillate Fuel #2: Breathing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	0.29	---	---	1000 Gallon-Years Storage Capacity
4-03-010-21	Distillate Fuel #2: Working Loss (Tank Diameter Independent)	---	---	---	---	---	0.02	---	---	1000 Gallons Throughput
4-03-010-22	Asphalt Oil: Breathing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-010-23	Asphalt Oil: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-010-24	Asphalt Oil: Breathing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-010-25	Grade 6 Fuel Oil: Breathing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-010-26	Grade 5 Fuel Oil: Breathing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-010-27	Grade 4 Fuel Oil: Breathing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-010-28	Grade 2 Fuel Oil: Breathing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-010-29	Grade 1 Fuel Oil: Breathing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-010-65	Grade 6 Fuel Oil: Breathing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-010-66	Grade 5 Fuel Oil: Breathing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-010-67	Grade 4 Fuel Oil: Breathing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-010-68	Grade 2 Fuel Oil: Breathing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-010-69	Grade 1 Fuel Oil: Breathing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-010-75	Grade 6 Fuel Oil: Working Loss (Independent Tank Diameter)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-010-76	Grade 5 Fuel Oil: Working Loss (Independent Tank Diameter)	---	---	---	---	---	---	---	---	1000 Gallons Throughput



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Fixed Roof Tanks (Varying Sizes) - 2911, 2992, 1311, 1321</i>										
4-03-010-77	Grade 4 Fuel Oil: Working Loss (Independent Tank Diameter)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-010-78	Grade 2 Fuel Oil: Working Loss (Independent Tank Diameter)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-010-79	Grade 1 Fuel Oil: Working Loss (Independent Tank Diameter)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-010-97	Specify Liquid: Breathing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-010-98	Specify Liquid: Breathing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-010-99	Specify Liquid: Working Loss (Tank Diameter Independent)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i>Floating Roof Tanks (Varying Sizes) - 2911, 2992, 1311, 1321</i>										
4-03-011-01	Gasoline RVP 13: Standing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-02	Gasoline RVP 10: Standing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-03	Gasoline RVP 7: Standing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-04	Gasoline RVP 13: Standing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-05	Gasoline RVP 10: Standing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-06	Gasoline RVP 7: Standing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-07	Gasoline RVP 13/10/7: Withdrawal Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-011-08	Gasoline RVP 13/10/7: Withdrawal Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-011-09	Crude Oil RVP 5: Standing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-10	Crude Oil RVP 5: Standing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-11	Jet Naphtha (JP-4): Standing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-12	Jet Naphtha (JP-4): Standing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-13	Jet Kerosene: Standing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Floating Roof Tanks (Varying Sizes) - 2911, 2992, 1311, 1321</i>										
4-03-011-14	Jet Kerosene: Standing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-15	Distillate Fuel #2: Standing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-16	Distillate Fuel #2: Standing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-17	Crude Oil RVP 5: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-011-18	Jet Naphtha (JP-4): Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-011-19	Jet Kerosene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-011-20	Distillate Fuel #2: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-011-25	Grade 6 Fuel Oil: Standing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-26	Grade 5 Fuel Oil: Standing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-27	Grade 4 Fuel Oil: Standing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-28	Grde 2 Fuel Oil: Stand Loss (67000 Bbl Tank Size) (Use 4-03-011-15)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-29	Grade 1 Fuel Oil: Standing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-30	Specify Liquid: Standing Loss - External - Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-31	Gasoline: Standing Loss - External - Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-32	Crude Oil: Standing Loss - External - Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-33	Jet Naphtha (JP-4): Standing Loss - External - Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-34	Jet Kerosene: Standing Loss - External - Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-35	Distillate Fuel #2: Standing Loss - External - Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-40	Specify Liquid: Standing Loss - External - Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-41	Gasoline: Standing Loss - External - Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-42	Crude Oil: Standing Loss - External - Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Floating Roof Tanks (Varying Sizes) - 2911, 2992, 1311, 1321</i>										
4-03-011-43	Jet Naphtha (JP-4): Standing Loss - External - Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-44	Jet Kerosene: Standing Loss - External - Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-45	Distillate Fuel #2: Standing Loss - External - Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-50	Specify Liquid: Standing Loss - Internal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-51	Gasoline: Standing Loss - Internal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-52	Crude Oil: Standing Loss - Internal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-53	Jet Naphtha (JP-4): Standing Loss - Internal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-54	Jet Kerosene: Standing Loss - Internal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-55	Distillate Fuel #2: Standing Loss - Internal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-65	Grade 6 Fuel Oil: Standing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-66	Grade 5 Fuel Oil: Standing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-67	Grade 4 Fuel Oil: Standing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-68	Grd 2 Fuel Oil: Stand. Loss (250000 Bbl Tank Size) (Use 4-03-011-16)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-69	Grade 1 Fuel Oil: Standing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-75	Grade 6 Fuel Oil: Withdrawal Loss (Independent Tank Diameter)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-011-76	Grade 5 Fuel Oil: Withdrawal Loss (Independent Tank Diameter)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-011-77	Grade 4 Fuel Oil: Withdrawal Loss (Independent Tank Diameter)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-011-78	Grade 2 Fuel Oil: Withdrawal Loss (Independent Tank Diameter)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-011-79	Grade 1 Fuel Oil: Withdrawal Loss (Independent Tank Diameter)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-011-80	Gasoline RVP 13: Withdrawal Loss (Independent Tank Diameter)	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Floating Roof Tanks (Varying Sizes) - 2911, 2992, 1311, 1321</u>										
4-03-011-81	Gasoline RVP 10: Withdrawal Loss (Independent Tank Diameter)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-011-82	Gasoline RVP 7: Withdrawal Loss (Independent Tank Diameter)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-011-97	Specify Liquid: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-03-011-98	Specify Liquid: Standing Loss (67000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-011-99	Specify Liquid: Standing Loss (250000 Bbl. Tank Size)	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
<u>Variable Vapor Space - 2911, 2992, 1311, 1321</u>										
4-03-012-01	Gasoline RVP 13: Filling Loss	---	---	---	---	---	9.6	---	---	1000 Gallons Throughput
4-03-012-02	Gasoline RVP 10: Filling Loss	---	---	---	---	---	7.7	---	---	1000 Gallons Throughput
4-03-012-03	Gasoline RVP 7: Filling Loss	---	---	---	---	---	5.4	---	---	1000 Gallons Throughput
4-03-012-04	Jet Naphtha (JP-4): Filling Loss	---	---	---	---	---	2.3	---	---	1000 Gallons Throughput
4-03-012-05	Jet Kerosene: Filling Loss	---	---	---	---	---	0.025	---	---	1000 Gallons Throughput
4-03-012-06	Distillate Fuel #2: Filling Loss	---	---	---	---	---	0.022	---	---	1000 Gallons Throughput
4-03-012-07	Benzene: Filling Loss	---	---	---	---	---	2.1	---	---	1000 Gallons Throughput
4-03-012-99	Specify Liquid: Filling Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Fugitive Emissions - 1300, 2900</u>										
4-03-888-01	Specify in Comments Field	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-888-02	Specify in Comments Field	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-888-03	Specify in Comments Field	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-888-04	Specify in Comments Field	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-03-888-05	Specify in Comments Field	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
<u>Other Not Classified - multiple (See Appendix D)</u>										
4-03-999-99	See Comment	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><b>PETROLEUM AND SOLVENT EVAPORATION -Petroleum Liquids Storage (non-Refinery)</b></i>										
<i><b>Bulk Terminals - 5171, 4226</b></i>										
4-04-001-01	Gasoline RVP 13: Breathing Loss (67000 Bbl Capacity) - Fixed Roof Tank	---	---	---	---	---	30.5	---	---	1000 Gallon-Years Storage Capacity
4-04-001-02	Gasoline RVP 10: Breathing Loss (67000 Bbl Capacity) - Fixed Roof Tank	---	---	---	---	---	23.4	---	---	1000 Gallon-Years Storage Capacity
4-04-001-03	Gasoline RVP 7: Breathing Loss (67000 Bbl. Capacity) - Fixed Roof Tank	---	---	---	---	---	16.5	---	---	1000 Gallon-Years Storage Capacity
4-04-001-04	Gasoline RVP 13: Breathing Loss (250000 Bbl Capacity)-Fixed Roof Tank	---	---	---	---	---	22	---	---	1000 Gallon-Years Storage Capacity
4-04-001-05	Gasoline RVP 10: Breathing Loss (250000 Bbl Capacity)-Fixed Roof Tank	---	---	---	---	---	16.9	---	---	1000 Gallon-Years Storage Capacity
4-04-001-06	Gasoline RVP 7: Breathing Loss (250000 Bbl Capacity) - Fixed Roof Tank	---	---	---	---	---	11.9	---	---	1000 Gallon-Years Storage Capacity
4-04-001-07	Gasoline RVP 13: Working Loss (Diam. Independent) - Fixed Roof Tank	---	---	---	---	---	10	---	---	1000 Gallons Throughput
4-04-001-08	Gasoline RVP 10: Working Loss (Diameter Independent) - Fixed Roof Tank	---	---	---	---	---	8.2	---	---	1000 Gallons Throughput
4-04-001-09	Gasoline RVP 7: Working Loss (Diameter Independent) - Fixed Roof Tank	---	---	---	---	---	5.7	---	---	1000 Gallons Throughput
4-04-001-10	Gasoline RVP 13: Standing Loss (67000 Bbl Capacity)-Floating Roof Tank	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-11	Gasoline RVP 10: Standing Loss (67000 Bbl Capacity)-Floating Roof Tank	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-12	Gasoline RVP 7: Standing Loss (67000 Bbl Capacity)-Floating Roof Tank	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-13	Gasoline RVP 13: Standing Loss (250000 Bbl Cap.) - Floating Roof Tank	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-14	Gasoline RVP 10: Standing Loss (250000 Bbl Cap.) - Floating Roof Tank	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-15	Gasoline RVP 7: Standing Loss (250000 Bbl Cap.) - Floating Roof Tank	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-16	Gasoline RVP 13/10/7: Withdrawal Loss (67000 Bbl Cap.) - Float Rf Tnk	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-001-17	Gasoline RVP 13/10/7: Withdrawal Loss (250000 Bbl Cap.) - Float Rf Tnk	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-001-18	Gasoline RVP 13: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space	---	---	---	---	---	9.6	---	---	1000 Gallons Throughput
4-04-001-19	Gasoline RVP 10: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space	---	---	---	---	---	7.7	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Bulk Terminals - 5171, 4226</u></i>										
4-04-001-20	Gasoline RVP 7: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space	---	---	---	---	---	5.4	---	---	1000 Gallons Throughput
4-04-001-21	Diesel Fuel: Standing Loss (Diameter Independent) - Fixed Roof Tank	---	---	---	---	---	---	---	---	1000 Gallon-Years Stored
4-04-001-22	Diesel Fuel: Working Loss (Diameter Independent) - Fixed Roof Tank	---	---	---	---	---	---	---	---	1000 Gallon-Years Stored
4-04-001-30	Specify Liquid: Standing Loss - External Floating Roof w/ Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-31	Gasoline RVP 13: Standing Loss - Ext. Floating Roof w/ Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-32	Gasoline RVP 10: Standing Loss - Ext. Floating Roof w/ Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-33	Gasoline RVP 7: Standing Loss - External Floating Roof w/ Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-40	Specify Liquid: Standing Loss - Ext. Float Roof Tank w/ Second'y Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-41	Gasoline RVP 13: Standing Loss - Ext. Floating Roof w/ Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-42	Gasoline RVP 10: Standing Loss - Ext. Floating Roof w/ Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-43	Gasoline RVP 7: Standing Loss - Ext. Floating Roof w/ Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-48	Gasoline RVP 13/10/7: Withdrawal Loss - Ext. Float Roof (Pri/Sec Seal)	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-04-001-49	Specify Liquid: External Floating Roof (Primary/Secondary Seal)	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-04-001-50	Miscellaneous Losses/Leaks: Loading Racks	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-04-001-51	Valves, Flanges, and Pumps	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-04-001-52	Vapor Collection Losses	---	---	---	---	---	5.2	---	---	1000 Gallons Transferred
4-04-001-53	Vapor Control Unit Losses	---	---	---	---	---	5	---	---	1000 Gallons Transferred
4-04-001-54	Tank Truck Vapor Leaks	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-04-001-60	Specify Liquid: Standing Loss - Internal Floating Roof w/ Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-61	Gasoline RVP 13: Standing Loss - Int. Floating Roof w/ Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-62	Gasoline RVP 10: Standing Loss - Int. Floating Roof w/ Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-63	Gasoline RVP 7: Standing Loss - Internal Floating Roof w/ Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Bulk Terminals - 5171, 4226</u></i>										
4-04-001-70	Specify Liquid: Standing Loss - Int. Floating Roof w/ Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-71	Gasoline RVP 13: Standing Loss - Int. Floating Roof w/ Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-72	Gasoline RVP 10: Standing Loss - Int. Floating Roof w/ Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-73	Gasoline RVP 7: Standing Loss - Int. Floating Roof w/ Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-001-78	Gasoline RVP 13/10/7: Withdrawal Loss - Int. Float Roof (Pri/Sec Seal)	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-04-001-79	Specify Liquid: Internal Floating Roof (Primary/Secondary Seal)	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-04-001-99	See Comment	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Bulk Plants - 5171, 4226</u></i>										
4-04-002-01	Gasoline RVP 13: Breathing Loss (67000 Bbl Capacity) - Fixed Roof Tank	---	---	---	---	---	30.5	---	---	1000 Gallon-Years Storage Capacity
4-04-002-02	Gasoline RVP 10: Breathing Loss (67000 Bbl Capacity) - Fixed Roof Tank	---	---	---	---	---	23.4	---	---	1000 Gallon-Years Storage Capacity
4-04-002-03	Gasoline RVP 7: Breathing Loss (67000 Bbl. Capacity) - Fixed Roof Tank	---	---	---	---	---	16.5	---	---	1000 Gallon-Years Storage Capacity
4-04-002-04	Gasoline RVP 13: Working Loss (67000 Bbl. Capacity) - Fixed Roof Tank	---	---	---	---	---	10	---	---	1000 Gallons Throughput
4-04-002-05	Gasoline RVP 10: Working Loss (67000 Bbl. Capacity) - Fixed Roof Tank	---	---	---	---	---	8.2	---	---	1000 Gallons Throughput
4-04-002-06	Gasoline RVP 7: Working Loss (67000 Bbl. Capacity) - Fixed Roof Tank	---	---	---	---	---	5.7	---	---	1000 Gallons Throughput
4-04-002-07	Gasoline RVP 13: Standing Loss (67000 Bbl Cap.) - Floating Roof Tank	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-08	Gasoline RVP 10: Standing Loss (67000 Bbl Cap.) - Floating Roof Tank	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-09	Gasoline RVP 7: Standing Loss (67000 Bbl Cap.) - Floating Roof Tank	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-10	Gasoline RVP 13/10/7: Withdrawal Loss (67000 Bbl Cap.) - Float Rf Tnk	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-002-11	Gasoline RVP 13: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space	---	---	---	---	---	9.6	---	---	1000 Gallons Throughput
4-04-002-12	Gasoline RVP 10: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space	---	---	---	---	---	7.7	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Bulk Plants - 5171, 4226</i>										
4-04-002-13	Gasoline RVP 7: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space	---	---	---	---	---	5.4	---	---	1000 Gallons Throughput
4-04-002-30	Specify Liquid: Standing Loss - External Floating Roof w/ Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-31	Gasoline RVP 13: Standing Loss - Ext. Floating Roof w/ Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-32	Gasoline RVP 10: Standing Loss - Ext. Floating Roof w/ Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-33	Gasoline RVP 7: Standing Loss - External Floating Roof w/ Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-40	Specify Liquid: Standing Loss - Ext. Floating Roof w/ Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-41	Gasoline RVP 13: Standing Loss - Ext. Floating Roof w/ Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-42	Gasoline RVP 10: Standing Loss - Ext. Floating Roof w/ Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-43	Gasoline RVP 7: Standing Loss - Ext. Floating Roof w/ Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-48	Gasoline RVP 10/13/7: Withdrawal Loss - Ext. Float Roof (Pri/Sec Seal)	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-04-002-49	Specify Liquid: External Floating Roof (Primary/Secondary Seal)	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-04-002-50	Loading Racks	---	---	---	---	---	4.8	---	---	1000 Gallons Transferred
4-04-002-51	Valves, Flanges, and Pumps	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-04-002-52	Miscellaneous Losses/Leaks: Vapor Collection Losses	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-04-002-53	Miscellaneous Losses/Leaks: Vapor Control Unit Losses	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-04-002-54	Tank Truck Vapor Losses	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-04-002-55	Loading Racks - Jet Fuel	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-04-002-60	Specify Liquid: Standing Loss - Internal Floating Roof w/ Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-61	Gasoline RVP 13: Standing Loss - Int. Floating Roof w/ Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-62	Gasoline RVP 10: Standing Loss - Int. Floating Roof w/ Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-63	Gasoline RVP 7: Standing Loss - Internal Floating Roof w/ Primary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-70	Specify Liquid: Standing Loss - Int. Floating Roof w/ Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Bulk Plants - 5171, 4226</u></i>										
4-04-002-71	Gasoline RVP 13: Standing Loss - Int. Floating Roof w/ Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-72	Gasoline RVP 10: Standing Loss - Int. Floating Roof w/ Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-73	Gasoline RVP 7: Standing Loss - Int. Floating Roof w/ Secondary Seal	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-002-78	Gasoline RVP 10/13/7: Withdrawal Loss - Int. Float Roof (Pri/Sec Seal)	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-04-002-79	Specify Liquid: Internal Floating Roof (Primary/Secondary Seal)	---	---	---	---	---	---	---	---	1000 Gallons Transferred
<i><u>Oil and Gas Field Storage and Working Tanks - 1311</u></i>										
4-04-003-01	Fixed Roof Tank: Breathing Loss	---	---	---	---	---	36	---	---	1000 Gallon-Years Storage Capacity
4-04-003-02	Fixed Roof Tank: Working Loss	---	---	---	---	---	1.1	---	---	1000 Gallons Throughput
4-04-003-03	External Floating Roof Tank with Primary Seals: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-003-04	External Floating Roof Tank with Secondary Seals: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-003-05	Internal Floating Roof Tank: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-003-06	External Floating Roof Tank: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-07	Internal Floating Roof Tank: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-11	Fixed Roof Tank, Condensate, working+breathing+flashing losses	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-12	Fixed Roof Tank, Crude Oil, working+breathing+flashing losses	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-13	Fixed Roof Tank, Lube Oil, working+breathing+flashing losses	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-14	Fixed Roof Tank, Specialty Chem-working+breathing+flashing	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-15	Fixed Roof Tank, Produced Water, working+breathing+flashing	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-16	Fixed Roof Tank, Diesel, working+breathing+flashing losses	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-21	External Floating Roof Tank, Condensate, working+breathing+flashing	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-22	External Floating Roof Tank, Crude Oil, working+breathing+flashing	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Oil and Gas Field Storage and Working Tanks - 1311</i>										
4-04-003-23	External Floating Roof Tank, Lube Oil, working+breathing+flashing	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-24	External Floating Roof Tank, Specialty Chem-working+breathing+flashing	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-25	External Floating Roof Tank, Produced Water-working+breathing+flashing	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-26	External Floating Roof Tank, Diesel, working+breathing+flashing	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-31	Internal Floating Roof Tank, Condensate, working+breathing+flashing	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-32	Internal Floating Roof Tank, Crude Oil, working+breathing+flashing	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-33	Internal Floating Roof Tank, Lube Oil, working+breathing+flashing	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-34	Internal Floating Roof Tank, Specialty Chem-working+breathing+flashing	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-35	Internal Floating Roof Tank, Produced Water-working+breathing+flashing	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-36	Internal Floating Roof Tank, Diesel, working+breathing+flashing	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-04-003-40	Pressure Tanks (pressure relief from pop-off valves)	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i>Petroleum Products - Underground Tanks - 5171, 4226</i>										
4-04-004-01	Gasoline RVP 13: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-004-02	Gasoline RVP 13: Working Loss	---	---	---	---	---	14.9	---	---	1000 Gallons Throughput
4-04-004-03	Gasoline RVP 10: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-004-04	Gasoline RVP 10: Working Loss	---	---	---	---	---	11.9	---	---	1000 Gallons Throughput
4-04-004-05	Gasoline RVP 7: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-004-06	Gasoline RVP 7: Working Loss	---	---	---	---	---	8.3	---	---	1000 Gallons Throughput
4-04-004-07	Crude Oil RVP 5: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-004-08	Crude Oil RVP 5: Working Loss	---	---	---	---	---	4.9	---	---	1000 Gallons Throughput
4-04-004-09	Jet Naphtha (JP-4): Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-004-10	Jet Naphtha (JP-4): Working Loss	---	---	---	---	---	3.6	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Petroleum Products - Underground Tanks - 5171, 4226</u></i>										
4-04-004-11	Jet Kerosene: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-004-12	Jet Kerosene: Working Loss	---	---	---	---	---	0.04	---	---	1000 Gallons Throughput
4-04-004-13	Distillate Fuel #2: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-004-14	Distillate Fuel #2: Working Loss	---	---	---	---	---	0.03	---	---	1000 Gallons Throughput
4-04-004-97	Specify Liquid: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-04-004-98	Specify Liquid: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>PETROLEUM AND SOLVENT EVAPORATION -Printing/Publishing</u></i>										
<i><u>Drying - 2700</u></i>										
4-05-001-01	Dryer	---	---	---	---	57	2000	---	---	Tons Used
4-05-001-99	Dryer	---	---	---	---	---	---	---	---	Gallons Used
<i><u>General - 2751</u></i>										
4-05-002-01	Letter Press: 2751	---	---	---	---	---	238	---	---	Tons Used
4-05-002-02	Ink Thinning Solvent (Kerosene)	---	---	---	---	---	2000	---	---	Tons Added
4-05-002-03	Ink Thinning Solvents (Mineral Solvents)	---	---	---	---	---	2000	---	---	Tons Added
4-05-002-11	Letter Press: 2751	---	---	---	---	---	1200	---	---	Tons Used
4-05-002-12	Printing: Letter Press	---	---	---	---	---	1.5	---	---	Gallons Used
4-05-002-15	Letterpress: Cleaning Solution	---	---	---	---	---	---	---	---	Tons Consumed
<i><u>General - 2751</u></i>										
4-05-003-01	Printing: Flexographic	---	---	---	---	---	711	---	---	Tons Used
4-05-003-02	Ink Thinning Solvent (Carbitol)	---	---	---	---	---	2000	---	---	Tons Added
4-05-003-03	Ink Thinning Solvent (Cellosolve)	---	---	---	---	---	2000	---	---	Tons Added
4-05-003-04	Ink Thinning Solvent (Ethyl Alcohol)	---	---	---	---	---	2000	---	---	Tons Added
4-05-003-05	Ink Thinning Solvent (Isopropyl Alcohol)	---	---	---	---	---	2000	---	---	Tons Added
4-05-003-06	Ink Thinning Solvent (n-Propyl Alcohol)	---	---	---	---	---	2000	---	---	Tons Added
4-05-003-07	Ink Thinning Solvent (Naphtha)	---	---	---	---	---	2000	---	---	Tons Added
4-05-003-11	Printing: Flexographic	---	---	---	---	---	1910	---	---	Tons Used
4-05-003-12	Printing: Flexographic	---	---	---	---	---	4.4	---	---	Gallons Used
4-05-003-14	Printing: Flexographic: Propyl Alcohol Cleanup	---	---	---	---	---	2000	---	---	Tons Consumed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>General - 2751</u>										
4-05-003-15	Flexographic: Steam: Water-based	---	---	---	---	---	---	---	---	Tons Used
4-05-003-16	Flexographic: Steam: Water-based	---	---	---	---	---	---	---	---	Tons Used
4-05-003-17	Flexographic: Steam: Water-based	---	---	---	---	---	---	---	---	Tons Stored
4-05-003-18	Flexographic: Steam: Water-based in Ink	---	---	---	---	---	---	---	---	Tons Used
4-05-003-19	Flexographic: Steam: Water-based Ink Storage	---	---	---	---	---	---	---	---	Tons Stored
<u>General - 2752</u>										
4-05-004-01	Lithographic: 2752	---	---	---	---	---	198	---	---	Tons Used
4-05-004-11	Lithographic: 2752	---	---	---	---	---	1000	---	---	Tons Used
4-05-004-12	Lithographic: 2752	---	---	---	---	---	1.24	---	---	Gallons Used
4-05-004-13	Lithographic: Isopropyl Alcohol Cleanup	---	---	---	---	---	---	---	---	Tons Used
4-05-004-14	Flexographic: Propyl Alcohol Cleanup	---	---	---	---	---	---	---	---	Tons Consumed
4-05-004-15	Offset Lithography: Dampening Solution with Alcohol Substitute	---	---	---	---	---	---	---	---	Tons Used
4-05-004-16	Offset Lithography: Dampening Solution with High Solvent Content	---	---	---	---	---	---	---	---	Tons Used
4-05-004-17	Offset Lithography: Cleaning Solution: Water-based	---	---	---	---	---	---	---	---	Tons Used
4-05-004-18	Offset Lithography: Dampening Solution with Isopropyl Alcohol	---	---	---	---	---	---	---	---	Tons Used
4-05-004-21	Offset Lithography: Heatset Ink Mixing	---	---	---	---	---	---	---	---	Tons Used
4-05-004-22	Offset Lithography: Heatset Solvent Storage	---	---	---	---	---	---	---	---	Tons Stored
4-05-004-31	Offset Lithography: Nonheated Lithographic Inks	---	---	---	---	---	---	---	---	Tons Used
4-05-004-32	Offset Lithography: Nonheated Lithographic Inks	---	---	---	---	---	---	---	---	Tons Used
4-05-004-33	Offset Lithography: Nonheated Lithographic Inks	---	---	---	---	---	---	---	---	Gallons Used
<u>General - 2751, 2754</u>										
4-05-005-01	Gravure: 2754	---	---	---	---	---	711	---	---	Tons Used
4-05-005-02	Ink Thinning Solvent: Dimethylformamide	---	---	---	---	---	2000	---	---	Tons Added
4-05-005-03	Ink Thinning Solvent: Ethyl Acetate	---	---	---	---	---	2000	---	---	Tons Added
4-05-005-06	Ink Thinning Solvent: Methyl Ethyl Ketone	---	---	---	---	---	2000	---	---	Tons Added
4-05-005-07	Ink Thinning Solvent: Methyl Isobutyl Ketone	---	---	---	---	---	2000	---	---	Tons Added
4-05-005-10	Ink Thinning Solvent: Toluene	---	---	---	---	---	2000	---	---	Tons Added
4-05-005-11	Gravure: 2754	---	---	---	---	---	1910	---	---	Tons Used
4-05-005-12	Gravure: 2754	---	---	---	---	---	4.4	---	---	Gallons Used

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>General - 2751, 2754</u>										
4-05-005-13	Gravure: 2754	---	---	---	---	---	12.4	---	---	Gallons Used
4-05-005-14	Gravure: Cleanup Solvent	---	---	---	---	---	---	---	---	Tons Consumed
4-05-005-97	Other Not Classified	---	---	---	---	---	---	---	---	Pounds Consumed
4-05-005-98	Ink Thinning Solvent: Other Not Specified	---	---	---	---	---	---	---	---	1000 Gallons Used
4-05-005-99	Ink Thinning Solvent: Other Not Specified	---	---	---	---	---	2000	---	---	Tons Added
<u>General - 2751</u>										
4-05-006-01	Ink Mixing	---	---	---	---	---	---	---	---	Tons Used
<u>General - 2751</u>										
4-05-007-01	Solvent Storage	---	---	---	---	---	---	---	---	Tons Stored
<u>General - multiple (See Appendix D)</u>										
4-05-008-01	Screen Printing	---	---	---	---	---	---	---	---	Tons Used
4-05-008-02	Fugitive Emissions: Cleaning Rags	---	---	---	---	---	---	---	---	Tons Used
4-05-008-11	Screen Printing	---	---	---	---	---	---	---	---	Tons Used
4-05-008-12	Screen Printing	---	---	---	---	---	---	---	---	Gallons Used
<u>Fugitive Emissions - 2700</u>										
4-05-888-01	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
4-05-888-02	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
4-05-888-03	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
4-05-888-04	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
4-05-888-05	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
<u>PETROLEUM AND SOLVENT EVAPORATION -Transportation and Marketing of Petroleum Products</u>										
<u>Tank Cars and Trucks - 5169, 5171, 5172</u>										
4-06-001-01	Gasoline: Splash Loading	---	---	---	---	---	12.4	---	---	1000 Gallons Transferred
4-06-001-26	Gasoline: Submerged Loading	---	---	---	---	---	4.1	---	---	1000 Gallons Transferred
4-06-001-29	Asphalt: Splash Loading	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-06-001-30	Distillate Oil: Submerged Loading	---	---	---	---	---	0.48	---	---	1000 Gallons Transferred
4-06-001-31	Gasoline: Submerged Loading (Normal Service)	---	---	---	---	---	5	---	---	1000 Gallons Transferred
4-06-001-32	Crude Oil: Submerged Loading (Normal Service)	---	---	---	---	---	2	---	---	1000 Gallons Transferred
4-06-001-33	Jet Naphtha: Submerged Loading (Normal Service)	---	---	---	---	---	1.5	---	---	1000 Gallons Transferred
4-06-001-34	Kerosene: Submerged Loading (Normal Services)	---	---	---	---	---	0.16	---	---	1000 Gallons Transferred

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Tank Cars and Trucks - 5169, 5171, 5172</i>										
4-06-001-35	Distillate Oil: Submerged Loading (Normal Service)	---	---	---	---	---	0.014	---	---	1000 Gallons Transferred
4-06-001-36	Gasoline: Splash Loading (Normal Service)	---	---	---	---	---	12	---	---	1000 Gallons Transferred
4-06-001-37	Crude Oil: Splash Loading (Normal Service)	---	---	---	---	---	5.5	---	---	1000 Gallons Transferred
4-06-001-38	Jet Naphtha: Splash Loading (Normal Service)	---	---	---	---	---	4	---	---	1000 Gallons Transferred
4-06-001-39	Kerosene: Splash Loading (Normal Service)	---	---	---	---	---	0.04	---	---	1000 Gallons Transferred
4-06-001-40	Distillate Oil: Splash Loading (Normal Service)	---	---	---	---	---	0.03	---	---	1000 Gallons Transferred
4-06-001-41	Gasoline: Submerged Loading (Balanced Service)	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-06-001-42	Crude Oil: Submerged Loading (Balanced Service)	---	---	---	---	---	3	---	---	1000 Gallons Transferred
4-06-001-43	Jet Naphtha: Submerged Loading (Balanced Service)	---	---	---	---	---	2.5	---	---	1000 Gallons Transferred
4-06-001-44	Gasoline: Splash Loading (Balanced Service)	---	---	---	---	---	8	---	---	1000 Gallons Transferred
4-06-001-45	Crude Oil: Splash Loading (Balanced Service)	---	---	---	---	---	3	---	---	1000 Gallons Transferred
4-06-001-46	Jet Naphtha: Splash Loading (Balanced Service)	---	---	---	---	---	2.5	---	---	1000 Gallons Transferred
4-06-001-47	Gasoline: Submerged Loading (Clean Tanks)	---	---	---	---	---	4	---	---	1000 Gallons Transferred
4-06-001-48	Crude Oil: Submerged Loading (Clean Tanks)	---	---	---	---	---	1.7	---	---	1000 Gallons Transferred
4-06-001-49	Jet Naphtha: Submerged Loading (Clean Tanks)	---	---	---	---	---	1.5	---	---	1000 Gallons Transferred
4-06-001-60	Kerosene: Submerged Loading (Clean Tanks)	---	---	---	---	---	0.017	---	---	1000 Gallons Transferred
4-06-001-61	Distillate Oil: Submerged Loading (Clean Tanks)	---	---	---	---	---	0.013	---	---	1000 Gallons Transferred
4-06-001-62	Gasoline: Loaded with Fuel (Transit Losses)	---	---	---	---	---	0.01	---	---	1000 Gallons Transferred
4-06-001-63	Gasoline: Return with Vapor (Transit Losses)	---	---	---	---	---	0.11	---	---	1000 Gallons Transferred
4-06-001-64	Crude Oil: Loaded with Product	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-06-001-65	Crude Oil: Loaded with Vapor	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-06-001-66	Jet Fuel: Loaded with Product	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-06-001-67	Jet Fuel: Loaded with Vapor	---	---	---	---	---	---	---	---	Tons Transferred
4-06-001-68	Kerosene: Loaded with Product	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-06-001-69	Kerosene: Loaded with Vapor	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-06-001-70	Distillate Oil: Loaded with Product	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-06-001-71	Distillate Oil: Loaded with Vapor	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-06-001-72	Transit Losses - LPG: Loaded with Fuel	---	---	---	---	---	---	---	---	1000 Gallons Transported
4-06-001-73	Transit Losses - LPG: Return with Vapor	---	---	---	---	---	---	---	---	1000 Gallons Transported
4-06-001-97	Not Classified	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-06-001-98	Not Classified	---	---	---	---	---	---	---	---	1000 Gallons Transferred

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Tank Cars and Trucks - 5169, 5171, 5172</u>										
4-06-001-99	Not Classified	---	---	---	---	---	---	---	---	1000 Gallons Transferred
<u>Marine Vessels - 4491</u>										
4-06-002-31	Gasoline: Ship Loading - Cleaned and Vapor Free Tanks	---	---	---	---	---	0.7	---	---	1000 Gallons Transferred
4-06-002-32	Gasoline: Ocean Barges Loading	---	---	---	---	---	0.7	---	---	1000 Gallons Transferred
4-06-002-33	Gasoline: Barge Loading - Cleaned and Vapor Free Tanks	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-06-002-34	Gasoline: Ship Loading - Ballasted Tank	---	---	---	---	---	1.7	---	---	1000 Gallons Transferred
4-06-002-35	Gasoline: Ocean Barges Loading - Ballasted Tank	---	---	---	---	---	1.7	---	---	1000 Gallons Transferred
4-06-002-36	Gasoline: Ship Loading - Uncleaned Tanks	---	---	---	---	---	2.6	---	---	1000 Gallons Transferred
4-06-002-37	Gasoline: Ocean Barges Loading - Uncleaned Tanks	---	---	---	---	---	2.6	---	---	1000 Gallons Transferred
4-06-002-38	Gasoline: Barges Loading - Uncleaned Tanks	---	---	---	---	---	3.9	---	---	1000 Gallons Transferred
4-06-002-39	Gasoline: Tanker Ship - Ballasted Tank Condition	---	---	---	---	---	0.8	---	---	1000 Gallons Transferred
4-06-002-40	Gasoline: Barge Loading - Average Tank Condition	---	---	---	---	---	3.4	---	---	1000 Gallons Transferred
4-06-002-41	Gasoline: Tanker Ship - Ballasting	---	---	---	---	---	1.7	---	---	1000 Gallon-Years Existing
4-06-002-42	Gasoline: Transit Loss	---	---	---	---	---	140.4	---	---	1000 Gallons Transported
4-06-002-43	Crude Oil: Loading Tankers	---	---	---	---	---	0.61	---	---	1000 Gallons Transferred
4-06-002-44	Jet Fuel: Loading Tankers	---	---	---	---	---	0.5	---	---	1000 Gallons Transferred
4-06-002-45	Kerosene: Loading Tankers	---	---	---	---	---	0.005	---	---	1000 Gallons Transferred
4-06-002-46	Distillate Oil: Loading Tankers	---	---	---	---	---	0.005	---	---	1000 Gallons Transferred
4-06-002-48	Crude Oil: Loading Barges	---	---	---	---	---	1	---	---	1000 Gallons Transferred
4-06-002-49	Jet Fuel: Loading Barges	---	---	---	---	---	1.2	---	---	1000 Gallons Transferred
4-06-002-50	Kerosene: Loading Barges	---	---	---	---	---	0.013	---	---	1000 Gallons Transferred
4-06-002-51	Distillate Oil: Loading Barges	---	---	---	---	---	0.012	---	---	1000 Gallons Transferred
4-06-002-53	Crude Oil: Tanker Ballasting	---	---	---	---	---	1.1	---	---	1000 Gallon-Years Existing
4-06-002-54	Crude Oil: Transit Loss	---	---	---	---	---	69.6	---	---	1000 Gallons Transported
4-06-002-55	Jet Fuel: Transit Loss	---	---	---	---	---	57	---	---	1000 Gallons Transported
4-06-002-56	Kerosene: Transit Loss	---	---	---	---	---	0.26	---	---	1000 Gallons Transported
4-06-002-57	Distillate Oil: Transit Loss	---	---	---	---	---	0.26	---	---	1000 Gallons Transported
4-06-002-59	Tanker/Barge Cleaning	---	---	---	---	---	---	---	---	1000 Gallon-Years Existing
4-06-002-60	Gasoline: Barge Loading - Ballasted	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-06-002-61	Gasoline: Tanker Ship - Uncleaned Tanks	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-06-002-98	Not Classified	---	---	---	---	---	---	---	---	1000 Gallons Transferred

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Marine Vessels - 4491</i></u>										
4-06-002-99	Not Classified	---	---	---	---	---	---	---	---	1000 Gallons Transferred
<u><i>Gasoline Retail Operations - Stage I - 5541</i></u>										
4-06-003-01	Splash Filling	---	---	---	---	---	11.5	---	---	1000 Gallons Transferred
4-06-003-02	Submerged Filling w/o Controls	---	---	---	---	---	7.3	---	---	1000 Gallons Transferred
4-06-003-05	Unloading	---	---	---	---	---	1	---	---	1000 Gallons Transferred
4-06-003-06	Balanced Submerged Filling	---	---	---	---	---	0.3	---	---	1000 Gallons Throughput
4-06-003-07	Underground Tank Breathing and Emptying	---	---	---	---	---	1	---	---	1000 Gallons Throughput
4-06-003-99	Not Classified	---	---	---	---	---	---	---	---	1000 Gallons Transferred
<u><i>Filling Vehicle Gas Tanks - Stage II - 5541</i></u>										
4-06-004-01	Vapor Loss w/o Controls	---	---	---	---	---	11	---	---	1000 Gallons Pumped
4-06-004-02	Liquid Spill Loss w/o Controls	---	---	---	---	---	0.7	---	---	1000 Gallons Pumped
4-06-004-03	Vapor Loss w/o Controls	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-06-004-99	Not Classified	---	---	---	---	---	---	---	---	1000 Gallons Pumped
<u><i>Pipeline Petroleum Transport - General - All Products - 5171, 4612</i></u>										
4-06-005-01	Pipeline Leaks	---	---	---	---	---	---	---	---	1000 Mile-Years Existing
4-06-005-02	Pipeline Venting	---	---	---	---	---	---	---	---	1000 Barrel-Miles Throughput
4-06-005-03	Pump Station	---	---	---	---	---	---	---	---	1000 Barrel-Miles Throughput
4-06-005-04	Pump Station Leaks	---	---	---	---	---	---	---	---	1000 Barrel-Miles Throughput
<u><i>Consumer (Corporate) Fleet Refueling - Stage II - 5500, 5540, 5980, 5989</i></u>										
4-06-006-01	Vapor Loss w/o Controls	---	---	---	---	---	---	---	---	1000 Gallons Pumped
4-06-006-02	Liquid Spill Loss w/o Controls	---	---	---	---	---	---	---	---	1000 Gallons Pumped
4-06-006-03	Vapor Loss w/controls	---	---	---	---	---	---	---	---	1000 Gallons Pumped
4-06-006-30	Asphalt: Splash Loading	---	---	---	---	---	---	---	---	1000 Gallons Pumped
4-06-006-51	Diesel: Vapor Loss w/o Controls	---	---	---	---	---	---	---	---	1000 Gallons Pumped
<u><i>Consumer (Corporate) Fleet Refueling - Stage I - 4931</i></u>										
4-06-007-01	Splash Filling	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-06-007-02	Submerged Filling w/o Controls	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-06-007-06	Balanced Submerged Filling	---	---	---	---	---	---	---	---	1000 Gallons Transferred



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Consumer (Corporate) Fleet Refueling - Stage I - 4931</u></i>										
4-06-007-07	Underground Tank Breathing and Emptying	---	---	---	---	---	---	---	---	1000 Gallons Transferred
<i><u>Fugitive Emissions - 4400, 4500, 5100</u></i>										
4-06-888-01	Specify in Comments Field	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-06-888-02	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
4-06-888-03	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
4-06-888-04	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
4-06-888-05	Specify in Comments Field	---	---	---	---	---	---	---	---	Each-Year Operating
<i><u>PETROLEUM AND SOLVENT EVAPORATION -Organic Chemical Storage</u></i>										
<i><u>Fixed Roof Tanks - Acid Anhydrides - 2800, 2900, 3000, 5100</u></i>										
4-07-004-01	Acetic Anhydrides: Breathing Loss	---	---	---	---	---	1.2	---	---	1000 Gallon-Years Storage Capacity
4-07-004-02	Acetic Anhydrides: Working Loss	---	---	---	---	---	0.13	---	---	1000 Gallons Throughput
4-07-004-03	Maleic Anhydride: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-004-04	Maleic Anhydride: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-004-05	Phthalic Anhydride: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-004-06	Phthalic Anhydride: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-004-97	Specify Anhydride: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-004-98	Specify Anhydride: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fixed Roof Tanks - Alcohols - 2800, 2900, 3000, 5100</u></i>										
4-07-008-01	N-Butyl Alcohol: Breathing Loss	---	---	---	---	---	0.9	---	---	1000 Gallon-Years Storage Capacity
4-07-008-02	N-Butyl Alcohol: Working Loss	---	---	---	---	---	0.1	---	---	1000 Gallons Throughput
4-07-008-03	Sec-Butyl Alcohol: Breathing Loss	---	---	---	---	---	2	---	---	1000 Gallon-Years Storage Capacity
4-07-008-04	Sec-Butyl Alcohol: Working Loss	---	---	---	---	---	0.32	---	---	1000 Gallons Throughput
4-07-008-05	Tert-Butyl Alcohol: Breathing Loss	---	---	---	---	---	3.6	---	---	1000 Gallon-Years Storage Capacity
4-07-008-06	Tert-Butyl Alcohol: Working Loss	---	---	---	---	---	0.76	---	---	1000 Gallons Throughput
4-07-008-07	Cyclohexanol: Breathing Loss	---	---	---	---	---	0.58	---	---	1000 Gallon-Years Storage Capacity

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Fixed Roof Tanks - Alcohols - 2800, 2900, 3000, 5100</u></i>										
4-07-008-08	Cyclohexanol: Working Loss	---	---	---	---	---	0.046	---	---	1000 Gallons Throughput
4-07-008-09	Ethyl Alcohol: Breathing Loss	---	---	---	---	---	2.9	---	---	1000 Gallon-Years Storage Capacity
4-07-008-10	Ethyl Alcohol: Working Loss	---	---	---	---	---	0.66	---	---	1000 Gallons Throughput
4-07-008-11	Isobutyl Alcohol: Breathing Loss	---	---	---	---	---	1.3	---	---	1000 Gallon-Years Storage Capacity
4-07-008-12	Isobutyl Alcohol: Working Loss	---	---	---	---	---	0.17	---	---	1000 Gallons Throughput
4-07-008-13	Isopropyl Alcohol: Breathing Loss	---	---	---	---	---	3.8	---	---	1000 Gallon-Years Storage Capacity
4-07-008-14	Isopropyl Alcohol: Working Loss	---	---	---	---	---	0.86	---	---	1000 Gallons Throughput
4-07-008-15	Methyl Alcohol: Breathing Loss	---	---	---	---	---	3.7	---	---	1000 Gallon-Years Storage Capacity
4-07-008-16	Methyl Alcohol: Working Loss	---	---	---	---	---	1.07	---	---	1000 Gallons Throughput
4-07-008-17	N-Propyl Alcohol: Breathing Loss	---	---	---	---	---	1.8	---	---	1000 Gallon-Years Storage Capacity
4-07-008-18	N-Propyl Alcohol: Working Loss	---	---	---	---	---	0.3	---	---	1000 Gallons Throughput
4-07-008-19	Xylol: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-008-20	Xylol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-008-97	Specify Alcohol: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-008-98	Specify Alcohol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fixed Roof Tanks - Alkanes (Paraffins) - 2800, 2900, 3000, 5100</u></i>										
4-07-016-01	N-Decane: Breathing Loss	---	---	---	---	---	0.61	---	---	1000 Gallon-Years Storage Capacity
4-07-016-02	N-Decane: Working Loss	---	---	---	---	---	0.04	---	---	1000 Gallons Throughput
4-07-016-03	N-Dodecane: Breathing Loss	---	---	---	---	---	0.13	---	---	1000 Gallon-Years Storage Capacity
4-07-016-04	N-Dodecane: Working Loss	---	---	---	---	---	0.004	---	---	1000 Gallons Throughput
4-07-016-05	N-Heptane: Breathing Loss	---	---	---	---	---	5.8	---	---	1000 Gallon-Years Storage Capacity
4-07-016-06	N-Heptane: Working Loss	---	---	---	---	---	1.3	---	---	1000 Gallons Throughput
4-07-016-07	Isopentane: Breathing Loss	---	---	---	---	---	57.2	---	---	1000 Gallon-Years Storage Capacity
4-07-016-08	Isopentane: Working Loss	---	---	---	---	---	16.3	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Fixed Roof Tanks - Alkanes (Paraffins) - 2800, 2900, 3000, 5100</u>										
4-07-016-09	Pentadecane: Breathing Loss	---	---	---	---	---	0.05	---	---	1000 Gallon-Years Storage Capacity
4-07-016-10	Pentadecane: Working Loss	---	---	---	---	---	0.0008	---	---	1000 Gallons Throughput
4-07-016-11	Naphtha: Breathing Loss	---	---	---	---	---	0.17	---	---	1000 Gallon-Years Storage Capacity
4-07-016-12	Naphtha: Working Loss	---	---	---	---	---	0.006	---	---	1000 Gallons Throughput
4-07-016-13	Petroleum Distillate: Breathing Loss	---	---	---	---	---	0.17	---	---	1000 Gallon-Years Storage Capacity
4-07-016-14	Petroleum Distillate: Working Loss	---	---	---	---	---	0.006	---	---	1000 Gallons Throughput
4-07-016-15	Hexane: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-016-16	Hexane: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-016-97	Specify Alkane: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-016-98	Specify Alkane: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Fixed Roof Tanks - Alkenes (Olefins) - 2800, 2900, 3000, 5100</u>										
4-07-020-01	Dodecene: Breathing Loss	---	---	---	---	---	0.15	---	---	1000 Gallon-Years Storage Capacity
4-07-020-02	Dodecene: Working Loss	---	---	---	---	---	0.005	---	---	1000 Gallons Throughput
4-07-020-03	Heptenes - General: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-020-04	Heptenes - General: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-020-97	Specify Olefin: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-020-98	Specify Olefin: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Fixed Roof Tanks - Amides - 2911, 3764, 9711</u>										
4-07-028-01	Dimethylformamide: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-028-02	Dimethylformamide: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Fixed Roof Tanks - Amines - 2800, 2900, 3000, 5100</u>										
4-07-032-01	Aniline: Breathing Loss	---	---	---	---	---	0.24	---	---	1000 Gallon-Years Storage Capacity
4-07-032-02	Aniline: Working Loss	---	---	---	---	---	0.13	---	---	1000 Gallons Throughput
4-07-032-03	Ethanolamines: Breathing Loss	---	---	---	---	---	0.1	---	---	1000 Gallon-Years Storage Capacity

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Fixed Roof Tanks - Amines - 2800, 2900, 3000, 5100</u></i>										
4-07-032-04	Ethanolamines: Working Loss	---	---	---	---	---	0.004	---	---	1000 Gallons Throughput
4-07-032-05	Ethyleneamines: Breathing Loss	---	---	---	---	---	7	---	---	1000 Gallon-Years Storage Capacity
4-07-032-06	Ethyleneamines: Working Loss	---	---	---	---	---	2.6	---	---	1000 Gallons Throughput
4-07-032-07	Monoethanolamine: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-032-08	Monoethanolamine: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-032-09	Hexamine: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-032-10	Hexamine: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-032-11	Ethylenediamine: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-032-12	Ethylenediamine: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-032-97	Specify Amine: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-032-98	Specify Amine: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fixed Roof Tanks - Aromatics - 2800, 2900, 3000, 5100</u></i>										
4-07-036-01	Benzene: Breathing Loss	---	---	---	---	---	8	---	---	1000 Gallon-Years Storage Capacity
4-07-036-02	Benzene: Working Loss	---	---	---	---	---	2.25	---	---	1000 Gallons Throughput
4-07-036-03	Cresol: Breathing Loss	---	---	---	---	---	0.13	---	---	1000 Gallon-Years Storage Capacity
4-07-036-04	Cresol: Working Loss	---	---	---	---	---	0.005	---	---	1000 Gallons Throughput
4-07-036-05	Cumene: Breathing Loss	---	---	---	---	---	1.4	---	---	1000 Gallon-Years Storage Capacity
4-07-036-06	Cumene: Working Loss	---	---	---	---	---	0.16	---	---	1000 Gallons Throughput
4-07-036-07	Diisopropyl Benzene: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-036-08	Diisopropyl Benzene: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-036-09	Ethyl Benzene: Breathing Loss	---	---	---	---	---	2	---	---	1000 Gallon-Years Storage Capacity
4-07-036-10	Ethyl Benzene: Working Loss	---	---	---	---	---	0.26	---	---	1000 Gallons Throughput
4-07-036-11	Methyl Styrene: Breathing Loss	---	---	---	---	---	0.64	---	---	1000 Gallon-Years Storage Capacity
4-07-036-12	Methyl Styrene: Working Loss	---	---	---	---	---	0.05	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Fixed Roof Tanks - Aromatics - 2800, 2900, 3000, 5100</u></i>										
4-07-036-13	Styrene: Breathing Loss	---	---	---	---	---	1.4	---	---	1000 Gallon-Years Storage Capacity
4-07-036-14	Styrene: Working Loss	---	---	---	---	---	0.17	---	---	1000 Gallons Throughput
4-07-036-15	Toluene: Breathing Loss	---	---	---	---	---	3.5	---	---	1000 Gallon-Years Storage Capacity
4-07-036-16	Toluene: Working Loss	---	---	---	---	---	0.66	---	---	1000 Gallons Throughput
4-07-036-17	m-Xylene: Breathing Loss	---	---	---	---	---	1.8	---	---	1000 Gallon-Years Storage Capacity
4-07-036-18	m-Xylene: Working Loss	---	---	---	---	---	0.23	---	---	1000 Gallons Throughput
4-07-036-19	o-Xylene: Breathing Loss	---	---	---	---	---	1.5	---	---	1000 Gallon-Years Storage Capacity
4-07-036-20	o-Xylene: Working Loss	---	---	---	---	---	0.18	---	---	1000 Gallons Throughput
4-07-036-21	p-Xylene: Breathing Loss	---	---	---	---	---	1.9	---	---	1000 Gallon-Years Storage Capacity
4-07-036-22	p-Xylene: Working Loss	---	---	---	---	---	0.24	---	---	1000 Gallons Throughput
4-07-036-23	Xylenes, Mixed: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-036-24	Xylenes, Mixed: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-036-25	Creosote: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-036-26	Creosote: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-036-97	Specify Aromatic: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-036-98	Specify Aromatic: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fixed Roof Tanks - Carboxylic Acids - 2800, 2900, 3000, 5100</u></i>										
4-07-040-01	Acetic Acid: Breathing Loss	---	---	---	---	---	1.5	---	---	1000 Gallon-Years Storage Capacity
4-07-040-02	Acetic Acid: Working Loss	---	---	---	---	---	0.24	---	---	1000 Gallons Throughput
4-07-040-03	Acrylic Acid: Breathing Loss	---	---	---	---	---	0.65	---	---	1000 Gallon-Years Storage Capacity
4-07-040-04	Acrylic Acid: Working Loss	---	---	---	---	---	0.064	---	---	1000 Gallons Throughput
4-07-040-05	Adipic Acid (Soln): Breathing Loss	---	---	---	---	---	0.0003	---	---	1000 Gallon-Years Storage Capacity
4-07-040-06	Adipic Acid (Soln): Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-040-07	Formic Acid: Breathing Loss	---	---	---	---	---	2.6	---	---	1000 Gallon-Years Storage Capacity

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Fixed Roof Tanks - Carboxylic Acids - 2800, 2900, 3000, 5100</u></i>										
4-07-040-08	Formic Acid: Working Loss	---	---	---	---	---	0.57	---	---	1000 Gallons Throughput
4-07-040-09	Propionic Acid: Breathing Loss	---	---	---	---	---	0.63	---	---	1000 Gallon-Years Storage Capacity
4-07-040-10	Propionic Acid: Working Loss	---	---	---	---	---	0.06	---	---	1000 Gallons Throughput
4-07-040-11	Chloroacetic Acid: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-040-12	Chloroacetic Acid: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-040-97	Specify Acid: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-040-98	Specify Acid: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-040-99	Specify Acid: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fixed Roof Tanks - Esters - 2800, 2900, 3000, 5100</u></i>										
4-07-044-01	Butyl Acetate: Breathing Loss	---	---	---	---	---	2.4	---	---	1000 Gallon-Years Storage Capacity
4-07-044-02	Butyl Acetate: Working Loss	---	---	---	---	---	0.34	---	---	1000 Gallons Throughput
4-07-044-03	Butyl Acrylate: Breathing Loss	---	---	---	---	---	1.59	---	---	1000 Gallon-Years Storage Capacity
4-07-044-04	Butyl Acrylate: Working Loss	---	---	---	---	---	0.2	---	---	1000 Gallons Throughput
4-07-044-05	Ethyl Acetate: Breathing Loss	---	---	---	---	---	8.5	---	---	1000 Gallon-Years Storage Capacity
4-07-044-06	Ethyl Acetate: Working Loss	---	---	---	---	---	2.3	---	---	1000 Gallons Throughput
4-07-044-07	Ethyl Acrylate: Breathing Loss	---	---	---	---	---	5.2	---	---	1000 Gallon-Years Storage Capacity
4-07-044-08	Ethyl Acrylate: Working Loss	---	---	---	---	---	1.1	---	---	1000 Gallons Throughput
4-07-044-09	Isobutyl Acrylate: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-044-10	Isobutyl Acrylate: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-044-11	Isopropyl Acetate: Breathing Loss	---	---	---	---	---	7.3	---	---	1000 Gallon-Years Storage Capacity
4-07-044-12	Isopropyl Acetate: Working Loss	---	---	---	---	---	1.8	---	---	1000 Gallons Throughput
4-07-044-13	Methyl Acetate: Breathing Loss	---	---	---	---	---	14.4	---	---	1000 Gallon-Years Storage Capacity
4-07-044-14	Methyl Acetate: Working Loss	---	---	---	---	---	4.8	---	---	1000 Gallons Throughput
4-07-044-15	Methyl Acrylate: Breathing Loss	---	---	---	---	---	8.2	---	---	1000 Gallon-Years Storage Capacity
4-07-044-16	Methyl Acrylate: Working Loss	---	---	---	---	---	2.2	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Fixed Roof Tanks - Esters - 2800, 2900, 3000, 5100</u></i>										
4-07-044-17	Methyl Methacrylate: Breathing Loss	---	---	---	---	---	3.8	---	---	1000 Gallon-Years Storage Capacity
4-07-044-18	Methyl Methacrylate: Working Loss	---	---	---	---	---	0.7	---	---	1000 Gallons Throughput
4-07-044-19	Vinyl Acetate: Breathing Loss	---	---	---	---	---	9.4	---	---	1000 Gallon-Years Storage Capacity
4-07-044-20	Vinyl Acetate: Working Loss	---	---	---	---	---	2.7	---	---	1000 Gallons Throughput
4-07-044-21	n-Propyl Acetate: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-044-22	n-Propyl Acetate: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-044-23	i-Butyl-i-Butyrate: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-044-24	i-Butyl-i-Butyrate: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-044-25	Acrylic Esters: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-044-26	Acrylic Esters: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-044-97	Specify Ester: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-044-98	Specify Ester: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fixed Roof Tanks - Ethers - 2800, 2900, 3000, 5100</u></i>										
4-07-048-01	Methyl-tert-Butyl Ether: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-048-02	Methyl-tert-Butyl Ether: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-048-05	1,4-Dioxane: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-048-06	1,4-Dioxane: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-048-97	Specify Ether: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-048-98	Specify Ether: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fixed Roof Tanks - Glycol Ethers - 2800, 2900, 3000, 5100</u></i>										
4-07-052-01	Butyl Carbitol: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-052-02	Butyl Carbitol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-052-03	Butyl Cellosolve: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-052-04	Butyl Cellosolve: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Fixed Roof Tanks - Glycol Ethers - 2800, 2900, 3000, 5100</u></i>										
4-07-052-05	Carbitol: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-052-06	Carbitol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-052-07	Cellosolve: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-052-08	Cellosolve: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-052-09	Diethylene Glycol: Breathing Loss	---	---	---	---	---	0.003	---	---	1000 Gallon-Years Storage Capacity
4-07-052-10	Diethylene Glycol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-052-11	Methyl Carbitol: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-052-12	Methyl Carbitol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-052-13	Methyl Cellosolve: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-052-14	Methyl Cellosolve: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-052-15	Polyethylene Glycol: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-052-16	Polyethylene Glycol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-052-17	Triethylene Glycol: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-052-18	Triethylene Glycol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-052-97	Specify Glycol Ether: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-052-98	Specify Glycol Ether: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fixed Roof Tanks - Glycols - 2800, 2900, 3000, 5100</u></i>										
4-07-056-01	1,4-Butanediol: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-056-02	1,4-Butanediol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-056-03	Ethylene Glycol: Breathing Loss	---	---	---	---	---	0.052	---	---	1000 Gallon-Years Storage Capacity
4-07-056-04	Ethylene Glycol: Working Loss	---	---	---	---	---	0.002	---	---	1000 Gallons Throughput
4-07-056-05	Dipropylene Glycol: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-056-06	Dipropylene Glycol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-056-07	Glycerol: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Fixed Roof Tanks - Glycols - 2800, 2900, 3000, 5100</i>										
4-07-056-08	Glycerol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-056-09	Propylene Glycol: Breathing Loss	---	---	---	---	---	0.007	---	---	1000 Gallon-Years Storage Capacity
4-07-056-10	Propylene Glycol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-056-97	Specify Glycol: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-056-98	Specify Glycol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i>Fixed Roof Tanks - Halogenated Organics - 2800, 2900, 3000, 5100</i>										
4-07-060-01	Benzyl Chloride: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-060-02	Benzyl Chloride: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-060-03	Caprolactum (Soln): Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-060-04	Caprolactum (Soln): Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-060-05	Carbon Tetrachloride: Breathing Loss	---	---	---	---	---	17.8	---	---	1000 Gallon-Years Storage Capacity
4-07-060-06	Carbon Tetrachloride: Working Loss	---	---	---	---	---	5.2	---	---	1000 Gallons Throughput
4-07-060-07	Chlorobenzene: Breathing Loss	---	---	---	---	---	2.5	---	---	1000 Gallon-Years Storage Capacity
4-07-060-08	Chlorobenzene: Working Loss	---	---	---	---	---	0.36	---	---	1000 Gallons Throughput
4-07-060-09	o-Dichlorobenzene: Breathing Loss	---	---	---	---	---	0.69	---	---	1000 Gallon-Years Storage Capacity
4-07-060-10	o-Dichlorobenzene: Working Loss	---	---	---	---	---	0.05	---	---	1000 Gallons Throughput
4-07-060-11	p-Dichlorobenzene: Breathing Loss	---	---	---	---	---	0.82	---	---	1000 Gallon-Years Storage Capacity
4-07-060-12	p-Dichlorobenzene: Working Loss	---	---	---	---	---	0.06	---	---	1000 Gallons Throughput
4-07-060-13	Epichlorohydrin: Breathing Loss	---	---	---	---	---	2.5	---	---	1000 Gallon-Years Storage Capacity
4-07-060-14	Epichlorohydrin: Working Loss	---	---	---	---	---	0.4	---	---	1000 Gallons Throughput
4-07-060-15	Ethylene Dibromide: Breathing Loss	---	---	---	---	---	4.9	---	---	1000 Gallon-Years Storage Capacity
4-07-060-16	Ethylene Dibromide: Working Loss	---	---	---	---	---	0.77	---	---	1000 Gallons Throughput
4-07-060-17	Ethylene Dichloride: Breathing Loss	---	---	---	---	---	8.7	---	---	1000 Gallon-Years Storage Capacity
4-07-060-18	Ethylene Dichloride: Working Loss	---	---	---	---	---	2.3	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Fixed Roof Tanks - Halogenated Organics - 2800, 2900, 3000, 5100</u></i>										
4-07-060-19	Methylene Chloride: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-060-20	Methylene Chloride: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-060-21	Perchloroethylene: Breathing Loss	---	---	---	---	---	5	---	---	1000 Gallon-Years Storage Capacity
4-07-060-22	Perchloroethylene: Working Loss	---	---	---	---	---	0.84	---	---	1000 Gallons Throughput
4-07-060-23	Trichloroethylene: Breathing Loss	---	---	---	---	---	11.1	---	---	1000 Gallon-Years Storage Capacity
4-07-060-24	Trichloroethylene: Working Loss	---	---	---	---	---	2.9	---	---	1000 Gallons Throughput
4-07-060-27	1,1,1-Trichloroethane: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-060-28	1,1,1-Trichloroethane: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-060-29	Chlorosolve: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-060-30	Chlorosolve: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-060-31	Methyl Chloride: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-060-32	Methyl Chloride: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-060-33	Chloroform: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-060-34	Chloroform: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-060-35	Hexachlorobenzene: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-060-36	Hexachlorobenzene: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-060-97	Specify Halogenated Organic: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-060-98	Specify Halogenated Organic: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fixed Roof Tanks - Isocyanates - 2800, 2900, 3000, 5100</u></i>										
4-07-064-01	MDI: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-064-02	MDI: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-064-03	TDI: Breathing Loss	---	---	---	---	---	0.044	---	---	1000 Gallon-Years Storage Capacity
4-07-064-04	TDI: Working Loss	---	---	---	---	---	0.0008	---	---	1000 Gallons Throughput
4-07-064-97	Specify Isocyanate: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Fixed Roof Tanks - Isocyanates - 2800, 2900, 3000, 5100</u></i>										
4-07-064-98	Specify Isocyanate: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fixed Roof Tanks - Ketones - 2800, 2900, 3000, 5100</u></i>										
4-07-068-01	Cyclohexanone: Breathing Loss	---	---	---	---	---	1.7	---	---	1000 Gallon-Years Storage Capacity
4-07-068-02	Cyclohexanone: Working Loss	---	---	---	---	---	0.2	---	---	1000 Gallons Throughput
4-07-068-03	Acetone: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-068-04	Acetone: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-068-05	Methyl Ethyl Ketone: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-068-06	Methyl Ethyl Ketone: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-068-07	Methyl Isobutyl Ketone: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-068-08	Methyl Isobutyl Ketone: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-068-13	Methylamyl Ketone: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-068-14	Methylamyl Ketone: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-068-97	Specify Ketone: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-068-98	Specify Ketone: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fixed Roof Tanks - Mercaptans - 2911, 3764, 9711</u></i>										
4-07-072-03	Perchloromethyl Mercaptan: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-072-04	Perchloromethyl Mercaptan: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fixed Roof Tanks - Nitriles - 2800, 2900, 3000, 5100</u></i>										
4-07-076-01	Acrylonitrile: Breathing Loss	---	---	---	---	---	6.1	---	---	1000 Gallon-Years Storage Capacity
4-07-076-02	Acrylonitrile: Working Loss	---	---	---	---	---	1.8	---	---	1000 Gallons Throughput
4-07-076-03	Acetonitrile: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-076-04	Acetonitrile: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-076-97	Specify Nitrile: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-076-98	Specify Nitrile: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Fixed Roof Tanks - Nitro Compounds - 2800, 2900, 3000, 5100</u></i>										
4-07-080-01	Nitrobenzene: Breathing Loss	---	---	---	---	---	0.43	---	---	1000 Gallon-Years Storage Capacity
4-07-080-02	Nitrobenzene: Working Loss	---	---	---	---	---	0.027	---	---	1000 Gallons Throughput
4-07-080-97	Specify in Comments: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-080-98	Specify in Comments: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fixed Roof Tanks - Phenols - 2800, 2900, 3000, 5100</u></i>										
4-07-084-01	Nonylphenol: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-084-02	Nonylphenol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-084-03	Phenol: Breathing Loss	---	---	---	---	---	0.15	---	---	1000 Gallon-Years Storage Capacity
4-07-084-04	Phenol: Working Loss	---	---	---	---	---	0.006	---	---	1000 Gallons Throughput
4-07-084-05	2,4-Dichlorophenol: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-084-06	2,4-Dichlorophenol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-084-97	Specify Phenol: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-084-98	Specify Phenol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Fixed Roof Tanks - Miscellaneous - multiple (See Appendix D)</u></i>										
4-07-146-01	Carbon Disulfide: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-146-02	Carbon Disulfide: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-146-03	Dimethyl Sulfoxide: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-146-04	Dimethyl Sulfoxide: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-146-05	Tetrahydrofuran: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-146-06	Tetrahydrofuran: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-146-97	Specify In Comments: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-146-98	Specify In Comments: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Floating Roof Tanks - Acid Anhydrides - 2865</u></i>										
4-07-154-01	Acetic Acid Anhydride: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Floating Roof Tanks - Acid Anhydrides - 2865</u></i>										
4-07-154-02	Acetic Acid Anhydride: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-154-03	Maleic Anhydride: Standing loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-154-04	Maleic Anhydride: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-154-05	Phthalic Anhydride: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-154-06	Phthalic Anhydride: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Floating Roof Tanks - Alcohols - 2834, 2844, 2899, 5171</u></i>										
4-07-158-01	Methanol: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-158-02	Methanol: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-158-09	Ethyl Alcohol: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-158-10	Ethyl Alcohol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-158-11	Isopropanol: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-158-12	Isopropanol: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-158-17	N-propyl Alcohol: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-158-18	N-propyl Alcohol: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-158-19	Xylol: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-158-20	Xylol: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Floating Roof Tanks - Aldehydes - 2800, 2900, 3000, 5100</u></i>										
4-07-172-01	Acetaldehyde: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-172-02	Acetaldehyde: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-172-03	Acrolein: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-172-04	Acrolein: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-172-05	n-Butyraldehyde: Standing Loss	---	---	---	---	---	1.4	---	---	1000 Gallon-Years Storage Capacity
4-07-172-06	n-Butyraldehyde: Withdrawal Loss	---	---	---	---	---	0.002	---	---	1000 Gallons Throughput
4-07-172-07	Formalin: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-172-08	Formalin: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Floating Roof Tanks - Aldehydes - 2800, 2900, 3000, 5100</u></i>										
4-07-172-09	Isobutyraldehyde: Standing Loss	---	---	---	---	---	2.4	---	---	1000 Gallon-Years Storage Capacity
4-07-172-10	Isobutyraldehyde: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-172-11	Propionaldehyde: Standing Loss	---	---	---	---	---	3.9	---	---	1000 Gallon-Years Storage Capacity
4-07-172-12	Propionaldehyde: Withdrawal Loss	---	---	---	---	---	0.002	---	---	1000 Gallons Throughput
4-07-172-97	Specify Aldehyde: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-172-98	Specify Aldehyde: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Floating Roof Tanks - Alkanes (Paraffins) - 2800, 2900, 3000, 5100</u></i>										
4-07-176-01	Cyclohexane: Standing Loss	---	---	---	---	---	1.47	---	---	1000 Gallon-Years Storage Capacity
4-07-176-02	Cyclohexane: Withdrawal Loss	---	---	---	---	---	0.002	---	---	1000 Gallons Throughput
4-07-176-03	n-Hexane: Standing Loss	---	---	---	---	---	2.5	---	---	1000 Gallon-Years Storage Capacity
4-07-176-04	n-Hexane: Withdrawal Loss	---	---	---	---	---	0.002	---	---	1000 Gallons Throughput
4-07-176-05	n-Pentane: Standing Loss	---	---	---	---	---	9.4	---	---	1000 Gallon-Years Storage Capacity
4-07-176-06	n-Pentane: Withdrawal Loss	---	---	---	---	---	0.002	---	---	1000 Gallons Throughput
4-07-176-11	Naphtha: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-176-12	Naphtha: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-176-13	Petroleum Distillates: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-176-14	Petroleum Distillates: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-176-97	Specify Alkane: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-176-98	Specify Alkane: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Floating Roof Tanks - Alkenes (Olefins) - 2800, 2900, 3000, 5100</u></i>										
4-07-180-01	Isoprene: Standing Loss	---	---	---	---	---	9.7	---	---	1000 Gallon-Years Storage Capacity
4-07-180-02	Isoprene: Withdrawal Loss	---	---	---	---	---	0.002	---	---	1000 Gallons Throughput
4-07-180-03	Methylallene: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-180-04	Methylallene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Floating Roof Tanks - Alkenes (Olefins) - 2800, 2900, 3000, 5100</i></u>										
4-07-180-05	1-Pentene: Standing Loss	---	---	---	---	---	12.6	---	---	1000 Gallon-Years Storage Capacity
4-07-180-06	1-Pentene: Withdrawal Loss	---	---	---	---	---	0.002	---	---	1000 Gallons Throughput
4-07-180-07	Piperylene: Standing Loss	---	---	---	---	---	6.4	---	---	1000 Gallon-Years Storage Capacity
4-07-180-08	Piperylene: Withdrawal Loss	---	---	---	---	---	0.002	---	---	1000 Gallons Throughput
4-07-180-09	Cyclopentene: Standing Loss	---	---	---	---	---	5.8	---	---	1000 Gallon-Years Storage Capacity
4-07-180-10	Cyclopentene: Withdrawal Loss	---	---	---	---	---	0.002	---	---	1000 Gallons Throughput
4-07-180-97	Specify Olefin: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-180-98	Specify Olefin: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u><i>Floating Roof Tanks - Amides - 2911, 3764, 9711</i></u>										
4-07-188-01	Dimethylformamide: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-188-02	Dimethylformamide: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u><i>Floating Roof Tanks - Amines - 2911, 3764, 9711</i></u>										
4-07-192-01	Aniline: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-192-02	Aniline: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-192-07	Monoethanolamine: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-192-08	Monoethanolamine: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-192-09	Hexamine: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-192-10	Hexamine: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-192-11	Ethylenediamine: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-192-12	Ethylenediamine: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u><i>Floating Roof Tanks - Aromatics - 2851, 5171</i></u>										
4-07-196-01	Benzene: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-196-02	Benzene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-196-13	Styrene: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Floating Roof Tanks - Aromatics - 2851, 5171</u></i>										
4-07-196-14	Styrene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-196-15	Toluene: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-196-16	Toluene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-196-19	o-Xylene: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-196-20	o-Xylene: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-196-21	p-Xylene: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-196-22	p-Xylene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-196-23	Xylenes: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-196-24	Xylenes: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-196-97	Specify Aromatic: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-196-98	Specify Aromatic: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Floating Roof Tanks - Carboxylic Acids - 2911, 3764, 9711</u></i>										
4-07-200-01	Acetic Acid: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-200-02	Acetic Acid: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-200-03	Acrylic Acid: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-200-04	Acrylic Acid: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-200-11	Chloroacetic Acid: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-200-12	Chloroacetic Acid: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-200-97	Specify Carboxylic Acid: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-200-98	Specify Carboxylic Acid: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Floating Roof Tanks - Esters - 2821</u></i>										
4-07-204-01	Butyl Acetate: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-204-02	Butyl Acetate: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-204-05	Ethyl Acetate: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-204-06	Ethyl Acetate: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Floating Roof Tanks - Esters - 2821</i></u>										
4-07-204-17	Methyl Methacrylate: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-204-18	Methyl Methacrylate: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-204-19	Vinyl Acetate: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-204-20	Vinyl Acetate: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-204-25	Acrylic Esters: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-204-26	Acrylic Esters: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u><i>Floating Roof Tanks - Ethers - 2800, 2900, 3000, 5100</i></u>										
4-07-208-01	Ethyl Ether: Standing Loss	---	---	---	---	---	9.9	---	---	1000 Gallon-Years Storage Capacity
4-07-208-02	Ethyl Ether: Withdrawal Loss	---	---	---	---	---	0.002	---	---	1000 Gallons Throughput
4-07-208-03	Propylene Oxide: Standing Loss	---	---	---	---	---	7.8	---	---	1000 Gallon-Years Storage Capacity
4-07-208-04	Propylene Oxide: Withdrawal Loss	---	---	---	---	---	0.002	---	---	1000 Gallons Throughput
4-07-208-05	1,4-Dioxane: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-208-06	1,4-Dioxane: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-208-97	Specify Ether: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-208-98	Specify Ether: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u><i>Floating Roof Tanks - Glycol Ethers - 2869</i></u>										
4-07-212-05	Carbitol: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-212-06	Carbitol: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-212-07	Cellosolve: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-212-08	Cellosolve: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-212-17	Triethylene Glycol: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-212-18	Triethylene Glycol: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u><i>Floating Roof Tanks - Glycols - 4226</i></u>										
4-07-216-03	Ethylene Glycol: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-216-04	Ethylene Glycol: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i>Floating Roof Tanks - Halogenated Organics - 2800, 2900, 3000, 5100</i>										
4-07-220-01	Carbon Tetrachloride: Standing Loss	---	---	---	---	---	3.2	---	---	1000 Gallon-Years Storage Capacity
4-07-220-02	Carbon Tetrachloride: Withdrawal Loss	---	---	---	---	---	0.004	---	---	1000 Gallons Throughput
4-07-220-03	Chloroform: Standing Loss	---	---	---	---	---	4.6	---	---	1000 Gallon-Years Storage Capacity
4-07-220-04	Chloroform: Withdrawal Loss	---	---	---	---	---	0.004	---	---	1000 Gallons Throughput
4-07-220-05	Ethylene Dichloride: Standing Loss	---	---	---	---	---	1.4	---	---	1000 Gallon-Years Storage Capacity
4-07-220-06	Ethylene Dichloride: Withdrawal Loss	---	---	---	---	---	0.003	---	---	1000 Gallons Throughput
4-07-220-07	Methylene Chloride: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-220-08	Methylene Chloride: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-220-09	Trichlorethylene: Standing Loss	---	---	---	---	---	0.56	---	---	1000 Gallon-Years Storage Capacity
4-07-220-10	Trichlorethylene: Withdrawal Loss	---	---	---	---	---	0.004	---	---	1000 Gallons Throughput
4-07-220-11	1,1,1-Trichloroethane: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-220-12	1,1,1-Trichloroethane: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-220-21	Perchloroethylene: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-220-22	Perchloroethylene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-220-29	Chlorosolve: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-220-30	Chlorosolve: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-220-31	Methyl Chloride: Standing loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-220-32	Methyl Chloride: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-220-33	Chlorobenzene: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-220-34	Chlorobenzene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-220-35	Hexachlorobenzene: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-220-36	Hexachlorobenzene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-220-97	Specify Halogenated VOC: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-220-98	Specify Halogenated VOC: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Floating Roof Tanks - Ketones - 2800, 2900, 3000, 5100</i></u>										
4-07-228-01	Acetone: Standing Loss	---	---	---	---	---	2.6	---	---	1000 Gallon-Years Storage Capacity
4-07-228-02	Acetone: Withdrawal Loss	---	---	---	---	---	0.002	---	---	1000 Gallons Throughput
4-07-228-03	Methyl Ethyl Ketone: Standing Loss	---	---	---	---	---	1.3	---	---	1000 Gallon-Years Storage Capacity
4-07-228-04	Methyl Ethyl Ketone: Withdrawal Loss	---	---	---	---	---	0.002	---	---	1000 Gallons Throughput
4-07-228-05	Methyl Isobutyl Ketone: Standing Loss	---	---	---	---	---	0.31	---	---	1000 Gallon-Years Storage Capacity
4-07-228-06	Methyl Isobutyl Ketone: Withdrawal Loss	---	---	---	---	---	0.002	---	---	1000 Gallons Throughput
4-07-228-07	Cyclohexanone: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-228-08	Cyclohexanone: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-228-97	Specify Ketone: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-228-98	Specify Ketone: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u><i>Floating Roof Tanks - Mercaptans - 2800, 2900, 3000, 5100</i></u>										
4-07-232-01	Ethyl Mercaptan: Standing Loss	---	---	---	---	---	8.2	---	---	1000 Gallon-Years Storage Capacity
4-07-232-02	Ethyl Mercaptan: Withdrawal Loss	---	---	---	---	---	0.002	---	---	1000 Gallons Throughput
4-07-232-03	Perchloromethyl Mercaptan: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-232-04	Perchloromethyl Mercaptan: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-232-97	Specify Mercaptan: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-232-98	Specify Mercaptan: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u><i>Floating Roof Tanks - Nitriles - 2911, 3764, 9711</i></u>										
4-07-236-01	Acrylonitrile: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-236-02	Acrylonitrile: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-236-03	Acetonitrile: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-236-04	Acetonitrile: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u><i>Floating Roof Tanks - Phenols - 2911, 3764, 9711</i></u>										
4-07-244-03	Phenol: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Floating Roof Tanks - Phenols - 2911, 3764, 9711</u></i>										
4-07-244-04	Phenol: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-244-05	2,4-Dichlorophenol: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-244-06	2,4-Dichlorophenol: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Floating Roof Tanks - Miscellaneous - 2865</u></i>										
4-07-296-01	Carbon Disulfide: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-296-02	Carbon Disulfide: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-296-03	Dimethyl Sulfoxide: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-296-04	Dimethyl Sulfoxide: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-296-05	Tetrahydrofuran: Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-296-06	Tetrahydrofuran: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-296-97	Specify In Comments: Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-07-296-98	Specify In Comments: Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Pressure Tanks - Anhydrides - 2911, 3764, 9711</u></i>										
4-07-804-01	Acetic Anhydride: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-804-03	Maleic Anhydride: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Pressure Tanks - Alcohols - 2911, 3764, 9711</u></i>										
4-07-808-15	Methanol: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-808-19	Xylol: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Pressure Tanks - Aldehydes - 2800, 2900, 3000, 5100</u></i>										
4-07-812-01	Acetaldehyde: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-812-02	Acrolein: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Pressure Tanks - Alkanes (Paraffins) - 2800, 2900, 3000, 5100</u></i>										
4-07-816-01	Ethane: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-816-02	Butane: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-816-03	Methane: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-816-04	Natural Gas: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-816-05	Propane: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Pressure Tanks - Alkanes (Paraffins) - 2800, 2900, 3000, 5100</u></i>										
4-07-816-06	Isopentane: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-816-07	n-Pentane: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-816-99	Specify Gas: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Pressure Tanks - Alkenes (Olefins) - 2800, 2900, 3000, 5100</u></i>										
4-07-820-01	1,3-Butadiene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-820-02	1-Butene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-820-03	2-Butene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-820-04	Ethylene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-820-05	Isobutylene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-820-06	Propylene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-820-07	Isoprene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-820-08	Methylallene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-820-09	1-Pentene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-820-10	Piperylene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-820-11	Cyclopentene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-820-12	Vinylidene Chloride: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-820-99	Specify Alkene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Pressure Tanks - Alkynes (Acetylenes) - 2800, 2900, 3000, 5100</u></i>										
4-07-824-01	Acetylene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-824-99	Specify Alkyne: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Pressure Tanks - Amines - 2800, 2900, 3000, 5100</u></i>										
4-07-832-01	Methylamine: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-832-02	Dimethylamine: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-832-03	Trimethylamine: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-832-04	Hexamine: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-832-05	Aniline: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-832-99	Specify Amine: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<i><u>Pressure Tanks - Aromatics - 2911, 3764, 9711</u></i>										
4-07-836-01	Benzene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-836-21	p-Xylene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Pressure Tanks - Ethers - 2800, 2900, 3000, 5100</u>										
4-07-848-01	Ethylene Oxide: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-848-99	Specify Ether: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Pressure Tanks - Halogenated Organics - 2800, 2900, 3000, 5100</u>										
4-07-860-01	Ethyl Chloride: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-860-02	Methyl Chloride: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-860-03	Phosgene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-860-04	Vinyl Chloride: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-860-05	Trichlorotrifluoroethane: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-860-06	Carbon Tetrachloride: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-860-19	Methylene Chloride: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-860-21	Perchloroethylene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-860-23	Trichloroethylene: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-860-99	Specify Halogenated VOC: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Pressure Tanks - Isocyanates - 2800, 2900, 3000, 5100</u>										
4-07-864-01	Methyl Isocyanate: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-864-99	Specify Isocyanate: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Pressure Tanks - Ketones - 2911, 3764, 9711</u>										
4-07-868-01	Cyclohexanone: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-868-03	Acetone: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-868-05	Methyl Ethyl Ketone: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Pressure Tanks - Mercaptans (Thiols) - 2800, 2900, 3000, 5100</u>										
4-07-872-01	Methyl Mercaptan: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-872-03	Perchloromethyl Mercaptan: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-872-99	Specify Mercaptan: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Pressure Tanks - Phenols - 2911, 3764, 9711</u>										
4-07-884-03	Phenol: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-884-05	2,4-Dichlorophenol: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Miscellaneous - 2800, 2900, 3000, 5100</u>										
4-07-999-01	Carbon Disulfide: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-999-03	Dimethyl Sulfoxide: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Miscellaneous - 2800, 2900, 3000, 5100</u>										
4-07-999-05	Tetrahydrofuran: Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-07-999-97	Specify in Comments	---	---	---	---	---	1.44	---	---	Tons Produced
4-07-999-98	Specify in Comments	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-07-999-99	Other Not Classified	---	---	---	---	---	---	---	---	1000 Gallon-Years Stored
<u>PETROLEUM AND SOLVENT EVAPORATION -Organic Chemical Transportation</u>										
<u>Equipment Leaks - 2911</u>										
4-08-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Specific Liquid - 2800, 2900, 3000, 5100</u>										
4-08-999-95	Cars/Trucks: Loading Rack	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-08-999-97	Marine Vessels: Loading Rack	---	---	---	---	---	---	---	---	1000 Gallons Transferred
4-08-999-99	Loading Rack	---	---	---	---	---	---	---	---	1000 Gallons Transferred
<u>PETROLEUM AND SOLVENT EVAPORATION -Dry Cleaning</u>										
<u>Petroleum Solvent - Industrial - 2384</u>										
4-10-001-01	Stoddard	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-02	Stoddard	---	---	---	---	---	---	---	---	Tons Consumed
4-10-001-15	Washer/Extractor	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-25	Solvent Settling Tank: Batch Flow	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-26	Solvent Settling Tank: Continuous Flow	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-30	Dryer	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-31	Dryer: Loading/Unloading	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-32	Dryer: Drying Cycle	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-33	Dryer: Cool Down Cycle	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-40	Filtration	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-41	Filtration, Diatomite: Single Charge	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-42	Filtration, Diatomite: Multiple Charge	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-43	Filtration, Diatomite: Regenerative	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-44	Filtration, Cartridge, Carbon Core, Batch Operation	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-45	Filtration, Cartridge, All Carbon, Batch Operation	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-46	Filtration, Cartridge, Carbon Core, Continuous Operation	---	---	---	---	---	---	---	---	Tons Cleaned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Petroleum Solvent - Industrial - 2384</u></i>										
4-10-001-47	Filtration, Cartridge, All Carbon, Continuous Operation	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-60	Waste Disposal	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-61	Waste Disposal: Filter Waste, Drained	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-62	Waste Disposal: Filter Waste, Centrifuged	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-63	Waste Disposal: Settling Tank Sludge	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-64	Waste Disposal: Still Waste	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-65	Waste Disposal: Cartridge, All Carbon	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-001-66	Waste Disposal: Cartridge, Carbon Core Only	---	---	---	---	---	---	---	---	Tons Cleaned
<i><u>Petroleum Solvent - Commercial - 7216, 7211, 7218</u></i>										
4-10-002-01	Stoddard	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-02	Stoddard	---	---	---	---	---	---	---	---	Tons Consumed
4-10-002-15	Washer/Extractor	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-25	Solvent Settling Tank: Batch Flow	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-26	Solvent Settling Tank: Continuous Flow	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-30	Dryer	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-31	Dryer: Loading/Unloading	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-32	Dryer: Drying Cycle	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-33	Dryer: Cool Down Cycle	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-40	Filtration	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-41	Filtration, Diatomite: Single Charge	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-42	Filtration, Diatomite: Multiple Charge	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-43	Filtration, Diatomite: Regenerative	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-44	Filtration, Cartridge, Carbon Core, Batch Operation	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-45	Filtration, Cartridge, All Carbon, Batch Operation	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-46	Filtration, Cartridge, Carbon Core, Continuous Operation	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-47	Filtration, Cartridge, All Carbon, Continuous Operation	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-60	Waste Disposal	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-61	Waste Disposal: Filter Waste, Drained	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-62	Waste Disposal: Filter Waste, Centrifuged	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-63	Waste Disposal: Settling Tank Sludge	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-64	Waste Disposal: Still Waste	---	---	---	---	---	---	---	---	Tons Cleaned



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Petroleum Solvent - Commercial - 7216, 7211, 7218</u>										
4-10-002-65	Waste Disposal: Cartridge, All Carbon	---	---	---	---	---	---	---	---	Tons Cleaned
4-10-002-66	Waste Disposal: Cartridge, Carbon Core Only	---	---	---	---	---	---	---	---	Tons Cleaned
<u>Petroleum Solvent - Equipment Leaks - 7216, 7218, 7219</u>										
4-10-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Petroleum Solvent - Wastewater, Aggregate - 7200</u>										
4-10-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
4-10-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Petroleum Solvent - Wastewater, Points of Generation - 7200</u>										
4-10-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>PETROLEUM AND SOLVENT EVAPORATION -Tanks (Fixed and Floating)</u>										
<u>Fixed - 210 Bbl Size - 5171</u>										
4-25-001-01	Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-25-001-02	Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Fixed - 500 Bbl Size - 3479</u>										
4-25-002-01	Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-25-002-02	Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Fixed - 1,000 Bbl Size - 2800</u>										
4-25-003-01	Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-25-003-02	Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Floating - 1,000 Bbl Size - 2800</u>										
4-25-050-01	Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-25-050-02	Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Floating - 5,000 Bbl Size - 2800</u>										
4-25-051-01	Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
4-25-051-02	Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Floating - 1,000 Bbl Size - 2800</u>										
4-25-052-02	Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>PETROLEUM AND SOLVENT EVAPORATION -Organic Solvent Evaporation</u>										
<u>Solvent Extraction Process - 4000, 4700, 7600</u>										
4-90-001-01	Petroleum Naphtha (Stoddard)	---	---	---	---	---	2000	---	---	Tons Consumed
4-90-001-02	Methyl Ethyl Ketone	---	---	---	---	---	2000	---	---	Tons Consumed
4-90-001-03	Methyl Isobutyl Ketone	---	---	---	---	---	2000	---	---	Tons Consumed
4-90-001-04	Furfural	---	---	---	---	---	2000	---	---	Tons Consumed
4-90-001-05	Trichloroethylene	---	---	---	---	---	2000	---	---	Tons Consumed
4-90-001-99	Other Not Classified	---	---	---	---	---	2000	---	---	Tons Consumed
<u>Waste Solvent Recovery Operations - 4000, 4700, 7600</u>										
4-90-002-01	Storage Tank Vent	---	---	---	---	---	0.02	---	---	Tons Produced
4-90-002-02	Condenser Vent	---	---	---	---	---	3.3	---	---	Tons Produced
4-90-002-03	Incinerator Stack	1.44	0.89	---	---	---	0.02	---	---	Tons Produced
4-90-002-04	Solvent Spillage	---	---	---	---	---	0.2	---	---	Tons Produced
4-90-002-05	Solvent Loading	---	---	---	---	---	0.72	---	---	Tons Produced
4-90-002-06	Fugitive Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
4-90-002-07	Distillation Vent	---	---	---	---	---	---	---	---	Tons Produced
4-90-002-08	Decanting	---	---	---	---	---	---	---	---	Tons Produced
4-90-002-09	Salting	---	---	---	---	---	---	---	---	Tons Produced
4-90-002-99	Other Not Classified	---	---	---	---	---	---	---	---	Tons Produced
<u>Rail Car Cleaning - 4742, 4011, 4013</u>										
4-90-003-01	Ethylene Glycol	---	---	---	---	---	0.0007	---	---	Each Cleaned
4-90-003-02	Chlorobenzene	---	---	---	---	---	0.035	---	---	Each Cleaned
4-90-003-03	o-Dichlorobenzene	---	---	---	---	---	0.166	---	---	Each Cleaned
4-90-003-04	Creosote	---	---	---	---	---	5.18	---	---	Each Cleaned
4-90-003-99	Other Not Classified	---	---	---	---	---	---	---	---	Each Cleaned
<u>Tank Truck Cleaning - 4000, 4700, 7600</u>										
4-90-004-01	Acetone	---	---	---	---	---	0.69	---	---	Each Cleaned
4-90-004-02	Perchloroethylene	---	---	---	---	---	0.474	---	---	Each Cleaned
4-90-004-03	Methyl Methacrylate	---	---	---	---	---	0.071	---	---	Each Cleaned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u><i>Tank Truck Cleaning - 4000, 4700, 7600</i></u>										
4-90-004-04	Phenol	---	---	---	---	---	0.012	---	---	Each Cleaned
4-90-004-05	Propylene Glycol	---	---	---	---	---	0.002	---	---	Each Cleaned
4-90-004-99	Other Not Classified	---	---	---	---	---	---	---	---	Each Cleaned
<u><i>Air Stripping Tower - 4000, 4700, 7600</i></u>										
4-90-005-01	Trichloroethylene	---	---	---	---	---	2000	---	---	Tons Stripped
4-90-005-02	Perchloroethylene	---	---	---	---	---	2000	---	---	Tons Stripped
4-90-005-03	1,1,1-Trichloroethane	---	---	---	---	---	---	---	---	Tons Stripped
4-90-005-04	Chloroform	---	---	---	---	---	2000	---	---	Tons Stripped
4-90-005-99	Specify Solvent in Comments	---	---	---	---	---	---	---	---	Tons Stripped
<u><i>Freon Recovery/Recycling Operations - 2800</i></u>										
4-90-006-01	CFC-12 Recovery - Auto Air Conditioning	---	---	---	---	---	---	---	---	Gallons Recovered
<u><i>Fuel Fired Equipment - 4000, 4700, 7600</i></u>										
4-90-900-11	Distillate Oil (No. 2): Incinerators	---	---	---	---	---	0.4	---	---	1000 Gallons Burned
4-90-900-12	Residual Oil: Incinerators	---	---	---	---	---	0.56	---	---	1000 Gallons Burned
4-90-900-13	Natural Gas: Incinerators	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
4-90-900-15	Recovered Solvents: Miscellaneous Incinerators	---	---	---	---	---	---	---	---	1000 Gallons Burned
4-90-900-21	Distillate Oil (No. 2): Flares	---	---	---	---	---	---	---	---	1000 Gallons Burned
4-90-900-22	Residual Oil: Flares	---	---	---	---	---	---	---	---	1000 Gallons Burned
4-90-900-23	Natural Gas: Flares	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
<u><i>Miscellaneous Volatile Organic Compound Evaporation - 4000, 4700, 7600</i></u>										
4-90-999-98	Identify the Process and Solvent in Comments	---	---	---	---	---	---	---	---	Gallons Consumed
4-90-999-99	Identify the Process and Solvent in Comments	---	---	---	---	---	---	---	---	Tons Consumed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<b><u>WASTE DISPOSAL</u></b>										
<i><u>WASTE DISPOSAL -Solid Waste Disposal - Government</u></i>										
<i><u>Municipal Incineration - 4953</u></i>										
5-01-001-01	Starved Air: Multiple Chamber	1.9	1.4	---	1.7	3.16	1.5	0.299	0.12	Tons Burned
5-01-001-02	Mass Burn: Single Chamber	38	14	---	1.7	3.6	0.1	2.2	0.18	Tons Burned
5-01-001-03	Refuse Derived Fuel	80	44	---	1.7	5.02	---	1.92	0.201	Tons Burned
5-01-001-04	Mass Burn Refractory Wall Combustor	---	---	---	<sup>21</sup> 3.46	2.46	---	1.37	0.213	Tons Burned
5-01-001-05	Mass Burn Waterwall Combustor	---	---	---	<sup>21</sup> 3.46	3.56	---	0.463	0.213	Tons Burned
5-01-001-06	Mass Burn Rotary Waterwall Combustor	---	---	---	<sup>21</sup> 3.46	2.25	---	0.766	0.213	Tons Burned
5-01-001-07	Modular Excess Air Combustor	---	---	---	<sup>21</sup> 3.46	2.47	---	---	0.213	Tons Burned
5-01-001-08	Fluidized Bed: Refuse Derived Fuel	---	---	---	---	---	---	---	---	Tons Burned
<i><u>Open Burning Dump - 4953</u></i>										
5-01-002-01	General Refuse	16	16	---	1	6	30	85	---	Tons Burned
5-01-002-02	Vegetation Only	17	---	---	---	4	19	140	---	Tons Burned
<i><u>Landfill Dump - 4953</u></i>										
5-01-004-01	Unpaved Road Traffic	---	---	---	---	---	---	---	---	Cubic Yard-Miles Transported
5-01-004-02	Fugitive Emissions	---	---	---	---	---	---	---	---	Acre-Years Existing
5-01-004-03	Area Method	---	---	---	---	---	---	---	---	1000 Cubic Yards Processed
5-01-004-04	Trench Method	---	---	---	---	---	---	---	---	1000 Cubic Yards Processed
5-01-004-05	Ramp Method	---	---	---	---	---	---	---	---	1000 Cubic Yards Processed
5-01-004-06	Gas Collection System: Other	---	---	---	---	---	---	---	---	Million Cubic Feet Processed
5-01-004-10	Waste Gas Destruction: Waste Gas Flares	---	---	---	---	40	---	750	---	Million Dry Standard Cubic Feet Generated
5-01-004-11	Waste Gas Destruction: Incinerators	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
5-01-004-12	Waste Gas Destruction: Other	---	---	---	---	---	---	---	---	Million Cubic Feet Processed
5-01-004-20	Waste Gas Recovery: Gas Turbines	---	---	---	---	87	---	230	---	Million Dry Standard Cubic Feet Generated
5-01-004-21	Waste Gas Recovery: Internal Combustion Device	---	---	---	---	250	---	470	---	Million Dry Standard Cubic Feet Generated

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Landfill Dump - 4953</u>										
5-01-004-22	Waste Gas Recovery: Other	---	---	---	---	---	---	---	---	Million Cubic Feet Processed
5-01-004-23	Waste Gas Recovery: Boiler	---	---	---	---	33	---	5.7	---	Million Dry Standard Cubic Feet Generated
5-01-004-30	Waste Gas Purification: Absorption	---	---	---	---	---	---	---	---	Million Cubic Feet Processed
5-01-004-31	Waste Gas Purification: Adsorption	---	---	---	---	---	---	---	---	Million Cubic Feet Processed
5-01-004-32	Waste Gas Purification: Membranes	---	---	---	---	---	---	---	---	Million Cubic Feet Processed
5-01-004-33	Waste Purification: Other	---	---	---	---	---	---	---	---	Million Cubic Feet Processed
<u>Other Incineration - 4953</u>										
5-01-005-05	Medical Waste Incinerator, unspecified type, Infectious wastes only	---	---	---	---	---	---	---	---	Tons Burned
5-01-005-06	Sludge	---	---	---	---	<sup>27</sup> 1.04	---	<sup>27</sup> 7.73	---	Tons Burned
5-01-005-07	Conical Design (Tee Pee) Municipal Refuse	20	11	---	2	5	20	60	---	Tons Burned
5-01-005-08	Conical Design (Tee Pee) Wood Refuse	See App. C	3.85	---	0.1	1	11	130	---	Tons Burned
5-01-005-10	Trench Burner: Wood	13	4.94	---	0.1	4	19	---	---	Tons Burned
5-01-005-11	Trench Burner: Tires	138	52.4	---	---	---	6	---	---	Tons Burned
5-01-005-12	Trench Burner: Refuse	37	14.1	---	2.5	---	13	---	---	Tons Burned
5-01-005-15	Sludge: Multiple Hearth	100	8.2	---	20	5	1.7	31	0.1	Tons Fed
5-01-005-16	Sludge: Fluidized Bed	460	---	---	<sup>21</sup> 0.3	1.7	---	2.1	0.04	Tons Fed
5-01-005-17	Sludge: Electric Infrared	7.4	6	---	20	8.6	---	---	---	Tons Fed
5-01-005-18	Sewage Sludge Incinerator: Single Hearth Cyclone	---	---	---	---	---	---	---	---	Tons Fed
5-01-005-19	Sewage Sludge Incinerator: Rotary Kiln	---	---	---	---	---	---	---	---	Tons Fed
5-01-005-20	Sewage Sludge Incinerator: High Pressure, Wet Oxidation	---	---	---	---	---	---	---	---	Tons Fed
<u>Fire Fighting - 9224</u>										
5-01-006-01	Structure: Jet Fuel	---	---	---	---	---	---	---	---	1000 Gallons Burned
5-01-006-02	Structure: Distillate Oil	---	---	---	---	---	---	---	---	1000 Gallons Burned
5-01-006-03	Structure: Kerosene	---	---	---	---	---	---	---	---	1000 Gallons Burned
5-01-006-04	Structure: Wood Pallets	---	---	---	---	---	---	---	---	Tons Burned
<u>Sewage Treatment - 4952</u>										
5-01-007-01	Entire Plant	---	---	---	---	---	8.9	---	---	Million Gallons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Sewage Treatment - 4952</u></i>										
5-01-007-02	Primary Settling Tank	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-03	Secondary Settling Tank	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-04	Aeration Tank	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-07	POTW: Headworks Screening	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-08	Comminutor	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-10	Collector Sewers	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-15	POTW: Aerated Grit Chamber	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-19	Lift Station	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-20	POTW: Primary Settling Tank	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-31	POTW: Diffused Air Act Sludge	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-32	POTW: Mechanical Mix Air Act Sludge	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-33	POTW: Pure Oxygen Act Sludge	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-34	POTW: Trickling Filter	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-40	POTW: Secondary Clarifier	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-50	POTW: Tertiary Filters	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-60	POTW: Chlorine Contact Tank	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-61	POTW: Dechlorination	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-65	Weir	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-69	Storage Basin or Open Tank	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-71	POTW: Gravity Sludge Thickener	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-72	POTW: DAF Sludge Thickener	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-81	POTW: Anaerobic Digester	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-89	Sludge Digester Gas Flare	---	---	---	---	---	---	---	---	Million Cubic Feet Processed
5-01-007-91	POTW: Belt Filter Press	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-92	POTW: Sludge Centrifuge	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-93	POTW: Sludge Drying Bed	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-95	Sludge Storage Lagoons/Drying Beds	---	---	---	---	---	---	---	---	Million Gallons Processed
5-01-007-99	Other Not Classified	---	---	---	---	---	---	---	---	Million Gallons Processed
<i><u>Equipment Leaks - 4953</u></i>										
5-01-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Wastewater, Aggregate - 4953</u>										
5-01-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
5-01-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Wastewater, Points of Generation - 1442</u>										
5-01-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Auxillary Fuel/No Emissions - 4953</u>										
5-01-900-02	Coal	---	---	---	---	---	---	---	---	Tons Burned
5-01-900-05	Distillate Oil	---	---	---	---	---	---	---	---	1000 Gallons Burned
5-01-900-06	Natural Gas	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
5-01-900-10	Liquified Petroleum Gas (LPG)	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>WASTE DISPOSAL -Solid Waste Disposal - Commercial/Institutional</u>										
<u>Incineration - 4900</u>										
5-02-001-01	Multiple Chamber	7	4.7	---	2.5	3	3	10	---	Tons Burned
5-02-001-02	Single Chamber	15	5.7	---	2.5	2	15	20	---	Tons Burned
5-02-001-03	Controlled Air	---	1.04	---	---	---	---	---	---	Tons Burned
5-02-001-04	Conical Design (Tee Pee) Municipal Refuse	20	11	---	2	5	20	60	---	Tons Burned
5-02-001-05	Conical Design (Tee Pee) Wood Refuse	7	3.85	---	0.1	1	11	130	---	Tons Burned
<u>Open Burning - 4900</u>										
5-02-002-01	Wood	17	---	---	---	4	19	140	---	Tons Burned
5-02-002-02	Refuse	16	16	---	1	6	30	85	---	Tons Burned
5-02-002-03	Field Crops	---	---	---	---	---	---	---	---	Tons Burned
5-02-002-04	Vine Crops	---	---	---	---	---	---	---	---	Tons Burned
5-02-002-05	Weeds	---	---	---	---	---	---	---	---	Tons Burned
5-02-002-06	Orchard Crops	---	---	---	---	---	---	---	---	Tons Burned
5-02-002-07	Forest Residues	---	---	---	---	---	---	---	---	Tons Burned
<u>Apartment Incineration - 4900</u>										
5-02-003-01	Flue Fed	30	11.4	---	0.5	3	15	20	---	Tons Burned
5-02-003-02	Flue Fed with Afterburner and Draft Controls	6	4.02	---	0.5	10	3	10	---	Tons Burned
<u>Incineration: Special Purpose - 4900</u>										
5-02-005-01	Med Waste Controlled Air Incin-aka Starved air, 2-stg, or Modular comb	---	3.04	---	<sup>21</sup> 2.17	3.56	---	2.95	0.0728	Tons Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Incineration: Special Purpose - 4900</u>										
5-02-005-02	Med Waste Excess Air Incin - aka Batch, Multiple Chamber, or Retort	---	---	---	---	---	---	---	---	Tons Burned
5-02-005-03	Medical Waste Rotary Kiln Incinerator	34.5	---	---	<sup>21</sup> 1.09	4.63	---	0.382	0.124	Tons Burned
5-02-005-04	Medical Waste Incinerator, unspecified type (use 502005-01, -02, -03)	---	---	---	---	---	---	---	---	Tons Burned
5-02-005-05	Medical Waste Incinerator, unspecified type, Infectious wastes only	---	---	---	---	---	---	---	---	Tons Burned
5-02-005-06	Sludge	---	---	---	---	---	---	---	---	Tons Burned
5-02-005-07	VOC Contaminated Soil	---	---	---	---	---	---	---	---	Tons Burned
5-02-005-15	Sewage Sludge Incinerator: Multiple Hearth	---	---	---	---	---	---	---	---	Tons Fed
5-02-005-16	Sewage Sludge Incinerator: Fluidized Bed	---	---	---	---	---	---	---	---	Tons Fed
5-02-005-17	Sewage Sludge Incinerator: Electric Infrared	---	---	---	---	---	---	---	---	Tons Fed
5-02-005-18	Sewage Sludge Incinerator: Single Hearth Cyclone	---	---	---	---	---	---	---	---	Tons Fed
5-02-005-19	Sewage Sludge Incinerator: Rotary Kiln	---	---	---	---	---	---	---	---	Tons Fed
5-02-005-20	Sewage Sludge Incinerator: High Pressure, Wet Oxidation	---	---	---	---	---	---	---	---	Tons Fed
<u>Landfill Dump - 4900</u>										
5-02-006-01	Waste Gas Flares (Use 5-01-004-10)	---	---	---	---	---	5.6	---	---	Million Cubic Feet Burned
5-02-006-02	Municipal: Fugitive Emissions (Use 5-01-004-02)	---	---	---	---	---	---	---	---	Acre-Years Existing
<u>Asbestos Removal - 4900</u>										
5-02-009-01	General	---	---	---	---	---	---	---	---	Tons Removed
<u>Equipment Leaks - 4953</u>										
5-02-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Wastewater, Aggregate - 4953</u>										
5-02-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
5-02-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Wastewater, Points of Generation - 4953</u>										
5-02-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Auxillary Fuel/No Emissions - 4900</u>										
5-02-900-02	Coal	---	---	---	---	---	---	---	---	Tons Burned
5-02-900-05	Distillate Oil	---	---	---	---	---	---	---	---	1000 Gallons Burned
5-02-900-06	Natural Gas	---	---	---	---	---	---	---	---	Million Cubic Feet Burned



<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Auxillary Fuel/No Emissions - 4900</u>										
5-02-900-10	Liquified Petroleum Gas (LPG)	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>WASTE DISPOSAL -Solid Waste Disposal - Industrial</u>										
<u>Incineration - 4900</u>										
5-03-001-01	Multiple Chamber	7	4.7	---	2.5	3	3	10	---	Tons Burned
5-03-001-02	Single Chamber	15	5.7	---	2.5	2	15	20	0.00181	Tons Burned
5-03-001-03	Controlled Air	---	1.04	---	---	---	---	---	---	Tons Burned
5-03-001-04	Conical Design (Tee Pee) Municipal Refuse	20	11	---	2	5	20	60	---	Tons Burned
5-03-001-05	Conical Design (Tee Pee) Wood Refuse	7	3.85	---	0.1	1	11	130	---	Tons Burned
5-03-001-06	Trench Burner: Wood	13	4.94	---	0.1	4	---	---	---	Tons Burned
5-03-001-07	Trench Burner: Tires	138	52.4	---	---	---	6	---	---	Tons Burned
5-03-001-08	Auto Body Components	2	1.2	---	---	0.1	---	2.5	---	Each Burned
5-03-001-09	Trench Burner: Refuse	37	14.1	---	2.5	---	13	---	---	Tons Burned
5-03-001-11	Mass Burn Refractory Wall Combustor	---	---	---	<sup>21</sup> 3.46	2.46	---	1.37	0.213	Tons Burned
5-03-001-12	Mass Burn Waterwall Combustor	---	---	---	<sup>21</sup> 3.46	3.56	---	0.463	0.213	Tons Burned
5-03-001-13	Mass Burn Rotary Waterwall Combustor	---	---	---	<sup>21</sup> 3.46	2.25	---	0.766	0.213	Tons Burned
5-03-001-14	Modular Starved-air Combustor	---	---	---	<sup>21</sup> 3.23	3.16	---	0.299	---	Tons Burned
5-03-001-15	Modular Excess-air Combustor	---	---	---	<sup>21</sup> 3.46	2.47	---	---	0.213	Tons Burned
<u>Open Burning - 4900</u>										
5-03-002-01	Wood/Vegetation/Leaves	17	17	---	---	4	---	---	---	Tons Burned
5-03-002-02	Refuse	16	16	---	1	6	30	85	---	Tons Burned
5-03-002-03	Auto Body Components	See App. C	100	---	---	See App. C	32	See App. C	---	Footnote 61
5-03-002-04	Coal Refuse Piles	---	0.18	---	---	---	---	---	---	Cubic Yards Burned
5-03-002-05	Rocket Propellant	---	---	---	---	---	---	---	---	Tons Burned
<u>Incineration - 4900</u>										
5-03-005-01	Hazardous Waste	---	0.2	---	---	---	---	---	---	Million Btus Input
5-03-005-02	Hazardous Waste Incinerators: Fluidized Bed	---	---	---	---	---	---	---	---	Million Btus Input
5-03-005-03	Hazardous Waste Incinerators: Liquid Injection	---	---	---	---	---	---	---	---	Million Btus Input
5-03-005-04	Hazardous Waste Incinerators: Rotary Kiln	---	---	---	---	---	---	---	---	Million Btus Input
5-03-005-05	Hazardous Waste Incinerators: Multiple Hearth	---	---	---	---	---	---	---	---	Million Btus Input
5-03-005-06	Sludge	---	---	---	---	---	---	---	---	Tons Burned

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Incineration - 4900</u></i>										
5-03-005-15	Sewage Sludge Incinerator: Multiple Hearth	---	---	---	---	---	---	---	---	Tons Fed
5-03-005-16	Sewage Sludge Incinerator: Fluidized Bed	---	---	---	---	---	---	---	---	Tons Fed
5-03-005-17	Sewage Sludge Incinerator: Electric Infrared	---	---	---	---	---	---	---	---	Tons Fed
5-03-005-18	Sewage Sludge Incinerator: Single Hearth Cyclone	---	---	---	---	---	---	---	---	Tons Fed
5-03-005-19	Sewage Sludge Incinerator: Rotary Kiln	---	---	---	---	---	---	---	---	Tons Fed
5-03-005-20	Sewage Sludge Incinerator: High Pressure, Wet Oxidation	---	---	---	---	---	---	---	---	Tons Fed
5-03-005-99	Fuel Not Classified	---	---	---	---	---	---	---	---	Tons Burned
<i><u>Landfill Dump - 4900</u></i>										
5-03-006-01	Waste Gas Flares	---	---	---	<sup>21, 27</sup> 0.00000575	40	---	750	---	Million Dry Standard Cubic Feet Generated
5-03-006-02	Liquid Waste Disposal	---	---	---	---	---	---	---	---	Tons Burned
5-03-006-03	Hazardous: Fugitive Emissions	---	---	---	---	---	---	---	---	Acre-Years Existing
<i><u>Liquid Waste - 4900</u></i>										
5-03-007-01	General	3.8	3.8	---	---	42.6	4.5	---	---	1000 Gallons Burned
5-03-007-02	Waste Treatment: General	---	---	---	---	---	---	---	---	1000 Gallons Processed
5-03-007-09	Open Trench	---	---	---	---	---	---	---	---	Million Gallons Processed
5-03-007-10	Open Sump	---	---	---	---	---	---	---	---	Million Gallons Processed
5-03-007-11	Junction Box	---	---	---	---	---	---	---	---	Million Gallons Processed
5-03-007-13	Oil/Water Separator	---	---	---	---	---	---	---	---	Million Gallons Processed
5-03-007-19	Lift Station	---	---	---	---	---	---	---	---	Million Gallons Processed
5-03-007-24	Equalization Basin	---	---	---	---	---	---	---	---	Million Gallons Processed
5-03-007-27	Neutralization Basin	---	---	---	---	---	---	---	---	Million Gallons Processed
5-03-007-31	Diffused Air Activated Sludge	---	---	---	---	---	---	---	---	Million Gallons Processed
5-03-007-32	Mechanical Mix Activated Sludge	---	---	---	---	---	---	---	---	Million Gallons Processed
5-03-007-33	Pure Oxygen Activated Sludge	---	---	---	---	---	---	---	---	Million Gallons Processed
5-03-007-34	Trickling Filter	---	---	---	---	---	---	---	---	Million Gallons Processed
5-03-007-40	Clarifier	---	---	---	---	---	---	---	---	Million Gallons Processed
5-03-007-60	Chlorine Contact	---	---	---	---	---	---	---	---	Million Gallons Processed
5-03-007-65	Weir	---	---	---	---	---	---	---	---	Million Gallons Processed
5-03-007-69	Storage Basin or Open Tank	---	---	---	---	---	---	---	---	Million Gallons Processed
5-03-007-81	Sludge Digester	---	---	---	---	---	---	---	---	Million Gallons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Liquid Waste - 4900</u>										
5-03-007-89	Sludge Digester Gas Flare	---	---	---	---	---	---	---	---	Million Cubic Feet Processed
<u>Treatment, Storage, Disposal/TSDf - 4900</u>										
5-03-008-01	Surface Impoundment: Fugitive Emissions	---	---	---	---	---	---	---	---	1000 Gallons Throughput
5-03-008-10	Waste Piles: Fugitive Emissions	---	---	---	---	---	---	---	---	Acre-Years Existing
5-03-008-20	Land Treatment: Fugitive Emissions	---	---	---	---	---	---	---	---	Acre-Years Treated
5-03-008-30	Containers: Fugitive Emissions	---	---	---	---	---	222	---	---	1000 Each-Year Stored
5-03-008-99	General: Fugitive Emissions	---	---	---	---	---	---	---	---	Tons Processed
<u>Asbestos Removal - 4900</u>										
5-03-009-01	General	---	---	---	---	---	---	---	---	Tons Removed
<u>Equipment Leaks - 4953</u>										
5-03-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Wastewater, Aggregate - 4953</u>										
5-03-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
5-03-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Wastewater, Points of Generation - 4953</u>										
5-03-825-01	Liquid Injection Incinerator	---	---	---	---	---	---	---	---	1000 Gallons Throughput
5-03-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Auxillary Fuel/No Emissions - 4900</u>										
5-03-900-02	Coal	---	---	---	---	---	---	---	---	Tons Burned
5-03-900-05	Distillate Oil	---	---	---	---	---	---	---	---	1000 Gallons Burned
5-03-900-06	Natural Gas	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
5-03-900-07	Process Gas	---	---	---	---	---	---	---	---	Million Cubic Feet Burned
5-03-900-10	Liquified Petroleum Gas (LPG)	---	---	---	---	---	---	---	---	1000 Gallons Burned
<u>WASTE DISPOSAL -Site Remediation</u>										
<u>General Processes (Fixed and Floating Roof) - 5171, 5541, 7389</u>										
5-04-001-01	Breathing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
5-04-001-02	Working Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>General Processes (Fixed and Floating Roof) - 5171, 5541, 7389</u>										
5-04-001-03	Standing Loss	---	---	---	---	---	---	---	---	1000 Gallon-Years Storage Capacity
5-04-001-04	Withdrawal Loss	---	---	---	---	---	---	---	---	1000 Gallons Throughput
5-04-001-50	Storage Bins	---	---	---	---	---	---	---	---	1000 Gallons Processed
5-04-001-51	Liquid Waste: Transfer	---	---	---	---	---	---	---	---	1000 Gallons Processed
<u>General Processes - 3083, 3585, 3634, 4953, 8731</u>										
5-04-002-01	Miscellaneous	---	---	---	---	---	---	---	---	Tons Processed
5-04-002-02	Miscellaneous	---	---	---	---	---	---	---	---	Each-Year Operating
<u>General Processes - Refuse - 4911, 4953</u>										
5-04-003-01	Open Refuse Stockpiles: General	---	---	---	---	---	---	---	---	Tons Processed
5-04-003-02	Unloading: General	---	---	---	---	---	---	---	---	Tons Processed
5-04-003-03	Loading: General	---	---	---	---	---	---	---	---	Tons Processed
5-04-003-20	Storage Bins - Solid Waste	---	---	---	---	---	---	---	---	Tons Processed
<u>Excavation/Soils Handling - 4953</u>										
5-04-100-01	Excavation	---	---	---	---	---	---	---	---	Cubic Yards Handled
5-04-100-02	Excavation: Backhoes	---	---	---	---	---	---	---	---	Cubic Yards Handled
5-04-100-03	Excavation: Draglines	---	---	---	---	---	---	---	---	Cubic Yards Handled
5-04-100-04	Excavation: Bulldozers	---	---	---	---	---	---	---	---	Cubic Yards Handled
5-04-100-05	Excavation: Scrapers	---	---	---	---	---	---	---	---	Cubic Yards Handled
5-04-100-10	Transport	---	---	---	---	---	---	---	---	Cubic Yards Handled
5-04-100-20	Dumping	---	---	---	---	---	---	---	---	Cubic Yards Handled
5-04-100-21	Dumping: Machinery into Truck	---	---	---	---	---	---	---	---	Cubic Yards Handled
5-04-100-22	Dumping: Trucks onto Storage Piles	---	---	---	---	---	---	---	---	Cubic Yards Handled
5-04-100-30	Storage	---	---	---	---	---	---	---	---	Tons Stored
5-04-100-40	Grading	---	---	---	---	---	---	---	---	Square Feet Graded
<u>Stabilization/Solidification - 4953</u>										
5-04-101-01	Drying	---	---	---	---	---	---	---	---	Tons Treated
5-04-101-10	Mixing	---	---	---	---	---	---	---	---	Tons Treated
5-04-101-11	Mixing: Bins, Loading	---	---	---	---	---	---	---	---	Tons Treated
5-04-101-12	Mixing: Bins, Unloading	---	---	---	---	---	---	---	---	Tons Treated
5-04-101-20	Process	---	---	---	---	---	---	---	---	Tons Treated

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Stabilization/Solidification - 4953</u>										
5-04-101-21	Nonreactive	---	---	---	---	---	---	---	---	Tons Treated
5-04-101-22	Inorganic	---	---	---	---	---	---	---	---	Tons Treated
5-04-101-23	Organic, Thermoplastic Encapsulation	---	---	---	---	---	---	---	---	Tons Treated
5-04-101-24	Organic, Incorporated into Monomer or Prepolymer	---	---	---	---	---	---	---	---	Tons Treated
<u>Capping - 4953</u>										
5-04-102-10	Capping	---	---	---	---	---	---	---	---	1000 Square Feet Capped
5-04-102-11	Synthetic Membrane	---	---	---	---	---	---	---	---	1000 Square Feet Capped
5-04-102-12	Low Permeability Soil	---	---	---	---	---	---	---	---	1000 Square Feet Capped
5-04-102-13	Soil/Bentonite Admixtures	---	---	---	---	---	---	---	---	1000 Square Feet Capped
5-04-102-14	Constructed Cap, Asphalt	---	---	---	---	---	---	---	---	1000 Square Feet Capped
5-04-102-15	Constructed Cap, Concrete	---	---	---	---	---	---	---	---	1000 Square Feet Capped
5-04-102-16	Multilayer Cover	---	---	---	---	---	---	---	---	1000 Square Feet Capped
<u>In Situ Venting/Venting of Soils - 2834, 2891, 3585, 5171, 5541, 7389</u>										
5-04-103-10	Active Aeration	---	---	---	---	---	---	---	---	Cubic Yards Treated
5-04-103-11	Active Aeration: Vacuum	---	---	---	---	---	---	---	---	Cubic Yards Treated
5-04-103-12	Active Aeration, Vacuum: Vapor Recovery Well	---	---	---	---	---	---	---	---	Cubic Yards Treated
5-04-103-13	Active Aeration, Vacuum: Vacuum System	---	---	---	---	---	---	---	---	Cubic Yards Treated
5-04-103-14	Active Aeration, Vacuum: Control Device	---	---	---	---	---	---	---	---	Cubic Yards Treated
5-04-103-21	Active Aeration: Forced Air/Positive Pressure	---	---	---	---	---	---	---	---	Cubic Yards Treated
5-04-103-22	Active Aeration, Forced Air/Positive Pressure: Treatment Unit	---	---	---	---	---	---	---	---	Cubic Yards Treated
<u>Air Stripping of Groundwater - 2721, 2869, 4959, 5171, 5541, 7389</u>										
5-04-104-05	Oil/Water Separator	---	---	---	---	---	---	---	---	1000 Gallons Treated
5-04-104-06	Storage/Surge Tanks	---	---	---	---	---	---	---	---	1000 Gallons Treated
5-04-104-07	Holding Tanks	---	---	---	---	---	---	---	---	1000 Gallons Treated
5-04-104-08	Treatment Tanks	---	---	---	---	---	---	---	---	1000 Gallons Treated
5-04-104-09	Conduits	---	---	---	---	---	---	---	---	1000 Gallons Treated
5-04-104-20	Air Stripping Tower	---	---	---	---	---	---	---	---	1000 Gallons Treated
<u>Thermal Destruction - 4953</u>										
5-04-105-10	Waste Preparation	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-11	Waste Preparation: Blending	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SOx Lbs/Unit	<sup>7</sup> NOx Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Thermal Destruction - 4953</u></i>										
5-04-105-12	Waste Preparation: Screening	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-13	Waste Preparation: Shredding	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-14	Waste Preparation: Heating	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-20	Waste Feed System	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-21	Waste Feed System: Atomization	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-22	Waste Feed System: Ram	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-23	Waste Feed System: Auger	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-24	Waste Feed System: Gravity	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-25	Waste Feed System: Lance	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-30	Combustion Unit	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-31	Combustion Unit: Infrared Incinerator	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-32	Combustion Unit: Liquid Injection Incinerator	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-33	Combustion Unit: Hearth Incinerator	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-34	Combustion Unit: Fluidized Bed Incinerator	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-35	Combustion Unit: Rotary Kiln	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-36	Combustion Unit: Cement Kiln	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-37	Combustion Unit: Boiler	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-38	Combustion Unit: Pyrolysis	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-39	Combustion Unit: Molten Salt	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-40	Combustion Unit: High Temperature Fluid Wall	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-41	Combustion Unit: Plasma Arc	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-42	Combustion Unit: Wet Oxidation	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-43	Combustion Unit: Supercritical Water	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-60	Waste Disposal	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-61	Waste Disposal: Dewatering	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-62	Waste Disposal: Chemical Stabilization	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-63	Waste Disposal: Landfill	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-64	Waste Disposal: Residue Treatment, Neutralization	---	---	---	---	---	---	---	---	Tons Processed
5-04-105-65	Waste Disposal: Residue Treatment, Chemical	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Thermal Desorption - 2851</u></i>										
5-04-106-10	Pretreatment	---	---	---	---	---	---	---	---	Tons Processed

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<i><u>Thermal Desorption - 2851</u></i>										
5-04-106-20	Thermal Desorber	---	---	---	---	---	---	---	---	Tons Processed
5-04-106-21	Thermal Desorber: Indirect Heat Transfer	---	---	---	---	---	---	---	---	Tons Processed
5-04-106-22	Thermal Desorber: Kiln	---	---	---	---	---	---	---	---	Tons Processed
5-04-106-23	Thermal Desorber: Fluidized Bed	---	---	---	---	---	---	---	---	Tons Processed
5-04-106-40	Wastes	---	---	---	---	---	---	---	---	Tons Processed
5-04-106-41	Wastes: Hold Tanks	---	---	---	---	---	---	---	---	Tons Processed
5-04-106-42	Wastes: Separator	---	---	---	---	---	---	---	---	Tons Processed
5-04-106-43	Wastes: Sludge Concentrator	---	---	---	---	---	---	---	---	Tons Processed
5-04-106-44	Wastes: Waste Piles	---	---	---	---	---	---	---	---	Tons Processed
5-04-106-45	Wastes: Containers	---	---	---	---	---	---	---	---	Tons Processed
<i><u>Biological Treatment - 4953</u></i>										
5-04-107-10	Biooxidation	---	---	---	---	---	---	---	---	1000 Gallons Treated
5-04-107-11	Biooxidation: Microbial Aerobic, Bioattachment	---	---	---	---	---	---	---	---	1000 Gallons Treated
5-04-107-12	Biooxidation: Microbial Aerobic, Biosolubilization	---	---	---	---	---	---	---	---	1000 Gallons Treated
5-04-107-20	Anaerobic Biodegradation	---	---	---	---	---	---	---	---	Tons Treated
5-04-107-21	Anaerobic Biodegradation: Digester	---	---	---	---	---	---	---	---	Tons Treated
5-04-107-22	Anaerobic Biodegradation: Activated Sludge System	---	---	---	---	---	---	---	---	Tons Treated
5-04-107-23	Anaerobic Biodegradation: Fixed Film Reactors	---	---	---	---	---	---	---	---	Tons Treated
5-04-107-24	Anaerobic Biodegradation: Anaerobic Rotating Biological Contactors	---	---	---	---	---	---	---	---	Tons Treated
5-04-107-25	Anaerobic Biodegradation: Fluidized Bed Bioreactors	---	---	---	---	---	---	---	---	Tons Treated
5-04-107-26	Anaerobic Biodegradation: Upflow Anaerobic Sludge Blankets	---	---	---	---	---	---	---	---	Tons Treated
5-04-107-40	Surface Bioremediation	---	---	---	---	---	---	---	---	Tons Treated
5-04-107-60	Bioreactors	---	---	---	---	---	---	---	---	Tons Treated
5-04-107-61	Bioreactors: Activated Sludge	---	---	---	---	---	---	---	---	Tons Treated
5-04-107-62	Bioreactors: Fixed Film	---	---	---	---	---	---	---	---	Tons Treated
5-04-107-63	Bioreactors: Sequencing Batch	---	---	---	---	---	---	---	---	Tons Treated
5-04-107-64	Bioreactors: Fluidized Bed	---	---	---	---	---	---	---	---	Tons Treated
5-04-107-65	Bioreactors: Soil Slurry	---	---	---	---	---	---	---	---	Tons Treated
5-04-107-66	Bioreactors: Trickling Filter	---	---	---	---	---	---	---	---	Tons Treated
5-04-107-80	In Situ Bioremediation	---	---	---	---	---	---	---	---	1000 Cubic Feet Treated

<sup>1</sup> SCC	<sup>2</sup> PROCESS NAME	<sup>3</sup> PM, filt. Lbs/Unit	<sup>4</sup> PM-10 Lbs/Unit	<sup>5</sup> PM, cond. Lbs/Unit	<sup>6</sup> SO <sub>x</sub> Lbs/Unit	<sup>7</sup> NO <sub>x</sub> Lbs/Unit	<sup>8</sup> VOC Lbs/Unit	<sup>9</sup> CO Lbs/Unit	<sup>10</sup> Lead Lbs/Unit	<sup>11</sup> UNITS
<u>Equipment Leaks - 4953</u>										
5-04-800-01	Equipment Leaks	---	---	---	---	---	---	---	---	Each-Year Operating
<u>Wastewater, Aggregate - 2911, 9711</u>										
5-04-820-01	Process Area Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
5-04-820-02	Process Equipment Drains	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>Wastewater, Points of Generation - 2911, 9711</u>										
5-04-825-99	Specify Point of Generation	---	---	---	---	---	---	---	---	1000 Gallons Throughput
<u>General Processes Incinerators - 4953</u>										
5-04-900-04	General Processes Incinerators: Process Gas	---	---	---	---	---	---	---	---	Million Cubic Feet Burned



## FOOTNOTES FOR APPENDIX A: UNCONTROLLED EMISSION FACTOR LISTING

1. SCC = Source Classification Code. This Appendix includes only point source codes.
2. Process Name = Fourth level SCC Description.
3. PM, filt. = Filterable particulate matter. Primary PM = PM, filterable + PM, condensible.
4. PM-10 = Filterable particulate matter less than 10 microns in aerodynamic diameter.
5. PM, cond. = Condensible particulate matter. Primary PM = PM, filterable + PM, condensible.
6. SO<sub>x</sub> = Sulfur oxides, including SO<sub>2</sub> and SO<sub>3</sub>.
7. NO<sub>x</sub> = Oxides of nitrogen.
8. VOC - Volatile Organic Compounds.
9. CO = Carbon monoxide.
10. Lead = Lead, including lead oxide.
11. Units = Denominator of the emission factor. If no uncontrolled criteria pollutant emission factors are available for a particular SCC (see SCC 1-01-002-38), then the default SCC unit description is listed. The reader should note that there may be multiple unit descriptions.
12. For all criteria pollutants, except Lead, the emission factor units are "Pounds per Tons Bituminous Coal Burned"; for Lead, the emission factor unit is "Pounds per million BTUs Heat Input."
13. Equation is  $[39.6 (S) (Ca/S)^{-1.9}]$ . Where S = Sulfur Content weight percent and (Ca/S) is the molar calcium-to-sulfur ratio in the bed. This equation may be used when the (Ca/S) is between 1.5 and 7.0. When no calcium-based sorbents are used and the bed material is inert with respect to sulfur capture, use the emission factor for underfeed stokers to estimate SO<sub>2</sub>.
14. For all criteria pollutants, except Lead, the emission factor units are "Pounds per Tons Subbituminous Coal Burned"; for Lead, the emission factor unit is "Pounds per million BTUs Heat Input."
15. Where A = weight % ash content of lignite, wet basis. For example, if lignite is 3.4% ash, then A = 3.4.
16. The wall-fired unit emissions are defined as 79% of the tangential-fired unit emissions for this pollutant, where A = weight% ash content of lignite, wet basis. For example, if lignite is 3.4% ash, then A = 3.4.

## FOOTNOTES FOR APPENDIX A: UNCONTROLLED EMISSION FACTOR LISTING (CONTINUED)

17. To determine emission factor in lb/ton, multiply emission factor by wt% sulfur content of lignite, wet basis. For high sodium ash ( $\text{Na}_2\text{O} > 8\%$ ), use emission factor of 22 lb/ton/wt% sulfur. For low sodium ash ( $\text{Na}_2\text{O} < 2\%$ ), use 34 lb/ton/wt% sulfur.
18. For all criteria pollutants, except PM-condensable, the emission factor units are "Pounds per Tons Lignite Burned"; for PM-condensable, the emission factor unit is "Pounds per Million BTUs Heat Input."
19. Where S = weight percent of sulfur content of lignite, wet basis.
20. Where S = wt. % of sulfur in oil.
21. Emission factor is for  $\text{SO}_2$ .
22. For Number 6 Oil,  $A = 1.12(S) + 0.37$ ; for No. 5 Oil,  $A = 1.2$ ; for No. 4,  $A = 0.84$ ; for No. 2 Oil,  $A = 0.24$ ; S = Sulfur Content weight percent.
23. For all criteria pollutants, except Lead, the emission factor units are "Pounds per 1000 Gallons Distillate Oil (No. 1 & 2) Burned"; for Lead, the emission factor unit is "Pounds per million BTUs Heat Input."
24. For all criteria pollutants, except PM, filterable and  $\text{PM}_{10}$ , the emission factor units are "Pounds per 1,000 Gallons of Distillate Oil (No. 4) Burned"; for PM, filterable and  $\text{PM}_{10}$ , the emission factor unit is "Pounds per 1,000 Gallons of Residual Oil Burned."
25. For all criteria pollutants, except Lead, the emission factor units are "Pounds per Tons of Wood Waste Burned"; for Lead, the emission factor unit is "Pounds per Tons of Bark Burned."
26. Where "S" is in  $\text{gr}/100 \text{ ft}^3$ .
27. Emission Factor is listed as "controlled" in FIRE 6.23; however, this control technology does not control this pollutant, and thus this factor is considered "uncontrolled."
28. The emission factor unit for CO is "Pounds per Million BTUs of Heat Input"; the emission factor unit for Lead is "Pounds per Tons of Solid Waste Burned."
29. For all criteria pollutants, except PM, filterable and  $\text{PM}_{10}$ , the emission factor units are "Pounds per Million Cubic Feet of Process Gas Burned"; for PM, filterable and  $\text{PM}_{10}$ , the emission factor unit is "Pounds per Million Cubic Feet of Natural Gas Burned."
30. Where S = Sulfur content weight percent. Emission factors based on an average distillate oil heating value of 139 MMBtu/1000 gallons. To convert from (lb/MMBtu) to (lb/1000 gallons), multiply by 139.

## FOOTNOTES FOR APPENDIX A: UNCONTROLLED EMISSION FACTOR LISTING (CONTINUED)

31. Where S = Sulfur content weight percent. Emission factor based on an average natural gas heating value (HHV) of 1020 BTU/scf at 60 deg. F. To convert from (lb/MMBtu) to (lb/Million cubic feet), multiply by 1020.
32. Where S = percent sulfur in the fuel. Derived from emission factor intended for distillate oil-fired turbines.
33. Equation is  $0.000406 * S1 + 0.00957 * S2$ . Where S1 = Sulfur in fuel oil; S2 = Sulfur in natural gas.
34. For all criteria pollutants, except NO<sub>x</sub>, the emission factor units are "Pounds per Tons Carbon Black Produced"; for NO<sub>x</sub>, the emission factor unit is "Pounds per million BTUs Heat Input."
35. For all criteria pollutants, except PM, filterable, the emission factor units are "Pounds per Tons Raw Beets Processed"; for PM, filterable, the emission factor unit is "Pounds per Tons Pressed Wet Pulp Fed."
36. Equation is  $0.95Y + 0.195T_i - 0.51S - 0.86T_s + 1.90$ , where Y = initial baker's percent of yeast, T<sub>i</sub> = total yeast action time in hours, S = final (spike) baker's percent of yeast, and T<sub>s</sub> = spiking time in hours.
37. For all criteria pollutants, except PM, filterable, the emission factor units are "Pounds per Tons Material Produced"; for PM, filterable, the emission factor unit is "Pounds per Pounds Material Charged."
38. For SO<sub>x</sub>, PM<sub>10</sub>, and PM, filterable, the emission factor units are "Pounds per Tons Concentrated Ore Processed"; for Lead, the emission factor unit is "Pounds per Tons Lead Produced."
39. For all criteria pollutants, except PM, filterable, the emission factor units are "Pounds per Tons Metal Produced"; for PM, filterable, the emission factor unit is "Pounds per Metal Processed."
40. For PM, filterable and VOC, the emission factor units are "Pounds per Tons Coke-free Charge Processed"; for PM<sub>10</sub>, the emission factor is "Pounds per Tons Ore Processed."
41. For SO<sub>x</sub>, NO<sub>x</sub>, PM, filterable, and VOC, the emission factor units are "Pounds per Tons Metal Charged"; for PM<sub>10</sub>, the emission factor unit is "Pounds per Tons Metal Produced"; for Lead and CO, the emission factor units are "Pounds per Tons Gray Iron Produced."
42. For all criteria pollutants, except Lead, the emission factor units are "Pounds per Tons Metal Charged"; for Lead, the emission factor unit is "Pounds per Tons Gray Iron Produced."
43. For CO, VOC, Lead and NO<sub>x</sub>, the emission factor units are "Pounds per Tons Gray Iron Produced"; for PM<sub>10</sub>, the emission factor unit is "Pounds per Tons Metal Produced"; for SO<sub>x</sub> and PM, filterable, the emission factor units are "Pounds per Tons Metal Charged."

## FOOTNOTES FOR APPENDIX A: UNCONTROLLED EMISSION FACTOR LISTING (CONTINUED)

44. For PM, filterable, and VOC, the emission factor units are “Pounds per Tons Metal Charged”; for PM<sub>10</sub>, the emission factor unit is “Pounds per Tons Metal Produced.”
45. For SO<sub>x</sub>, NO<sub>x</sub>, CO, PM<sub>10</sub>, the emission factor units are “Pounds per Tons Metal Charged”; for Lead and PM, filterable, the emission factor units are “Pounds per Tons Metal Produced.”
46. For SO<sub>x</sub>, NO<sub>x</sub>, PM<sub>10</sub>, the emission factor units are “Pounds per Tons Metal Charged”; for PM, filterable and Lead, the emission factor unit is “Pounds per Tons Metal Produced”; for CO, the emission factor unit is “Pounds per Tons Lead Produced.”
47. For PM, filterable and PM<sub>10</sub>, the emission factor units are “Pounds per Tons of Metal Charged”; for Lead, the emission factor unit is “Pounds per Tons of Metal Produced.”
48. For PM, filterable, and Lead, the emission factor units are “Pounds per Tons Lead Produced”; for PM<sub>10</sub>, the emission factor unit is “Pounds per Tons Metal Charged.”
49. For all criteria pollutants, except PM, filterable, the emission factor units are “Pounds per Tons Material Produced”; for PM, filterable, the emission factor unit is “Pounds per Tons Zinc Used.”
50. For VOC, NO<sub>x</sub>, and PM<sub>10</sub>, the emission factor units are “Pounds per Tons Material Produced”; for PM, filterable, and SO<sub>x</sub>, the emission factor units are “Pounds per Tons Feed Material Processed.”
51. For VOC and PM<sub>10</sub>, the emission factor units are “Pounds per Tons Scrap Processed”; for PM, filterable, the emission factor unit is “Pounds per Tons Material Produced.”
52. For NO<sub>x</sub> and CO, the emission factor units are “Pounds per Tons Clinker Produced”; for PM, filterable, PM<sub>10</sub>, SO<sub>x</sub>, and Lead, the emission factor units are “Pounds per Tons Cement Produced.”
53. For NO<sub>x</sub>, PM<sub>10</sub>, CO, and PM, filterable, the emission factor units are “Pounds per Tons Clinker Produced”; for SO<sub>x</sub> and Lead, the emission factor units are “Pounds per Tons Cement Produced.”
54. For facilities using raw material with a sulfur content greater than 0.07 percent. For facilities using raw material with a sulfur content of 0.07 percent or less, use 9.5 S pounds per ton. “S” = Weight percent of sulfur.
55. For PM, filterable, the emission factor unit is “Pounds per Tons Raw Material Processed”; for PM<sub>10</sub>, the emission factor unit is “Pounds per Tons Finished Product Produced.”
56. For SO<sub>x</sub>, the emission factor unit is “Pounds per Tons Wet Coal Dried”; for PM, filterable, the emission factor unit is “Pounds per Tons Coal Dried.”
57. For PM, filterable, the emission factor unit is “Pounds per 1,000 Tons Coal Dried”; for SO<sub>x</sub>, the emission factor unit is “Pounds per 1,000 Tons of Wet Coal Dried.”

**FOOTNOTES FOR APPENDIX A: UNCONTROLLED EMISSION  
FACTOR LISTING (CONTINUED)**

58. For all criteria pollutants, except Lead, the emission factor units are "Pounds per 1000 Barrels Oil Burned"; for Lead, the emission factor unit is "Pounds per Million BTUs Heat Input."
59. For all criteria pollutant, except CO, the emission factor units are "Pounds per Tons of Air-Dried Unbleached Pulp Produced"; for CO, the emission factor unit is "Pounds per Tons of Black Liquor Solid Burned."
60. For all criteria pollutants, except Lead, the emission factor units are "Pounds per 1000 Gallons Crude Oil Burned"; for Lead, the emission factor unit is "Pounds per Million BTUs Heat Input."
61. The PM, filterable emission factor unit is "Pounds per Each Vehicle Burned"; the VOC emission factor unit is "Pounds per Tons Material Burned."

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# **APPENDIX B**

## **UNCONTROLLED PM<sub>2.5</sub> EMISSION FACTORS**

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**FOOTNOTES FOR APPENDIX B: UNCONTROLLED EMISSION  
FACTOR LISTING FOR  $PM_{2.5}$**

1. Where A = Ash weight percent of fuel, as fired. For example if ash weight of the fuel is 8.2% then A = 8.2.
2. Where A = weight % ash content of lignite, wet basis. For example, if lignite is 3.4% ash, then A = 3.4.
3. Where S = Weight% sulfur content in the fuel. (Factor is derived: 52% of the PM, filterable factor.)
4. For Number 6 Oil,  $A = 1.12(S) + 0.37$ ; for No. 5 Oil,  $A = 1.2$ ; for No. 4,  $A = 0.84$ ; for No. 2 Oil,  $A = 0.24$ ; S = Sulfur Content weight percent. (Factor is derived: 52% of the PM, filterable factor).

SCC	PROCESS NAME	PM2.5, filt. Lbs/Unit	UNITS
<b><u>EXTERNAL COMBUSTION BOILERS</u></b>			
<b><u>External Combustion Boilers - Electric Generation</u></b>			
<b><u>External Combustion Boilers: Electric Generation - Anthracite Coal - SIC 4911</u></b>			
1-01-001-01	Pulverized Coal	<sup>1</sup> 0.6A	Tons Anthracite Burned
<b><u>External Combustion Boilers: Electric Generation - Bituminous/Subbituminous Coal - SIC 4911</u></b>			
1-01-002-01	Pulverized Coal: Wet Bottom (Bituminous Coal)	<sup>1</sup> 1.48A	Tons Bituminous Coal Burned
1-01-002-02	Pulverized Coal: Dry Bottom (Bituminous Coal)	<sup>1</sup> 0.6A	Tons Bituminous Coal Burned
1-01-002-03	Cyclone Furnace (Bituminous Coal)	<sup>1</sup> 0.11A	Tons Bituminous Coal Burned
1-01-002-04	Spreader Stoker (Bituminous Coal)	4.6	Tons Bituminous Coal Burned
1-01-002-05	Traveling Grate (Overfeed) Stoker (Bituminous Coal)	2.2	Tons Bituminous Coal Burned
1-01-002-12	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	<sup>1</sup> 0.6A	Tons Bituminous Coal Burned
<b><u>External Combustion Boilers: Electric Generation - Lignite - SIC 4911</u></b>			
1-01-003-01	Pulverized Coal: Dry Bottom, Wall Fired	<sup>2</sup> 0.79*(0.66A)	Tons Lignite Burned
1-01-003-02	Pulverized Coal: Dry Bottom, Tangential Fired	<sup>2</sup> 0.66A	Tons Lignite Burned
1-01-003-06	Spreader Stoker	<sup>2</sup> 0.56A	Tons Lignite Burned
<b><u>External Combustion Boilers: Electric Generation - Residual Oil - SIC 4911</u></b>			
1-01-004-01	Grade 6 Oil: Normal Firing	<sup>3</sup> 4.3*(1.12S + 0.37)	1000 Gallons Residual Oil Burned
1-01-004-04	Grade 6 Oil: Tangential Firing	<sup>3</sup> 4.3*(1.12S + 0.37)	1000 Gallons Residual Oil Burned
1-01-004-05	Grade 5 Oil: Normal Firing	<sup>4</sup> 4.3A	1000 Gallons Residual Oil Burned
1-01-004-06	Grade 5 Oil: Tangential Firing	<sup>4</sup> 4.3A	1000 Gallons Residual Oil Burned
<b><u>External Combustion Boilers: Electric Generation - Distillate Oil - SIC 4911</u></b>			
1-01-005-04	Grade 4 Oil: Normal Firing	<sup>4</sup> 4.3A	1000 Gallons Residual Oil Burned
1-01-005-05	Grade 4 Oil: Tangential Firing	3.6	1000 Gallons Residual Oil Burned
<b><u>External Combustion Boilers: Electric Generation - Wood/Bark Waste - SIC 4911</u></b>			
1-01-009-01	Bark-fired Boiler	10	Tons Wood Waste Burned
1-01-009-02	Wood/Bark Fired Boiler	5.47	Tons Wood/Bark Burned
<b><u>External Combustion Boilers - Industrial</u></b>			
<b><u>External Combustion Boilers: Industrial - Anthracite Coal - SIC 1000-3999</u></b>			
1-02-001-01	Pulverized Coal	<sup>1</sup> 0.6A	Tons Anthracite Burned
<b><u>External Combustion Boilers: Industrial - Bituminous/Subbituminous Coal - SIC 1000-3999</u></b>			
1-02-002-01	Pulverized Coal: Wet Bottom	1.48A	Tons Bituminous Coal Burned

SCC	PROCESS NAME	PM2.5, filt. Lbs/Unit	UNITS
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**External Combustion Boilers - Industrial**

**External Combustion Boilers: Industrial - Bituminous/Subbituminous Coal - SIC 1000-3999**

1-02-002-02	Pulverized Coal: Dry Bottom	<sup>1</sup> 0.6A	Tons Bituminous Coal Burned
1-02-002-03	Cyclone Furnace	<sup>1</sup> 0.11A	Tons Bituminous Coal Burned
1-02-002-04	Spreader Stoker	4.6	Tons Bituminous Coal Burned
1-02-002-05	Overfeed Stoker	2.2	Tons Bituminous Coal Burned
1-02-002-06	Underfeed Stoker	3.8	Tons Bituminous Coal Burned
1-02-002-12	Pulverized Coal: Dry Bottom (Tangential)	<sup>1</sup> 0.6A	Tons Bituminous Coal Burned

**External Combustion Boilers: Industrial - Residual Oil - SIC 1000-3999**

1-02-004-01	Grade 6 Oil	<sup>4</sup> 4.67A	1000 Gallons Residual Oil Burned
1-02-004-02	10-100 Million Btu/hr **	<sup>4</sup> 4.67A	1000 Gallons Residual Oil Burned
1-02-004-03	< 10 Million Btu/hr **	<sup>4</sup> 4.67A	1000 Gallons Residual Oil Burned
1-02-004-04	Grade 5 Oil	5.6	1000 Gallons Residual Oil Burned

**External Combustion Boilers: Industrial - Distillate Oil - SIC 1000-3999**

1-02-005-01	Grades 1 and 2 Oil	0.25	1000 Gallons Distillate Oil Burned
1-02-005-02	10-100 Million Btu/hr **	0.25	1000 Gallons Distillate Oil Burned
1-02-005-03	< 10 Million Btu/hr **	0.25	1000 Gallons Distillate Oil Burned
1-02-005-04	Grade 4 Oil	3.9	1000 Gallons Residual Oil Burned

**External Combustion Boilers: Industrial - Wood/Bark Waste - SIC 1000-3999**

1-02-009-01	Bark-fired Boiler (> 50,000 Lb Steam)	10	Tons Wood Waste Burned
1-02-009-02	Wood/Bark-fired Boiler (> 50,000 Lb Steam)	5.47	Tons Wood/Bark Burned
1-02-009-04	Bark-fired Boiler (< 50,000 Lb Steam)	10	Tons Wood Waste Burned
1-02-009-05	Wood/Bark-fired Boiler (< 50,000 Lb Steam)	5.47	Tons Wood/Bark Burned

**External Combustion Boilers - Commercial/Institutional**

**External Combustion Boilers: Commercial/Institutional - Anthracite Coal - SIC 4000-4899, 4920-9999**

1-03-001-01	Pulverized Coal	<sup>1</sup> 0.6A	Tons Anthracite Burned
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**External Combustion Boilers: Commercial/Institutional - Bituminous/Subbituminous Coal - SIC 4000-4899, 4920-9999**

1-03-002-03	Cyclone Furnace (Bituminous Coal)	<sup>1</sup> 0.11A	Tons Bituminous Coal Burned
1-03-002-05	Pulverized Coal: Wet Bottom (Bituminous Coal)	1.48A	Tons Bituminous Coal Burned
1-03-002-06	Pulverized Coal: Dry Bottom (Bituminous Coal)	<sup>1</sup> 0.6A	Tons Bituminous Coal Burned

SCC	PROCESS NAME	PM2.5, filt. Lbs/Unit	UNITS
<b><u>External Combustion Boilers - Commercial/Institutional</u></b>			
<b><u>External Combustion Boilers: Commercial/Institutional - Bituminous/Subbituminous Coal - SIC 4000-4899, 4920-9999</u></b>			
1-03-002-07	Overfeed Stoker (Bituminous Coal)	2.2	Tons Bituminous Coal Burned
1-03-002-08	Underfeed Stoker (Bituminous Coal)	3.8	Tons Bituminous Coal Burned
1-03-002-09	Spreader Stoker (Bituminous Coal)	4.6	Tons Bituminous Coal Burned
1-03-002-16	Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)	<sup>1</sup> 0.6A	Tons Bituminous Coal Burned
<b><u>External Combustion Boilers: Commercial/Institutional - Residual Oil - SIC 4000-4899, 4920-9999</u></b>			
1-03-004-01	Grade 6 Oil	<sup>4</sup> 1.92A	1000 Gallons Residual Oil Burned
1-03-004-02	10-100 Million Btu/hr **	<sup>4</sup> 1.92A	1000 Gallons Residual Oil Burned
1-03-004-03	< 10 Million Btu/hr **	<sup>4</sup> 1.92A	1000 Gallons Residual Oil Burned
1-03-004-04	Grade 5 Oil	2.3	1000 Gallons Residual Oil Burned
<b><u>External Combustion Boilers: Commercial/Institutional - Distillate Oil - SIC 4000-4899, 4920-9999</u></b>			
1-03-005-01	Grades 1 and 2 Oil	0.83	1000 Gallons Distillate Oil Burned
1-03-005-02	10-100 Million Btu/hr **	0.83	1000 Gallons Distillate Oil Burned
1-03-005-03	< 10 Million Btu/hr **	0.83	1000 Gallons Distillate Oil Burned
1-03-005-04	Grade 4 Oil	0.83	1000 Gallons Distillate Oil Burned
<b><u>External Combustion Boilers: Commercial/Institutional - Wood/Bark Waste - SIC 4000-4899, 4920-9999</u></b>			
1-03-009-01	Bark-fired Boiler	10	Tons Wood Waste Burned
1-03-009-02	Wood/Bark-fired Boiler	5.47	Tons Wood/Bark Burned

SCC	PROCESS NAME	PM2.5, filt. Lbs/Unit	UNITS
<b><u>INTERNAL COMBUSTION ENGINES</u></b>			
<b><u>Internal Combustion Engines - Industrial</u></b>			
<b><u>Internal Combustion Engines: Industrial - Distillate Oil (Diesel) - SIC 1000-3999</u></b>			
2-02-001-02	Reciprocating	42.5	1000 Gallons Distillate Oil (Diesel) Burned
<b><u>Internal Combustion Engines: Industrial - Natural Gas - SIC 1000-3999</u></b>			
2-02-002-52	2-cycle Lean Burn	0.0384	Million Btus Fuel Input
2-02-002-53	4-cycle Rich Burn	0.0095	Million Btus Fuel Input
2-02-002-54	4-cycle Lean Burn	0.0000771	Million Btus Fuel Input
<b><u>Internal Combustion Engines: Industrial - Large Bore Engine - SIC 1000-3999</u></b>			
2-02-004-01	Diesel	6.5	1000 Gallons Diesel Burned
<b><u>Internal Combustion Engines - Commercial/Institutional</u></b>			
<b><u>Internal Combustion Engines: Commercial/Institutional - Distillate Oil (Diesel) - SIC 4000-4899, 4920-9999</u></b>			
2-03-001-01	Reciprocating	42.5	1000 Gallons Distillate Oil (Diesel) Burned
<b><u>Internal Combustion Engines: Commercial/Institutional - Gasoline - SIC 4000-4899, 4920-9999</u></b>			
2-03-003-01	Reciprocating	12.6	1000 Gallons Gasoline Burned

SCC	PROCESS NAME	PM2.5, filt. Lbs/Unit	UNITS
<b><u>INDUSTRIAL PROCESSES</u></b>			
<b><u>Industrial Processes - Chemical Manufacturing</u></b>			
<b><u>Industrial Processes: Chemical Manufacturing - Ammonium Nitrate Production - SIC 2873</u></b>			
3-01-027-07	Rotary Drum Granulator	0.27	Tons Ammonium Nitrate Produced
3-01-027-22	Prilling Tower: Low Density	0.52	Tons Ammonium Nitrate Produced
3-01-027-24	Prilling Cooler: Low Density	0.015	Tons Ammonium Nitrate Produced
3-01-027-25	Prilling Dryer: Low Density	0.046	Tons Ammonium Nitrate Produced
3-01-027-29	Rotary Drum Granulator Coolers	0.0097	Tons Ammonium Nitrate Produced
<b><u>Industrial Processes: Chemical Manufacturing - Urea Production - SIC 2873</u></b>			
3-01-040-08	Non-fluidized Bed Prilling (Agricultural Grade)	3	Tons Urea Produced
3-01-040-09	Non-fluidized Bed Prilling (Feed Grade)	1.8	Tons Urea Produced
3-01-040-10	Fluidized Bed Prilling (Agricultural Grade)	2.7	Tons Urea Produced
3-01-040-11	Fluidized Bed Prilling (Feed Grade)	0.5	Tons Urea Produced
3-01-040-12	Rotary Drum Cooler	0.31	Tons Urea Produced
<b><u>Industrial Processes - Food and Agriculture</u></b>			
<b><u>Industrial Processes: Food and Agriculture - Grain Millings - SIC 2041</u></b>			
3-02-007-09	Barley Malting: Gas-fired Malt Kiln	0.075	Tons Grain Processed
<b><u>Industrial Processes: Food and Agriculture - Beer Production - SIC 2082</u></b>			
3-02-009-30	Brewers Grain Dryer: Natural Gas-fired	0.091	Tons Dried Grain Produced
3-02-009-32	Brewers Grain Dryer: Steam-heated	0.091	Tons Dried Grain Produced
<b><u>Industrial Processes: Food and Agriculture - Meat Smokehouses - SIC 2012, 2013</u></b>			
3-02-013-02	Batch Smokehouses: Smoking Cycle	23	Tons Sawdust Used
3-02-013-04	Continuous Smokehouse: Smoke Zone	66	Tons Sawdust Used
<b><u>Industrial Processes - Primary Metal Production</u></b>			
<b><u>Industrial Processes: Primary Metal Production - Aluminum Ore (Electro-reduction) - SIC 3334</u></b>			
3-03-001-02	Horizontal Stud Soderberg Cell	39.2	Tons Molten Aluminum Produced
3-03-001-08	Prebake: Fugitive Emissions	1.4	Tons Molten Aluminum Produced
3-03-001-09	H.S.S.: Fugitive Emissions	1.7	Tons Molten Aluminum Produced
<b><u>Industrial Processes: Primary Metal Production - By-product Coke Manufacturing - SIC 3312</u></b>			
3-03-003-03	Oven Pushing	0.19	Tons Coal Charged
3-03-003-04	Quenching	See App. C	

SCC	PROCESS NAME	PM2.5, filt. Lbs/Unit	UNITS
<b><u>Industrial Processes - Primary Metal Production</u></b>			
<b><u>Industrial Processes: Primary Metal Production - By-product Coke Manufacturing - SIC 3312</u></b>			
3-03-003-13	Coal Preheater	2.1	Tons Coal Charged
3-03-003-17	Combustion Stack: Coke Oven Gas (COG)	0.44	Tons Coal Charged
<b><u>Industrial Processes: Primary Metal Production - Ferroalloy, Open Furnace - SIC 3313</u></b>			
3-03-006-01	50% FeSi: Electric Smelting Furnace	40	Tons Material Produced
3-03-006-04	Silicon Metal: Electric Smelting Furnace	654	Tons Material Produced
3-03-006-05	Silicomanganese: Electric Smelting Furnace	125	Tons Material Produced
3-03-006-06	80% Ferromanganese	17	Tons Material Produced
3-03-006-07	80% Ferrochromium	99	Tons Material Produced
<b><u>Industrial Processes: Primary Metal Production - Iron Production (See 3-03-015 for Integrated Iron &amp; Steel MACT) - SIC</u></b>			
3-03-008-13	Windbox	0.56	Tons Material Produced
3-03-008-25	Cast House	0.14	Tons Material Produced
<b><u>Industrial Processes: Primary Metal Production - Steel Manufacturing (See 3-03-015 for Integrated Iron &amp; Steel MACT) -</u></b>			
3-03-009-01	Open Hearth Furnace: Stack	12.7	Tons Material Produced
3-03-009-13	Basic Oxygen Furnace: Open Hood-Stack	0.0044	Tons Material Produced
3-03-009-16	Charging: BOF	0.13	Tons Material Produced
3-03-009-17	Tapping: BOF	0.34	Tons Material Produced
<b><u>Industrial Processes - Secondary Metal Production</u></b>			
<b><u>Industrial Processes: Secondary Metal Production - Aluminum - SIC 3341, 3353, 3354, 3355, 3363, 3365</u></b>			
3-04-001-03	Smelting Furnace/Reverberatory	2.16	Tons Metal Produced
3-04-001-04	Fluxing: Chlorination	199	Tons Metal Processed
<b><u>Industrial Processes: Secondary Metal Production - Grey Iron Foundries - SIC 3321</u></b>			
3-04-003-01	Cupola	11.6	Tons Metal Produced
3-04-003-18	Pouring, Cooling	1	Tons Metal Produced
3-04-003-31	Casting Shakeout	1.34	Tons Metal Produced
<b><u>Industrial Processes - Mineral Products</u></b>			
<b><u>Industrial Processes: Mineral Products - Brick Manufacture - SIC 3251</u></b>			
3-05-003-10	Curing and Firing: Sawdust Fired Tunnel Kilns	0.16	Tons Brick Produced
3-05-003-13	Curing and Firing: Coal-fired Tunnel Kilns	0.28	Tons Brick Produced

SCC	PROCESS NAME	PM2.5, filt. Lbs/Unit	UNITS
<b><u>Industrial Processes - Mineral Products</u></b>			
<b><u>Industrial Processes: Mineral Products - Castable Refractory - SIC 3255</u></b>			
3-05-005-01	Fire Clay: Rotary Dryer	1.6	Tons Feed Material Fed
3-05-005-06	Fire Clay: Rotary Calciner	8.3	Tons Feed Material Fed
<b><u>Industrial Processes: Mineral Products - Cement Manufacturing (Wet Process) - SIC 3241</u></b>			
3-05-007-06	Kilns	9.1	Tons Clinker Produced
<b><u>Industrial Processes: Mineral Products - Coal Mining, Cleaning, and Material Handling (See 305310) - SIC 1111, 1221, 12</u></b>			
3-05-010-01	Fluidized Bed	3.8	Tons Wet Coal Dried
<b><u>Industrial Processes: Mineral Products - Glass Manufacture - SIC 3211, 3221, 3229</u></b>			
3-05-014-02	Container Glass: Melting Furnace	1.3	Tons Glass Produced
3-05-014-03	Flat Glass: Melting Furnace	1.8	Tons Glass Produced
3-05-014-04	Pressed and Blown Glass: Melting Furnace	16	Tons Glass Produced
<b><u>Industrial Processes: Mineral Products - Lime Manufacture - SIC 3274</u></b>			
3-05-016-18	Calcining: Coal-fired Rotary Kiln	4.9	Tons Lime Manufactured
3-05-016-20	Calcining: Coal- and Gas-fired Rotary Kiln	1.1	Tons Lime Manufactured
<b><u>Industrial Processes: Mineral Products - Clay processing: Kaolin - SIC multiple (See Appendix D)</u></b>			
3-05-041-41	Calcining, multiple hearth furnace	7.8	Tons Clay Produced
3-05-041-42	Calcining, flash calciner	280	Tons Clay Produced
<b><u>Industrial Processes: Mineral Products - Clay processing: Fire clay - SIC multiple (See Appendix D)</u></b>			
3-05-043-30	Drying, rotary dryer	1.6	Tons Clay Processed
3-05-043-40	Calcining, rotary calciner	8.3	Tons Clay Processed
<b><u>Industrial Processes: Mineral Products - Clay processing: Bentonite - SIC multiple (See Appendix D)</u></b>			
3-05-044-30	Drying, rotary dryer	2	Tons Clay Produced
<b><u>Industrial Processes - Pulp and Paper and Wood Products</u></b>			
<b><u>Industrial Processes: Pulp and Paper and Wood Products - Sulfate (Kraft) Pulping - SIC 2611, 2621, 2631</u></b>			
3-07-001-04	Recovery Furnace/Direct Contact Evaporator	150	Tons Air-Dried Unbleached Pulp Produced
3-07-001-05	Smelt Dissolving Tank	5.1	Tons Air-Dried Unbleached Pulp Produced
3-07-001-06	Lime Kiln	5.9	Tons Air-Dried Unbleached Pulp Produced
3-07-001-10	Recovery Furnace/Indirect Contact Evaporator	180	Tons Air-Dried Unbleached Pulp Produced



SCC	PROCESS NAME	PM2.5, filt. Lbs/Unit	UNITS
<b><u>WASTE DISPOSAL</u></b>			
<b><u>Waste Disposal - Solid Waste Disposal - Government</u></b>			
<b><u>Waste Disposal: Solid Waste Disposal - Government - Other Incineration - SIC 4953</u></b>			
5-01-005-15	Sludge: Multiple Hearth	2.2	Tons Dried Sludge Fed
5-01-005-17	Sludge: Electric Infrared	2	Tons Dried Sludge Fed
<b><u>Waste Disposal - Solid Waste Disposal - Commercial/Institutional</u></b>			
<b><u>Waste Disposal: Solid Waste Disposal - Commercial/Institutional - Incineration: Special Purpose - SIC 4900</u></b>			
5-02-005-01	Med Waste Controlled Air Incin-aka Starved air, 2-stg, or Modular comb	2.022	Tons Medical Waste Burned

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# **APPENDIX C**

## **SCCs WITH MULTIPLE EMISSION FACTORS**

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## SCCs With Multiple Emission Factors

### ***1-01-002-02 External Combustion Boilers - Electric Generation - Bituminous/Subbituminous Coal - Pulverized Coal: Dry Bottom (Bituminous Coal)***

#### **Nitrogen oxides (NO<sub>x</sub>)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
12	Lb per Tons of Bituminous Coal Burned	Factor is for Post-NSPS boilers.
22	Lb per Tons of Bituminous Coal Burned	Factor is for Pre-NSPS boilers.

### ***1-01-002-12 External Combustion Boilers - Electric Generation - Bituminous/Subbituminous Coal - Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)***

#### **Nitrogen oxides (NO<sub>x</sub>)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
10	Lb per Tons of Bituminous Coal Burned	Factor is for Post-NSPS boilers.
15	Lb per Tons of Bituminous Coal Burned	Factor is for Pre-NSPS boilers.

### ***1-01-002-22 External Combustion Boilers - Electric Generation - Bituminous/Subbituminous Coal - Pulverized Coal: Dry Bottom (Subbituminous Coal)***

#### **Nitrogen oxides (NO<sub>x</sub>)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
12	Lb per Tons of Subbituminous Coal Burned	Factor is for Pre-NSPS boilers.
7.4	Lb per Tons of Subbituminous Coal Burned	Factor is for Post-NSPS boilers.

### ***1-01-002-26 External Combustion Boilers - Electric Generation - Bituminous/Subbituminous Coal - Pulverized Coal: Dry Bottom Tangential (Subbituminous Coal)***

#### **Nitrogen oxides (NO<sub>x</sub>)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
7.2	Lb per Tons of Subbituminous Coal Burned	Factor is for Post-NSPS boilers.
8.4	Lb per Tons of Subbituminous Coal Burned	Factor is for Pre-NSPS boilers.

## SCCs With Multiple Emission Factors

### ***1-01-003-01 External Combustion Boilers - Electric Generation - Lignite - Pulverized Coal: Dry Bottom, Wall Fired***

#### **Nitrogen oxides (NOx)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
13	Lb per Tons of Lignite Burned	Pre-NSPS
6.3	Lb per Tons of Lignite Burned	NSPS

### ***1-01-006-01 External Combustion Boilers - Electric Generation - Natural Gas - Boilers > 100 Million Btu/hr except Tangential***

#### **Nitrogen oxides (NOx)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
190	Lb per Million Cubic Feet of Natural Gas Burned	Factor is for a Post-NSPS boiler.
280	Lb per Million Cubic Feet of Natural Gas Burned	Factor is for a Pre-NSPS boiler.

### ***1-02-002-02 External Combustion Boilers - Industrial - Bituminous/Subbituminous Coal - Pulverized Coal: Dry Bottom***

#### **Nitrogen oxides (NOx)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
12	Lb per Tons of Bituminous Coal Burned	Factor is for Post-NSPS boilers.
22	Lb per Tons of Bituminous Coal Burned	Factor is for Pre-NSPS boilers.

### ***1-02-002-12 External Combustion Boilers - Industrial - Bituminous/Subbituminous Coal - Pulverized Coal: Dry Bottom (Tangential)***

#### **Nitrogen oxides (NOx)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
10	Lb per Tons of Bituminous Coal Burned	Factor is for Post-NSPS boilers.
15	Lb per Tons of Bituminous Coal Burned	Factor is for Pre-NSPS boilers.

## SCCs With Multiple Emission Factors

### ***1-02-002-22 External Combustion Boilers - Industrial - Bituminous/Subbituminous Coal - Pulverized Coal: Dry Bottom (Subbituminous Coal)***

#### **Nitrogen oxides (NO<sub>x</sub>)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
12	Lb per Tons of Subbituminous Coal Burned	Factor is for Pre-NSPS boilers.
7.4	Lb per Tons of Subbituminous Coal Burned	Factor is for Post-NSPS boilers.

### ***1-02-002-26 External Combustion Boilers - Industrial - Bituminous/Subbituminous Coal - Pulverized Coal: Dry Bottom Tangential (Subbituminous Coal)***

#### **Nitrogen oxides (NO<sub>x</sub>)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
7.2	Lb per Tons of Subbituminous Coal Burned	Factor is for Post-NSPS boilers.
8.4	Lb per Tons of Subbituminous Coal Burned	Factor is for Pre-NSPS boilers.

### ***1-02-006-01 External Combustion Boilers - Industrial - Natural Gas - > 100 Million Btu/hr***

#### **Nitrogen oxides (NO<sub>x</sub>)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
190	Lb per Million Cubic Feet of Natural Gas Burned	Factor is for a Post-NSPS boiler.
280	Lb per Million Cubic Feet of Natural Gas Burned	Factor is for a Pre-NSPS boiler.

### ***1-03-002-06 External Combustion Boilers - Commercial/Institutional - Bituminous/Subbituminous Coal - Pulverized Coal: Dry Bottom (Bituminous Coal)***

#### **Nitrogen oxides (NO<sub>x</sub>)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
12	Lb per Tons of Bituminous Coal Burned	Factor is for Post-NSPS boilers.
22	Lb per Tons of Bituminous Coal Burned	Factor is for Pre-NSPS boilers.

### ***1-03-002-16 External Combustion Boilers - Commercial/Institutional - Bituminous/Subbituminous Coal - Pulverized Coal: Dry Bottom (Tangential) (Bituminous Coal)***

#### **Nitrogen oxides (NO<sub>x</sub>)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
10	Lb per Tons of Bituminous Coal Burned	Factor is for Post-NSPS boilers.
15	Lb per Tons of Bituminous Coal Burned	Factor is for Pre-NSPS boilers.

## SCCs With Multiple Emission Factors

### ***1-03-002-22 External Combustion Boilers - Commercial/Institutional - Bituminous/Subbituminous Coal - Pulverized Coal: Dry Bottom (Subbituminous Coal)***

#### **Nitrogen oxides (NOx)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
12	Lb per Tons of Subbituminous Coal Burned	Factor is for Pre-NSPS boilers.
7.4	Lb per Tons of Subbituminous Coal Burned	Factor is for Post-NSPS boilers.

### ***1-03-002-26 External Combustion Boilers - Commercial/Institutional - Bituminous/Subbituminous Coal - Pulverized Coal: Dry Bottom Tangential (Subbituminous Coal)***

#### **Nitrogen oxides (NOx)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
7.2	Lb per Tons of Subbituminous Coal Burned	Factor is for Post-NSPS boilers.
8.4	Lb per Tons of Subbituminous Coal Burned	Factor is for Pre-NSPS boilers.

### ***1-03-006-01 External Combustion Boilers - Commercial/Institutional - Natural Gas - > 100 Million Btu/hr***

#### **Nitrogen oxides (NOx)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
190	Lb per Million Cubic Feet of Natural Gas Burned	Factor is for a Post-NSPS boiler.
280	Lb per Million Cubic Feet of Natural Gas Burned	Factor is for a Pre-NSPS boiler.

### ***2-02-002-52 Internal Combustion Engines - Industrial - Natural Gas - 2-cycle Lean Burn***

#### **Carbon monoxide**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.353	Lb per Million Btus of Fuel Input	<90% load.
0.386	Lb per Million Btus of Fuel Input	90% - 105% load.

### ***2-02-002-52 Internal Combustion Engines - Industrial - Natural Gas - 2-cycle Lean Burn***

#### **Nitrogen oxides (NOx)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
1.94	Lb per Million Btus of Fuel Input	<90% load
3.17	Lb per Million Btus of Fuel Input	90% - 105% load



## ***SCCs With Multiple Emission Factors***

### ***2-02-002-53 Internal Combustion Engines - Industrial - Natural Gas - 4-cycle Rich Burn***

#### **Carbon monoxide**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
3.51	Lb per Million Btus of Fuel Input	<90% load
3.72	Lb per Million Btus of Fuel Input	90% - 105% load

### ***2-02-002-53 Internal Combustion Engines - Industrial - Natural Gas - 4-cycle Rich Burn***

#### **Nitrogen oxides (NOx)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
2.21	Lb per Million Btus of Fuel Input	90% - 105% load
2.27	Lb per Million Btus of Fuel Input	<90% load

### ***2-02-002-54 Internal Combustion Engines - Industrial - Natural Gas - 4-cycle Lean Burn***

#### **Carbon monoxide**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.317	Lb per Million Btus of Fuel Input	90% - 105% load
0.557	Lb per Million Btus of Fuel Input	<90% load

### ***2-02-002-54 Internal Combustion Engines - Industrial - Natural Gas - 4-cycle Lean Burn***

#### **Nitrogen oxides (NOx)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
4.08	Lb per Million Btus of Fuel Input	90% - 105% load
0.847	Lb per Million Btus of Fuel Input	<90% load

### ***3-01-013-02 Industrial Processes - Chemical Manufacturing - Nitric Acid - Absorber Tail Gas (Post-1970 Facilities)***

#### **Nitrogen oxides (NOx)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
10	Lb per Tons of Pure Acid Produced	High strength acid plant
57	Lb per Tons of Pure Acid Produced	Weak acid plant

## SCCs With Multiple Emission Factors

### 3-01-018-17 Industrial Processes - Chemical Manufacturing - Plastics Production - General

#### Volatile organic compounds (VOC)

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.1	Lb per Tons of Product Produced	Continuous Process Polystyrene. Styrene recovery unit condenser vent. Emission factor is for plants using vacuum pumps.
0.1	Lb per Tons of Product Produced	Continuous Process Polystyrene. Devolatilizer condenser vent. Emission factor is for plants using vacuum pumps.
0.106	Lb per Tons of Product Produced	In-situ Process Expandable Polystyrene. Holding tank vents.
10.74	Lb per Tons of Product Produced	In-situ Process Expandable Polystyrene. Entire Plant.
1.2 - 5	Lb per Tons of Product Produced	Batch Process Polystyrene. Entire plant.
0.014	Lb per Tons of Product Produced	Continuous Process Polystyrene. Other storage, high impact polystyrene.
0.16	Lb per Tons of Product Produced	Continuous Process Polystyrene. Styrene monomer storage.
0.016	Lb per Tons of Product Produced	In-situ Process Expandable Polystyrene. Product improvement vents.
0.016	Lb per Tons of Product Produced	Continuous Process Polystyrene. Dissolvers.
0.016	Lb per Tons of Product Produced	Continuous Process Polystyrene. Other storage, general purpose polystyrene.
0.18	Lb per Tons of Product Produced	Batch Process Polystyrene. Monomer storage and feed dissolver tanks. Emission factor is based on fixed roof design.
0.02	Lb per Tons of Product Produced	Continuous Process Polystyrene. Extruder quench vent. For plants using vacuum pumps.

## SCCs With Multiple Emission Factors

### Volatile organic compounds (VOC)

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.002	Lb per Tons of Product Produced	Continuous Process Polystyrene. Additives storage, high impact polystyrene.
0.002	Lb per Tons of Product Produced	Continuous Process Polystyrene. Ethylbenzene storage.
2.18	Lb per Tons of Product Produced	In-situ Process Expandable Polystyrene. Reactor vents.
0.24 - 2.7	Lb per Tons of Product Produced	Batch Process Polystyrene. Reactor vent drum vent. The higher factor is more likely during the manufacture of lower molecular weight products. Factor for any given process train will change with product grade.
0.26	Lb per Tons of Product Produced	Continuous Process Polystyrene. Styrene recovery unit condenser vent. Emission factor is for plants using steam jets.
0.26	Lb per Tons of Product Produced	In-situ Process Expandable Polystyrene. Mix tank vents.
2.6	Lb per Tons of Product Produced	In-situ Process Expandable Polystyrene. Storage vents and conveying losses.
0.3	Lb per Tons of Product Produced	Continuous Process Polystyrene. Extruder quench vent. For plants using steam jets.
0.3 - 0.6	Lb per Tons of Product Produced	Batch Process Polystyrene. Extruder quench vent. The higher factor is more likely during the manufacture of lower molecular weight products. Factor for any given process train will change with product grade.
0.004	Lb per Tons of Product Produced	Continuous Process Polystyrene. Additives storage, general purpose polystyrene.
0.004	Lb per Tons of Product Produced	Batch Process Polystyrene. Devolatilizer condensate tanks. Emission factor is based on fixed roof design.
0.42	Lb per Tons of Product Produced	Continuous Process Polystyrene. Entire plant. Emission factor is for plants using vacuum pumps.

### ***SCCs With Multiple Emission Factors***

#### **Volatile organic compounds (VOC)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.046	Lb per Tons of Product Produced	In-situ Process Expandable Polystyrene. Wash tank vents.
0.048 - 0.6	Lb per Tons of Product Produced	Continuous Process Polystyrene. Vacuum system. Lower value based on facility using refrigerated condensers as well as conventional cooling water exchangers; vacuum pumps in use. Higher value for facility using vacuum pumps.
0.5 - 1.5	Lb per Tons of Product Produced	Batch Process Polystyrene. Devolatilizer condenser vent. The higher factor is more likely during the manufacture of lower molecular weight products. Factor for any given process train will change with product grade.
5.54	Lb per Tons of Product Produced	In-situ Process Expandable Polystyrene. Dryer vents.
5.92	Lb per Tons of Product Produced	Continuous Process Polystyrene. Devolatilizer condenser vent. Emission factor is for plants using steam jets.
6.68	Lb per Tons of Product Produced	Continuous Process Polystyrene. Entire plant. Emission factor is for plants using steam jets.

### ***3-01-018-99 Industrial Processes - Chemical Manufacturing - Plastics Production - Others Not Specified***

#### **PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.33	Lb per Tons of Product Produced	Poly(ethylene terephthalate) (PET) production from dimethyl terephthalate (DMT). Storage of DMT.
0.34	Lb per Tons of Product Produced	Poly(ethylene terephthalate) (PET) production from dimethyl terephthalate (DMT). Total Plant.

### ***3-01-018-99 Industrial Processes - Chemical Manufacturing - Plastics Production - Others Not Specified***

#### **Volatile organic compounds (VOC)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.01	Lb per Tons of Product Produced	Poly(ethylene terephthalate) (PET) production from dimethyl terephthalate (DMT) or from terephthalic acid (TPA). Prepolymerizer reactor vacuum system.

## SCCs With Multiple Emission Factors

### Volatile organic compounds (VOC)

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.001	Lb per Tons of Product Produced	Poly(ethylene terephthalate) (PET) production from dimethyl terephthalate (DMT) or from terephthalic acid (TPA). Ethylene glycol recovery vacuum system.
1.46 - 7.8	Lb per Tons of Product Produced	Poly(ethylene terephthalate) (PET) production from dimethyl terephthalate (DMT). Entire plant. Lower value of range reflects emissions where spray condensers are used off the prepolymerizers and the polymerization reactors. Upper value reflects emissions where condensers are not used.
0.018	Lb per Tons of Product Produced	Poly(ethylene terephthalate) (PET) production from dimethyl terephthalate (DMT) or from terephthalic acid (TPA). Prepolymerizer vacuum system.
0.0018	Lb per Tons of Product Produced	Poly(ethylene terephthalate) (PET) production from dimethyl terephthalate (DMT) or from terephthalic acid (TPA). Ethylene glycol process tanks.
0.2	Lb per Tons of Product Produced	Poly(ethylene terephthalate) (PET) production from dimethyl terephthalate (DMT) or from terephthalic acid (TPA). Raw material storage.
0.02	Lb per Tons of Product Produced	Poly(ethylene terephthalate) (PET) production from dimethyl terephthalate (DMT). Ethylene glycol recovery condenser.
0.4 - 6.8	Lb per Tons of Product Produced	Poly(ethylene terephthalate) (PET) production from dimethyl terephthalate (DMT). Cooling Tower. Lower end of range reflects emissions where spray condensers are used off the prepolymerizers and the polymerization reactors; upper value reflects emissions where condensers were not used.
0.04	Lb per Tons of Product Produced	Poly(ethylene terephthalate) (PET) production from dimethyl terephthalate (DMT). Sludge storage and handling.
0.6	Lb per Tons of Product Produced	Poly(ethylene terephthalate) (PET) production from dimethyl terephthalate (DMT). Methanol recovery system.
0.72 - 7.2	Lb per Tons of Product Produced	Poly(ethylene terephthalate) (PET) production from terephthalic acid (TPA). Entire process. Lower value reflects emissions where spray condensers are used off all prepolymerizers and polymerizations reactors. Upper value reflects emissions where spray condensers are not used.
0.08	Lb per Tons of Product Produced	Poly(ethylene terephthalate) (PET) production from terephthalic acid (TPA). Esterification.

### ***SCCs With Multiple Emission Factors***

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#### ***3-01-024-02 Industrial Processes - Chemical Manufacturing - Synthetic Organic Fiber Manufacturing - Polyesters: Staple***

##### **Volatile organic compounds (VOC)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.1	Lb per Tons of Fiber Produced	Polyester, melt spun, yarn. Emissions are in aerosol form.
1.2	Lb per Tons of Fiber Produced	Polyester, melt spun, staple. Emissions are in aerosol form.

#### ***3-01-024-10 Industrial Processes - Chemical Manufacturing - Synthetic Organic Fiber Manufacturing - Acrylic: Uncontrolled***

##### **Volatile organic compounds (VOC)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
13.5	Lb per Tons of Product Produced	Acrylic and modacrylic wet spun After solvent recovery from the spinning, washing, and drawing up stages.
250	Lb per Tons of Product Produced	Modacrylic, dry spun
41.4	Lb per Tons of Product Produced	Acrylic, inorganic wet spun, homopolymer
5.5	Lb per Tons of Product Produced	Acrylic, inorganic wet spun, copolymer
80	Lb per Tons of Product Produced	Acrylic, dry spun

#### ***3-01-024-99 Industrial Processes - Chemical Manufacturing - Synthetic Organic Fiber Manufacturing - Other Not Classified***

##### **PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
1	Lb per Tons of Material Produced	Nylon 66, melt spun For plants with spinning equipment cleaning operations.
0.02	Lb per Tons of Material Produced	Nylon 6, melt spun, staple
0.02	Lb per Tons of Material Produced	Polyolefin, melt spun

### ***SCCs With Multiple Emission Factors***

#### ***3-01-024-99 Industrial Processes - Chemical Manufacturing - Synthetic Organic Fiber Manufacturing - Other Not Classified***

##### **Volatile organic compounds (VOC)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
10	Lb per Tons of Material Produced	Polyolefin, melt spun
224	Lb per Tons of Material Produced	Cellulose acetate filter tow
300	Lb per Tons of Material Produced	Vinyon, dry spun After recovery from spin cells.
398	Lb per Tons of Material Produced	Cellulose acetate and triacetate filament yarn
4.26	Lb per Tons of Material Produced	Nylon 66, melt spun
7.86	Lb per Tons of Material Produced	Nylon 6, melt spun, staple
8.46	Lb per Tons of Material Produced	Spandex, dry spun After recovery from spin cells.
0.9	Lb per Tons of Material Produced	Nylon 6, melt spun, yarn After recovery of emissions from the spin cells.

#### ***3-01-900-99 Industrial Processes - Chemical Manufacturing - Fuel Fired Equipment - Specify in Comments Field***

##### **Carbon monoxide**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
245	Lb per Tons of Carbon Black Produced	Carbon black manufacture, oil furnace process.
0.37	Lb per Million Btus of Heat Input	Industrial flares. Emission factor based on tests using crude propylene containing 80% propylene and 20% propane.

#### ***3-01-900-99 Industrial Processes - Chemical Manufacturing - Fuel Fired Equipment - Specify in Comments Field***

##### **PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0 - 27.4	Lb per Million Btus of Heat Input	Industrial flares. Emission factor based on tests using crude propylene containing 80% propylene and 20% propane. Measured as "soot".
2.7	Lb per Tons of Carbon Black Produced	Carbon black manufacture, oil furnace process.

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**SCCs With Multiple Emission Factors**

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**3-02-007-11 Industrial Processes - Food and Agriculture - Grain Millings - Durum Milling: Grain Receiving****PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.18	Lb per Tons of Grain Received	Grain receiving - Straight truck
0.032	Lb per Tons of Grain Received	Grain receiving - Railcar
0.035	Lb per Tons of Grain Received	Grain receiving - Hopper truck

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**3-02-007-11 Industrial Processes - Food and Agriculture - Grain Millings - Durum Milling: Grain Receiving****PM10, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.059	Lb per Tons of Grain Received	Grain receiving - Straight truck
0.0078	Lb per Tons of Grain Received	Grain receiving - Railcar
0.0078	Lb per Tons of Grain Received	Grain receiving - Hopper truck

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**3-02-007-21 Industrial Processes - Food and Agriculture - Grain Millings - Rye: Grain Receiving****PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.18	Lb per Tons of Grain Received	Grain receiving - Straight truck
0.032	Lb per Tons of Grain Received	Grain receiving - Railcar
0.035	Lb per Tons of Grain Received	Grain receiving - Hopper truck

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**3-02-007-21 Industrial Processes - Food and Agriculture - Grain Millings - Rye: Grain Receiving****PM10, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.059	Lb per Tons of Grain Received	Grain receiving - Straight truck
0.0078	Lb per Tons of Grain Received	Grain receiving - Railcar
0.0078	Lb per Tons of Grain Received	Grain receiving - Hopper truck



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**SCCs With Multiple Emission Factors**

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**3-02-007-31 Industrial Processes - Food and Agriculture - Grain Millings - Wheat: Grain Receiving****PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.18	Lb per Tons of Grain Received	Grain receiving - Straight truck
0.032	Lb per Tons of Grain Received	Grain receiving - Railcar
0.035	Lb per Tons of Grain Received	Grain receiving - Hopper truck

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**3-02-007-31 Industrial Processes - Food and Agriculture - Grain Millings - Wheat: Grain Receiving****PM10, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.059	Lb per Tons of Grain Received	Grain receiving - Straight truck
0.0078	Lb per Tons of Grain Received	Grain receiving - Hopper truck
0.0078	Lb per Tons of Grain Received	Grain receiving - Railcar

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**3-02-007-41 Industrial Processes - Food and Agriculture - Grain Millings - Dry Corn Milling: Grain Receiving****PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.18	Lb per Tons of Grain Received	Grain receiving - Straight truck
0.032	Lb per Tons of Grain Received	Grain receiving - Railcar
0.035	Lb per Tons of Grain Received	Grain receiving - Hopper truck

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**3-02-007-41 Industrial Processes - Food and Agriculture - Grain Millings - Dry Corn Milling: Grain Receiving****PM10, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.059	Lb per Tons of Grain Received	Grain receiving - Straight truck
0.0078	Lb per Tons of Grain Received	Grain receiving - Railcar
0.0078	Lb per Tons of Grain Received	Grain receiving - Hopper truck

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**SCCs With Multiple Emission Factors**

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**3-02-007-42 Industrial Processes - Food and Agriculture - Grain Millings - Dry Corn Milling: Grain Drying****PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.22	Lb per Tons of Grain Processed	Column dryer
3	Lb per Tons of Grain Processed	Rack dryer

**3-02-007-42 Industrial Processes - Food and Agriculture - Grain Millings - Dry Corn Milling: Grain Drying****PM10, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.055	Lb per Tons of Grain Processed	Column dryer
0.75	Lb per Tons of Grain Processed	Rack dryer

**3-02-007-60 Industrial Processes - Food and Agriculture - Grain Millings - Oat: General****PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.18	Lb per Tons of Grain Received	Grain receiving - Straight truck
0.032	Lb per Tons of Grain Received	Grain receiving - Railcar
0.035	Lb per Tons of Grain Received	Grain receiving - Hopper truck

**3-02-007-60 Industrial Processes - Food and Agriculture - Grain Millings - Oat: General****PM10, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.059	Lb per Tons of Grain Received	Grain receiving - Straight truck
0.0078	Lb per Tons of Grain Received	Grain receiving - Hopper truck
0.0078	Lb per Tons of Grain Received	Grain receiving - Railcar

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**SCCs With Multiple Emission Factor**

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**3-03-003-04 Industrial Processes - Primary Metal Production - By-product Coke Manufacturing - Quenching****PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
1.13	Lb per Tons of Coke Produced	Quenching was done using clean water.
1.3	Lb per Tons of Coke Produced	The emission factor was derived during quenching with baffles using dirty water.
5.24	Lb per Tons of Coke Produced	Quenching was done using dirty water.
0.54	Lb per Tons of Coke Produced	The emission factor was derived during quenching with baffles using clean water.

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**3-03-003-04 Industrial Processes - Primary Metal Production - By-product Coke Manufacturing - Quenching****PM10, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
1.2	Lb per Tons of Material Processed	Dirty water.
0.34	Lb per Tons of Material Processed	Clean water.

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**3-03-003-17 Industrial Processes - Primary Metal Production - By-product Coke Manufacturing - Combustion Stack: Coke Oven Gas (COG)****Sulfur oxides (SOx)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.28	Lb per Tons of Coke Produced	Desulfurized COG combustion stack.
4	Lb per Tons of Coke Produced	Raw COG combustion stack.

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**3-03-006-01 Industrial Processes - Primary Metal Production - Ferroalloy, Open Furnace - 50% FeSi: Electric Smelting Furnace****PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
70	Lb per Tons of Material Produced	Open furnace. Includes fumes captured by tapping hood (efficiency estimated at near 100%).
92	Lb per Tons of Material Produced	Covered furnace.

### ***SCCs With Multiple Emission Factors***

#### ***3-03-006-02 Industrial Processes - Primary Metal Production - Ferroalloy, Open Furnace - 75% FeSi: Electric Smelting Furnace***

##### **PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
206	Lb per Tons of Material Produced	Covered furnace. Does not include emissions from tapping or mix seal leaks.
316	Lb per Tons of Material Produced	Open furnace.

#### ***3-03-007-01 Industrial Processes - Primary Metal Production - Semi-covered Furnace - Ferromanganese: Electric Arc Furnace***

##### **PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
12	Lb per Tons of Material Produced	Covered furnace. Includes tapping fumes and mix seal leak fugitive emissions. Fugitive emissions measured at 33% of total uncontrollable emissions.
74	Lb per Tons of Material Produced	Sealed furnace. Assumes tapping not included in emission factor.

#### ***3-03-023-51 Industrial Processes - Primary Metal Production - Taconite Iron Ore Processing - Induration: Grate/Kiln, Gas-fired, Acid Pellets***

##### **Volatile organic compounds (VOC)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.0037	Lb per Tons of Pellets Produced	Based on Method 25A data.
0.075	Lb per Tons of Pellets Produced	Based on Method 25 data.

#### ***3-03-023-52 Industrial Processes - Primary Metal Production - Taconite Iron Ore Processing - Induration: Grate/Kiln, Gas-fired, Flux Pellets***

##### **Volatile organic compounds (VOC)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.0037	Lb per Tons of Pellets Produced	Based on Method 25A data.
0.075	Lb per Tons of Pellets Produced	Based on Method 25 data.

### ***SCCs With Multiple Emission Factors***

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#### ***3-03-024-04 Industrial Processes - Primary Metal Production - Metal Mining (General Processes) - Material Handling: Low Moisture Ore***

##### **PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
1.1	Lb per Tons of Ore Processed	Bauxite/alumina. Based on weight of material transferred.
0.12	Lb per Tons of Ore Processed	All minerals except bauxite. Based on weight of material transferred.

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#### ***3-04-003-01 Industrial Processes - Secondary Metal Production - Grey Iron Foundries - Cupola***

##### **PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
11.55	Lb per Tons of Metal Charged	Confidential Report No. ERC-116
13.8	Lb per Tons of Metal Charged	EPA. September 1985. In: Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Fourth Edition with Supplements A, B, and C, AP-42.

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#### ***3-05-003-02 Industrial Processes - Mineral Products - Brick Manufacture - Raw Material Grinding & Screening***

##### **PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.025	Lb per Tons of Raw Material Processed	Processing wet material.
8.5	Lb per Tons of Raw Material Processed	Processing dry material.

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#### ***3-05-003-02 Industrial Processes - Mineral Products - Brick Manufacture - Raw Material Grinding & Screening***

##### **PM10, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.0023	Lb per Tons of Raw Material Processed	Processing wet material.
0.53	Lb per Tons of Raw Material Processed	Processing dry material.

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**SCCs With Multiple Emission Factors**

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**3-05-012-04 Industrial Processes - Mineral Products - Fiberglass Manufacturing - Forming: Rotary Spun (Wool-type Fiber)****PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
36.21	Lb per Tons of Fiber Produced	R-19.
39.21	Lb per Tons of Fiber Produced	R-11.
55.42	Lb per Tons of Fiber Produced	Ductboard.
9.81	Lb per Tons of Fiber Produced	Heavy density.

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**5-01-005-08 Waste Disposal - Solid Waste Disposal - Government - Other Incineration - Conical Design (Tee Pee) Wood Refuse****PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
1	Lb per Tons of Wood Refuse Burned	Satisfactory operation: properly maintained burner with adjustable underfire air supply and adjustable, tangential overfire air inlets, approximately 500% excess air and 700 degrees F exit gas temperature. Moisture content as fired is approximately 50% for wood waste.
20	Lb per Tons of Wood Refuse Burned	Very unsatisfactory operation: improperly maintained burner with radial overfire air supply near bottom of shell and many gaping holes in shell, approximately 1500% excess air and 400 degrees F exit gas temperature. Moisture content as fired is approximately 50% for wood waste.
7	Lb per Tons of Wood Refuse Burned	Unsatisfactory operation: properly maintained burner with radial overfire air supply near bottom of shell, approximately 1200% excess air and 400 degrees F exit gas temperature. Moisture content as fired is approximately 50% for wood waste.

## ***SCCs With Multiple Emission Factors***

### ***5-03-002-03 Waste Disposal - Solid Waste Disposal - Industrial - Open Burning - Auto Body Components***

#### **Carbon monoxide**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
125	Lb per Tons of Material Burned	From AP-42 Section 2.5 Open Burning
2.5	Lb per Each of Vehicle Burned	From AP-42 Section 2.6 Automobile Body Incineration.

### ***5-03-002-03 Waste Disposal - Solid Waste Disposal - Industrial - Open Burning - Auto Body Components***

#### **Lead**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.0002	Lb per Tons of Material Burned	Shredded automobile tires.
0.00067	Lb per Tons of Material Burned	Chunk automobile tires.

### ***5-03-002-03 Waste Disposal - Solid Waste Disposal - Industrial - Open Burning - Auto Body Components***

#### **Nitrogen oxides (NOx)**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
0.1	Lb per Each of Vehicle Burned	From AP-42 Section 2.6 Automobile Body Incineration
4	Lb per Tons of Material Burned	From AP-42 Section 2.5 Open Burning

### ***5-03-002-03 Waste Disposal - Solid Waste Disposal - Industrial - Open Burning - Auto Body Components***

#### **PM, filterable**

Emission Factor	Emission Factor Units	Reason for SCC-Pollutant Duplicate
100	Lb per Tons of Material Burned	From AP-42 Section 2.5 Open Burning
2	Lb per Each of Vehicle Burned	From AP-42 Section 2.6 Automobile Body Incineration

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# **APPENDIX D**

## **SCCs WITH MULTIPLE SIC LINKINGS**

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The following pages list six-digit SCCs that link to multiple SIC Codes; these could not be listed in Appendix A due to space limitations

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
3-05-041	<i>Industrial Processes: Mineral Products - Clay processing: Kaolin</i>		3-05-044	<i>Industrial Processes: Mineral Products - Clay processing: Bentonite</i>	
	1450	Clay, Ceramic, & Refractory Minerals		1450	Clay, Ceramic, & Refractory Minerals
	1455	Kaolin And Ball Clay		1459	Clay And Related Minerals, Nec
	1459	Clay And Related Minerals, Nec		3200	Stone, Clay, And Glass Products
	3200	Stone, Clay, And Glass Products		3250	Structural Clay Products
	3250	Structural Clay Products		3251	Brick And Structural Clay Tile
	3251	Brick And Structural Clay Tile		3253	Ceramic Wall And Floor Tile
	3253	Ceramic Wall And Floor Tile		3255	Clay Refractories
	3255	Clay Refractories		3259	Structural Clay Products, Nec
	3259	Structural Clay Products, Nec		3260	Pottery And Related Products
	3260	Pottery And Related Products		3261	Vitreous Plumbing Fixtures
	3261	Vitreous Plumbing Fixtures		3262	Vitreous China Table & Kitchenware
	3262	Vitreous China Table & Kitchenware		3263	Semivitreous Table & Kitchenware
	3263	Semivitreous Table & Kitchenware		3264	Porcelain Electrical Supplies
	3264	Porcelain Electrical Supplies		3269	Pottery Products, Nec
	3269	Pottery Products, Nec			
3-05-042	<i>Industrial Processes: Mineral Products - Clay processing: Ball clay</i>		3-05-045	<i>Industrial Processes: Mineral Products - Clay processing: Fuller's earth</i>	
	1450	Clay, Ceramic, & Refractory Minerals		1450	Clay, Ceramic, & Refractory Minerals
	1455	Kaolin And Ball Clay		1459	Clay And Related Minerals, Nec
	1459	Clay And Related Minerals, Nec		3200	Stone, Clay, And Glass Products
	3200	Stone, Clay, And Glass Products		3250	Structural Clay Products
	3250	Structural Clay Products		3251	Brick And Structural Clay Tile
	3251	Brick And Structural Clay Tile		3253	Ceramic Wall And Floor Tile
	3253	Ceramic Wall And Floor Tile		3255	Clay Refractories
	3255	Clay Refractories		3259	Structural Clay Products, Nec
	3259	Structural Clay Products, Nec		3260	Pottery And Related Products
	3260	Pottery And Related Products		3261	Vitreous Plumbing Fixtures
	3261	Vitreous Plumbing Fixtures		3262	Vitreous China Table & Kitchenware
	3262	Vitreous China Table & Kitchenware		3263	Semivitreous Table & Kitchenware
	3263	Semivitreous Table & Kitchenware		3264	Porcelain Electrical Supplies
	3264	Porcelain Electrical Supplies		3269	Pottery Products, Nec
	3269	Pottery Products, Nec			
3-05-043	<i>Industrial Processes: Mineral Products - Clay processing: Fire clay</i>		3-05-046	<i>Industrial Processes: Mineral Products - Clay processing: Common clay and shale, NEC</i>	
	1450	Clay, Ceramic, & Refractory Minerals		1450	Clay, Ceramic, & Refractory Minerals
	1459	Clay And Related Minerals, Nec		1459	Clay And Related Minerals, Nec
	3200	Stone, Clay, And Glass Products		3200	Stone, Clay, And Glass Products
	3250	Structural Clay Products		3250	Structural Clay Products
	3251	Brick And Structural Clay Tile		3251	Brick And Structural Clay Tile
	3253	Ceramic Wall And Floor Tile		3253	Ceramic Wall And Floor Tile
	3255	Clay Refractories		3255	Clay Refractories
	3259	Structural Clay Products, Nec		3259	Structural Clay Products, Nec
	3260	Pottery And Related Products		3260	Pottery And Related Products
	3261	Vitreous Plumbing Fixtures		3261	Vitreous Plumbing Fixtures
	3262	Vitreous China Table & Kitchenware		3262	Vitreous China Table & Kitchenware
	3263	Semivitreous Table & Kitchenware		3263	Semivitreous Table & Kitchenware
	3264	Porcelain Electrical Supplies		3264	Porcelain Electrical Supplies
	3269	Pottery Products, Nec		3269	Pottery Products, Nec

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

Six-Digit SCC	SIC Code	SIC Description	Six-Digit SCC	SIC Code	SIC Description
3-06-999	Industrial Processes: Petroleum Industry - Petroleum Products - Not Classified			2869	Industrial Organic Chemicals, Nec
	1222	Bituminous Coal Underground		3312	Blast Furnaces And Steel Mills
	1311	Crude Petroleum And Natural Gas		3511	Turbines And Turbine Generator Sets
	1321	Natural Gas Liquids		3699	Electrical Equipment & Supplies, Nec
	2813	Industrial Gases		4911	Electric Services
	2819	Industrial Inorganic Chemicals, Nec	3-90-001	Industrial Processes: In-process Fuel Use - Anthracite Coal	
	2821	Plastics Materials And Resins		2621	Paper Mills
	2842	Polishes And Sanitation Goods		3251	Brick And Structural Clay Tile
	2865	Cyclic Crudes And Intermediates		3295	Minerals, Ground Or Treated
	2869	Industrial Organic Chemicals, Nec		3531	Construction Machinery
	2891	Adhesives And Sealants		4911	Electric Services
	2892	Explosives	7389	Business Services, Nec	
	2911	Petroleum Refining	8734	Testing Laboratories	
	2992	Lubricating Oils And Greases	3-90-002	Industrial Processes: In-process Fuel Use - Bituminous Coal	
	2999	Petroleum And Coal Products, Nec		1011	Iron Ores
	3011	Tires And Inner Tubes		1221	Bituminous Coal And Lignite Surface
	3089	Plastics Products, Nec		1422	Crushed And Broken Limestone
	3275	Gypsum Products		1459	Clay And Related Minerals, Nec
	4226	Special Warehousing And Storage, Nec		1474	Potash, Soda, And Borate Minerals
	4613	Refined Petroleum Pipelines		1499	Miscellaneous Nonmetallic Minerals
	4911	Electric Services		2063	Beet Sugar
	4922	Natural Gas Transmission		2819	Industrial Inorganic Chemicals, Nec
	5153	Grain And Field Beans		2874	Phosphatic Fertilizers
	5171	Petroleum Bulk Stations & Terminals	2951	Asphalt Paving Mixtures And Blocks	
	5172	Petroleum Products, Nec	2999	Petroleum And Coal Products, Nec	
	5984	Liquefied Petroleum Gas Dealers	3241	Cement, Hydraulic	
	7538	General Automotive Repair Shops	3251	Brick And Structural Clay Tile	
3-08-010	Industrial Processes: Rubber and Miscellaneous Plastics Products - Plastic Products Manufacturing		3271	Concrete Block And Brick	
	2531	Public Building & Related Furniture	3272	Concrete Products, Nec	
	2631	Paperboard Mills	3274	Lime	
	2821	Plastics Materials And Resins	3295	Minerals, Ground Or Treated	
	2851	Paints And Allied Products	3299	Nonmetallic Mineral Products, Nec	
	2891	Adhesives And Sealants	3341	Secondary Nonferrous Metals	
	3053	Gaskets, Packing And Sealing Devices	3999	Manufacturing Industries, Nec	
	3069	Fabricated Rubber Products, Nec	7389	Business Services, Nec	
	3081	Unsupported Plastics Film & Sheet	8711	Engineering Services	
	3085	Plastics Bottles	3-90-004	Industrial Processes: In-process Fuel Use - Residual Oil	
	3086	Plastics Foam Products		0723	Crop Preparation Services For Market
	3087	Custom Compound Purchased Resins		1011	Iron Ores
	3089	Plastics Products, Nec		1422	Crushed And Broken Limestone
	3231	Products Of Purchased Glass		1423	Crushed And Broken Granite
	3465	Automotive Stampings		1446	Industrial Sand
	3471	Plating And Polishing		1459	Clay And Related Minerals, Nec
	3496	Misc. Fabricated Wire Products		1499	Miscellaneous Nonmetallic Minerals
	3531	Construction Machinery		1611	Highway And Street Construction
	3544	Special Dies, Tools, Jigs & Fixtures		2037	Frozen Fruits And Vegetables
	3643	Current-carrying Wiring Devices	2046	Wet Corn Milling	
	3711	Motor Vehicles And Car Bodies	2063	Beet Sugar	
	3714	Motor Vehicle Parts And Accessories	2082	Malt Beverages	
	3873	Watches, Clocks, Watchcases & Parts	2092	Fresh Or Frozen Prepared Fish	
	3944	Games, Toys, And Children's Vehicles	2099	Food Preparations, Nec	
	3999	Manufacturing Industries, Nec	2262	Finishing Plants, Manmade	
	6512	Nonresidential Building Operators	2281	Yarn Spinning Mills	
3-85-001	Industrial Processes: Cooling Tower - Process Cooling		2436	Softwood Veneer And Plywood	
	2061	Raw Cane Sugar	2611	Pulp Mills	
	2821	Plastics Materials And Resins			
	2822	Synthetic Rubber			

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	2631	Paperboard Mills		2621	Paper Mills
	2679	Converted Paper Products, Nec		2679	Converted Paper Products, Nec
	2819	Industrial Inorganic Chemicals, Nec		2752	Commercial Printing, Lithographic
	2821	Plastics Materials And Resins		2816	Inorganic Pigments
	2824	Organic Fibers, Noncellulosic		2819	Industrial Inorganic Chemicals, Nec
	2833	Medicinals And Botanicals		2821	Plastics Materials And Resins
	2873	Nitrogenous Fertilizers		2824	Organic Fibers, Noncellulosic
	2874	Phosphatic Fertilizers		2833	Medicinals And Botanicals
	2895	Carbon Black		2841	Soap And Other Detergents
	2899	Chemical Preparations, Nec		2843	Surface Active Agents
	2911	Petroleum Refining		2851	Paints And Allied Products
	2951	Asphalt Paving Mixtures And Blocks		2861	Gum And Wood Chemicals
	2952	Asphalt Felts And Coatings		2865	Cyclic Crudes And Intermediates
	3086	Plastics Foam Products		2869	Industrial Organic Chemicals, Nec
	3221	Glass Containers		2873	Nitrogenous Fertilizers
	3241	Cement, Hydraulic		2874	Phosphatic Fertilizers
	3255	Clay Refractories		2911	Petroleum Refining
	3274	Lime		2951	Asphalt Paving Mixtures And Blocks
	3275	Gypsum Products		2952	Asphalt Felts And Coatings
	3295	Minerals, Ground Or Treated		2992	Lubricating Oils And Greases
	3297	Nonclay Refractories		2999	Petroleum And Coal Products, Nec
	3312	Blast Furnaces And Steel Mills		3069	Fabricated Rubber Products, Nec
	3341	Secondary Nonferrous Metals		3089	Plastics Products, Nec
	3357	Nonferrous Wiredrawing & Insulating		3211	Flat Glass
	3366	Copper Foundries		3221	Glass Containers
	3432	Plumbing Fixture Fittings And Trim		3241	Cement, Hydraulic
	3523	Farm Machinery And Equipment		3251	Brick And Structural Clay Tile
	3999	Manufacturing Industries, Nec		3255	Clay Refractories
	4911	Electric Services		3272	Concrete Products, Nec
	4953	Refuse Systems		3273	Ready-mixed Concrete
	5093	Scrap And Waste Materials		3274	Lime
	5171	Petroleum Bulk Stations & Terminals		3275	Gypsum Products
	8711	Engineering Services		3281	Cut Stone And Stone Products
	9711	National Security		3292	Asbestos Products
				3295	Minerals, Ground Or Treated
				3296	Mineral Wool
				3297	Nonclay Refractories
				3299	Nonmetallic Mineral Products, Nec
				3312	Blast Furnaces And Steel Mills
				3313	Electrometallurgical Products
				3316	Cold Finishing Of Steel Shapes
				3325	Steel Foundries, Nec
				3334	Primary Aluminum
				3339	Primary Nonferrous Metals, Nec
				3341	Secondary Nonferrous Metals
				3353	Aluminum Sheet, Plate, And Foil
				3354	Aluminum Extruded Products
				3357	Nonferrous Wiredrawing & Insulating
				3365	Aluminum Foundries
				3399	Primary Metal Products, Nec
				3423	Hand And Edge Tools, Nec
				3442	Metal Doors, Sash, And Trim
				3444	Sheet Metalwork
				3462	Iron And Steel Forgings
				3469	Metal Stampings, Nec
				3471	Plating And Polishing
				3479	Metal Coating And Allied Services
				3497	Metal Foil And Leaf
				3499	Fabricated Metal Products, Nec
				3524	Lawn And Garden Equipment
				3531	Construction Machinery
				3552	Textile Machinery
3-90-005	<i>Industrial Processes: In-process Fuel Use - Distillate Oil</i>				
	0723	Crop Preparation Services For Market			
	1011	Iron Ores			
	1411	Dimension Stone			
	1422	Crushed And Broken Limestone			
	1423	Crushed And Broken Granite			
	1429	Crushed And Broken Stone, Nec			
	1442	Construction Sand And Gravel			
	1446	Industrial Sand			
	1455	Kaolin And Ball Clay			
	1459	Clay And Related Minerals, Nec			
	1474	Potash, Soda, And Borate Minerals			
	1499	Miscellaneous Nonmetallic Minerals			
	1611	Highway And Street Construction			
	2022	Cheese, Natural And Processed			
	2023	Dry, Condensed, Evaporated Products			
	2041	Flour And Other Grain Mill Products			
	2046	Wet Corn Milling			
	2051	Bread, Cake, And Related Products			
	2062	Cane Sugar Refining			
	2077	Animal And Marine Fats And Oils			
	2099	Food Preparations, Nec			
	2431	Millwork			
	2493	Reconstituted Wood Products			
	2514	Metal Household Furniture			
	2611	Pulp Mills			

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

Six-Digit SCC	SIC Code	SIC Description	Six-Digit SCC	SIC Code	SIC Description
	3561	Pumps And Pumping Equipment		2035	Pickles, Sauces, And Salad Dressings
	3567	Industrial Furnaces And Ovens		2037	Frozen Fruits And Vegetables
	3575	Computer Terminals		2038	Frozen Specialties, Nec
	3579	Office Machines, Nec		2041	Flour And Other Grain Mill Products
	3621	Motors And Generators		2043	Cereal Breakfast Foods
	3639	Household Appliances, Nec		2044	Rice Milling
	3674	Semiconductors And Related Devices		2046	Wet Corn Milling
	3679	Electronic Components, Nec		2047	Dog And Cat Food
	3713	Truck And Bus Bodies		2048	Prepared Feeds, Nec
	3724	Aircraft Engines And Engine Parts		2051	Bread, Cake, And Related Products
	3731	Ship Building And Repairing		2052	Cookies And Crackers
	3743	Railroad Equipment		2061	Raw Cane Sugar
	3861	Photographic Equipment And Supplies		2062	Cane Sugar Refining
	3999	Manufacturing Industries, Nec		2063	Beet Sugar
	4011	Railroads, Line-haul Operating		2066	Chocolate And Cocoa Products
	4491	Marine Cargo Handling		2068	Salted And Roasted Nuts And Seeds
	4911	Electric Services		2074	Cottonseed Oil Mills
	4931	Electric And Other Services Combined		2075	Soybean Oil Mills
	4952	Sewerage Systems		2076	Vegetable Oil Mills, Nec
	4953	Refuse Systems		2077	Animal And Marine Fats And Oils
	5093	Scrap And Waste Materials		2082	Malt Beverages
	5153	Grain And Field Beans		2083	Malt
	5169	Chemicals & Allied Products, Nec		2085	Distilled And Blended Liquors
	5211	Lumber And Other Building Materials		2091	Canned And Cured Fish And Seafoods
	7532	Top & Body Repair & Paint Shops		2095	Roasted Coffee
	8062	General Medical & Surgical Hospitals		2096	Potato Chips And Similar Snacks
	8211	Elementary And Secondary Schools		2099	Food Preparations, Nec
	8221	Colleges And Universities		2111	Cigarettes
	9511	Air, Water, & Solid Waste Management		2211	Broadwoven Fabric Mills, Cotton
	9711	National Security		2221	Broadwoven Fabric Mills, Manmade
3-90-006	<i>Industrial Processes: In-process Fuel Use - Natural Gas</i>			2231	Broadwoven Fabric Mills, Wool
	0119	Cash Grains, Nec		2241	Narrow Fabric Mills
	0174	Citrus Fruits		2253	Knit Outerwear Mills
	0723	Crop Preparation Services For Market		2257	Weft Knit Fabric Mills
	0724	Cotton Ginning		2258	Lace & Warp Knit Fabric Mills
	1011	Iron Ores		2261	Finishing Plants, Cotton
	1041	Gold Ores		2262	Finishing Plants, Manmade
	1311	Crude Petroleum And Natural Gas		2269	Finishing Plants, Nec
	1321	Natural Gas Liquids		2273	Carpets And Rugs
	1389	Oil And Gas Field Services, Nec		2281	Yarn Spinning Mills
	1411	Dimension Stone		2284	Thread Mills
	1422	Crushed And Broken Limestone		2295	Coated Fabrics, Not Rubberized
	1423	Crushed And Broken Granite		2296	Tire Cord And Fabrics
	1429	Crushed And Broken Stone, Nec		2297	Nonwoven Fabrics
	1442	Construction Sand And Gravel		2299	Textile Goods, Nec
	1446	Industrial Sand		2329	Men's And Boys' Clothing, Nec
	1455	Kaolin And Ball Clay		2353	Hats, Caps, And Millinery
	1474	Potash, Soda, And Borate Minerals		2392	Housefurnishings, Nec
	1475	Phosphate Rock		2393	Textile Bags
	1499	Miscellaneous Nonmetallic Minerals		2396	Automotive And Apparel Trimmings
	1611	Highway And Street Construction		2421	Sawmills And Planing Mills, General
	1721	Painting And Paper Hanging		2429	Special Product Sawmills, Nec
	1799	Special Trade Contractors, Nec		2431	Millwork
	2011	Meat Packing Plants		2434	Wood Kitchen Cabinets
	2013	Sausages And Other Prepared Meats		2435	Hardwood Veneer And Plywood
	2021	Creamery Butter		2436	Softwood Veneer And Plywood
	2022	Cheese, Natural And Processed		2491	Wood Preserving
	2023	Dry, Condensed, Evaporated Products		2493	Reconstituted Wood Products
	2026	Fluid Milk		2499	Wood Products, Nec
	2033	Canned Fruits And Vegetables		2511	Wood Household Furniture
				2512	Upholstered Household Furniture
				2514	Metal Household Furniture

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	2521	Wood Office Furniture		3086	Plastics Foam Products
	2522	Office Furniture, Except Wood		3087	Custom Compound Purchased Resins
	2531	Public Building & Related Furniture		3089	Plastics Products, Nec
	2541	Wood Partitions And Fixtures		3111	Leather Tanning And Finishing
	2542	Partitions And Fixtures, Except Wood		3211	Flat Glass
	2591	Drapery Hardware & Blinds & Shades		3221	Glass Containers
	2599	Furniture And Fixtures, Nec		3229	Pressed And Blown Glass, Nec
	2611	Pulp Mills		3241	Cement, Hydraulic
	2621	Paper Mills		3251	Brick And Structural Clay Tile
	2631	Paperboard Mills		3253	Ceramic Wall And Floor Tile
	2653	Corrugated And Solid Fiber Boxes		3255	Clay Refractories
	2655	Fiber Cans, Drums & Similar Products		3259	Structural Clay Products, Nec
	2657	Folding Paperboard Boxes		3261	Vitreous Plumbing Fixtures
	2671	Paper Coated & Laminated, Packaging		3264	Porcelain Electrical Supplies
	2672	Paper Coated And Laminated, Nec		3269	Pottery Products, Nec
	2674	Bags: Uncoated Paper & Multiwall		3272	Concrete Products, Nec
	2675	Die-cut Paper And Board		3273	Ready-mixed Concrete
	2676	Sanitary Paper Products		3274	Lime
	2679	Converted Paper Products, Nec		3275	Gypsum Products
	2711	Newspapers		3281	Cut Stone And Stone Products
	2721	Periodicals		3291	Abrasive Products
	2731	Book Publishing		3292	Asbestos Products
	2732	Book Printing		3295	Minerals, Ground Or Treated
	2741	Miscellaneous Publishing		3296	Mineral Wool
	2752	Commercial Printing, Lithographic		3297	Nonclay Refractories
	2754	Commercial Printing, Gravure		3299	Nonmetallic Mineral Products, Nec
	2759	Commercial Printing, Nec		3312	Blast Furnaces And Steel Mills
	2796	Platemaking Services		3313	Electrometallurgical Products
	2812	Alkalies And Chlorine		3315	Steel Wire And Related Products
	2813	Industrial Gases		3316	Cold Finishing Of Steel Shapes
	2816	Inorganic Pigments		3317	Steel Pipe And Tubes
	2819	Industrial Inorganic Chemicals, Nec		3321	Gray And Ductile Iron Foundries
	2821	Plastics Materials And Resins		3322	Malleable Iron Foundries
	2822	Synthetic Rubber		3324	Steel Investment Foundries
	2823	Cellulosic Manmade Fibers		3325	Steel Foundries, Nec
	2824	Organic Fibers, Noncellulosic		3331	Primary Copper
	2833	Medicinals And Botanicals		3334	Primary Aluminum
	2834	Pharmaceutical Preparations		3339	Primary Nonferrous Metals, Nec
	2836	Biological Products Exc. Diagnostic		3341	Secondary Nonferrous Metals
	2841	Soap And Other Detergents		3351	Copper Rolling And Drawing
	2843	Surface Active Agents		3353	Aluminum Sheet, Plate, And Foil
	2851	Paints And Allied Products		3354	Aluminum Extruded Products
	2861	Gum And Wood Chemicals		3355	Aluminum Rolling And Drawing, Nec
	2865	Cyclic Crudes And Intermediates		3356	Nonferrous Rolling And Drawing, Nec
	2869	Industrial Organic Chemicals, Nec		3357	Nonferrous Wiredrawing & Insulating
	2873	Nitrogenous Fertilizers		3363	Aluminum Die-castings
	2874	Phosphatic Fertilizers		3364	Nonferrous Die-casting Exc. Aluminum
	2875	Fertilizers, Mixing Only		3365	Aluminum Foundries
	2879	Agricultural Chemicals, Nec		3366	Copper Foundries
	2891	Adhesives And Sealants		3369	Nonferrous Foundries, Nec
	2895	Carbon Black		3398	Metal Heat Treating
	2899	Chemical Preparations, Nec		3399	Primary Metal Products, Nec
	2911	Petroleum Refining		3411	Metal Cans
	2951	Asphalt Paving Mixtures And Blocks		3412	Metal Barrels, Drums, And Pails
	2952	Asphalt Felts And Coatings		3421	Cutlery
	2992	Lubricating Oils And Greases		3423	Hand And Edge Tools, Nec
	2999	Petroleum And Coal Products, Nec		3429	Hardware, Nec
	3053	Gaskets, Packing And Sealing Devices		3431	Metal Sanitary Ware
	3069	Fabricated Rubber Products, Nec		3432	Plumbing Fixture Fittings And Trim
	3081	Unsupported Plastics Film & Sheet		3433	Heating Equipment, Except Electric
	3082	Unsupported Plastics Profile Shapes		3441	Fabricated Structural Metal
	3085	Plastics Bottles		3442	Metal Doors, Sash, And Trim

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	3443	Fabricated Plate Work (boiler Shops)		3634	Electric Housewares And Fans
	3444	Sheet Metalwork		3639	Household Appliances, Nec
	3448	Prefabricated Metal Buildings		3641	Electric Lamps
	3449	Miscellaneous Metal Work		3643	Current-carrying Wiring Devices
	3451	Screw Machine Products		3644	Noncurrent-carrying Wiring Devices
	3452	Bolts, Nuts, Rivets, And Washers		3645	Residential Lighting Fixtures
	3462	Iron And Steel Forgings		3646	Commercial Lighting Fixtures
	3465	Automotive Stampings		3648	Lighting Equipment, Nec
	3466	Crowns And Closures		3661	Telephone And Telegraph Apparatus
	3469	Metal Stampings, Nec		3663	Radio & TV Communications Equipment
	3471	Plating And Polishing		3669	Communications Equipment, Nec
	3479	Metal Coating And Allied Services		3671	Electron Tubes
	3482	Small Arms Ammunition		3674	Semiconductors And Related Devices
	3489	Ordnance And Accessories, Nec		3679	Electronic Components, Nec
	3491	Industrial Valves		3691	Storage Batteries
	3492	Fluid Power Valves & Hose Fittings		3694	Engine Electrical Equipment
	3494	Valves And Pipe Fittings, Nec		3711	Motor Vehicles And Car Bodies
	3495	Wire Springs		3713	Truck And Bus Bodies
	3496	Misc. Fabricated Wire Products		3714	Motor Vehicle Parts And Accessories
	3497	Metal Foil And Leaf		3721	Aircraft
	3499	Fabricated Metal Products, Nec		3728	Aircraft Parts And Equipment, Nec
	3511	Turbines And Turbine Generator Sets		3731	Ship Building And Repairing
	3519	Internal Combustion Engines, Nec		3732	Boat Building And Repairing
	3523	Farm Machinery And Equipment		3743	Railroad Equipment
	3524	Lawn And Garden Equipment		3751	Motorcycles, Bicycles, And Parts
	3531	Construction Machinery		3795	Tanks And Tank Components
	3532	Mining Machinery		3799	Transportation Equipment, Nec
	3534	Elevators And Moving Stairways		3821	Laboratory Apparatus And Furniture
	3535	Conveyors And Conveying Equipment		3822	Environmental Controls
	3541	Machine Tools, Metal Cutting Types		3823	Process Control Instruments
	3542	Machine Tools, Metal Forming Types		3826	Analytical Instruments
	3543	Industrial Patterns		3841	Surgical And Medical Instruments
	3544	Special Dies, Tools, Jigs & Fixtures		3842	Surgical Appliances And Supplies
	3545	Machine Tool Accessories		3844	X-ray Apparatus And Tubes
	3546	Power-driven Handtools		3861	Photographic Equipment And Supplies
	3547	Rolling Mill Machinery		3911	Jewelry, Precious Metal
	3552	Textile Machinery		3914	Silverware And Plated Ware
	3553	Woodworking Machinery		3942	Dolls And Stuffed Toys
	3554	Paper Industries Machinery		3949	Sporting And Athletic Goods, Nec
	3559	Special Industry Machinery, Nec		3951	Pens And Mechanical Pencils
	3561	Pumps And Pumping Equipment		3955	Carbon Paper And Inked Ribbons
	3562	Ball And Roller Bearings		3993	Signs And Advertising Specialties
	3563	Air And Gas Compressors		3995	Burial Caskets
	3564	Blowers And Fans		3996	Hard Surface Floor Coverings, Nec
	3567	Industrial Furnaces And Ovens		3999	Manufacturing Industries, Nec
	3568	Power Transmission Equipment, Nec		4111	Local And Suburban Transit
	3569	General Industrial Machinery, Nec		4221	Farm Product Warehousing And Storage
	3571	Electronic Computers		4512	Air Transportation, Scheduled
	3572	Computer Storage Devices		4581	Airports, Flying Fields, & Services
	3579	Office Machines, Nec		4741	Rental Of Railroad Cars
	3585	Refrigeration And Heating Equipment		4911	Electric Services
	3589	Service Industry Machinery, Nec		4922	Natural Gas Transmission
	3596	Scales And Balances, Exc. Laboratory		4923	Gas Transmission And Distribution
	3599	Industrial Machinery, Nec		4924	Natural Gas Distribution
	3612	Transformers, Except Electronic		4925	Gas Production And/or Distribution
	3621	Motors And Generators		4939	Combination Utilities, Nec
	3624	Carbon And Graphite Products		4941	Water Supply
	3625	Relays And Industrial Controls		4952	Sewerage Systems
	3629	Electrical Industrial Apparatus, Nec		4953	Refuse Systems
	3631	Household Cooking Equipment		4961	Steam And Air-conditioning Supply
	3632	Household Refrigerators And Freezers		5039	Construction Materials, Nec
	3633	Household Laundry Equipment			



## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

Six-Digit SCC	SIC Code	SIC Description	Six-Digit SCC	SIC Code	SIC Description
	5078	Refrigeration Equipment And Supplies		4952	Sewerage Systems
	5085	Industrial Supplies		4953	Refuse Systems
	5088	Transportation Equipment & Supplies		5171	Petroleum Bulk Stations & Terminals
	5093	Scrap And Waste Materials		9511	Air, Water, & Solid Waste Management
	5111	Printing And Writing Paper			
	5142	Packaged Frozen Foods	3-90-008		<i>Industrial Processes: In-process Fuel Use - Coke</i>
	5149	Groceries And Related Products, Nec		1011	Iron Ores
	5153	Grain And Field Beans		2063	Beet Sugar
	5171	Petroleum Bulk Stations & Terminals		2421	Sawmills And Planing Mills, General
	5191	Farm Supplies		2493	Reconstituted Wood Products
	5511	New And Used Car Dealers		2621	Paper Mills
	5541	Gasoline Service Stations		2819	Industrial Inorganic Chemicals, Nec
	5699	Misc. Apparel & Accessory Stores		2869	Industrial Organic Chemicals, Nec
	6512	Nonresidential Building Operators		2911	Petroleum Refining
	6513	Apartment Building Operators		3241	Cement, Hydraulic
	7011	Hotels And Motels		3251	Brick And Structural Clay Tile
	7211	Power Laundries, Family & Commercial		3274	Lime
	7213	Linen Supply		3296	Mineral Wool
	7216	Drycleaning Plants, Except Rug		3321	Gray And Ductile Iron Foundries
	7218	Industrial Launderers		3339	Primary Nonferrous Metals, Nec
	7219	Laundry And Garment Services, Nec		3341	Secondary Nonferrous Metals
	7261	Funeral Service And Crematories		3714	Motor Vehicle Parts And Accessories
	7336	Commercial Art And Graphic Design		3999	Manufacturing Industries, Nec
	7389	Business Services, Nec		4911	Electric Services
	7532	Top & Body Repair & Paint Shops			
	7694	Armature Rewinding Shops	3-90-009		<i>Industrial Processes: In-process Fuel Use - Wood</i>
	7699	Repair Services, Nec		1011	Iron Ores
	8051	Skilled Nursing Care Facilities		1459	Clay And Related Minerals, Nec
	8062	General Medical & Surgical Hospitals		2013	Sausages And Other Prepared Meats
	8211	Elementary And Secondary Schools		2048	Prepared Feeds, Nec
	8221	Colleges And Universities		2063	Beet Sugar
	8699	Membership Organizations, Nec		2221	Broadwoven Fabric Mills, Manmade
	8711	Engineering Services		2231	Broadwoven Fabric Mills, Wool
	8731	Commercial Physical Research		2299	Textile Goods, Nec
	9223	Correctional Institutions		2421	Sawmills And Planing Mills, General
	9511	Air, Water, & Solid Waste Management		2429	Special Product Sawmills, Nec
	9711	National Security		2493	Reconstituted Wood Products
3-90-007		<i>Industrial Processes: In-process Fuel Use - Process Gas</i>		2499	Wood Products, Nec
	1311	Crude Petroleum And Natural Gas		2611	Pulp Mills
	2099	Food Preparations, Nec		2621	Paper Mills
	2395	Pleating And Stitching		2679	Converted Paper Products, Nec
	2813	Industrial Gases		2836	Biological Products Exc. Diagnostic
	2819	Industrial Inorganic Chemicals, Nec		2911	Petroleum Refining
	2865	Cyclic Crudes And Intermediates		3251	Brick And Structural Clay Tile
	2869	Industrial Organic Chemicals, Nec		3295	Minerals, Ground Or Treated
	2873	Nitrogenous Fertilizers		3296	Mineral Wool
	2895	Carbon Black		3339	Primary Nonferrous Metals, Nec
	2911	Petroleum Refining		3433	Heating Equipment, Except Electric
	3269	Pottery Products, Nec		3524	Lawn And Garden Equipment
	3312	Blast Furnaces And Steel Mills		3559	Special Industry Machinery, Nec
	3321	Gray And Ductile Iron Foundries		3999	Manufacturing Industries, Nec
	3357	Nonferrous Wire Drawing & Insulating		4952	Sewerage Systems
	3398	Metal Heat Treating		5153	Grain And Field Beans
	3585	Refrigeration And Heating Equipment		5812	Eating Places
	3599	Industrial Machinery, Nec	3-90-010		<i>Industrial Processes: In-process Fuel Use - Liquefied Petroleum Gas</i>
	3714	Motor Vehicle Parts And Accessories		0252	Chicken Eggs
	3999	Manufacturing Industries, Nec		0723	Crop Preparation Services For Market
	4789	Transportation Services, Nec		0724	Cotton Ginning
	4911	Electric Services		1011	Iron Ores
	4931	Electric And Other Services Combined		1041	Gold Ores

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	1422	Crushed And Broken Limestone		3341	Secondary Nonferrous Metals
	1446	Industrial Sand		3353	Aluminum Sheet, Plate, And Foil
	1611	Highway And Street Construction		3354	Aluminum Extruded Products
	2013	Sausages And Other Prepared Meats		3363	Aluminum Die-castings
	2015	Poultry Slaughtering And Processing		3399	Primary Metal Products, Nec
	2021	Creamery Butter		3411	Metal Cans
	2022	Cheese, Natural And Processed		3433	Heating Equipment, Except Electric
	2023	Dry, Condensed, Evaporated Products		3441	Fabricated Structural Metal
	2047	Dog And Cat Food		3444	Sheet Metalwork
	2048	Prepared Feeds, Nec		3448	Prefabricated Metal Buildings
	2051	Bread, Cake, And Related Products		3471	Plating And Polishing
	2052	Cookies And Crackers		3482	Small Arms Ammunition
	2068	Salted And Roasted Nuts And Seeds		3519	Internal Combustion Engines, Nec
	2075	Soybean Oil Mills		3523	Farm Machinery And Equipment
	2076	Vegetable Oil Mills, Nec		3524	Lawn And Garden Equipment
	2083	Malt		3554	Paper Industries Machinery
	2085	Distilled And Blended Liquors		3561	Pumps And Pumping Equipment
	2099	Food Preparations, Nec		3569	General Industrial Machinery, Nec
	2211	Broadwoven Fabric Mills, Cotton		3581	Automatic Vending Machines
	2221	Broadwoven Fabric Mills, Manmade		3599	Industrial Machinery, Nec
	2231	Broadwoven Fabric Mills, Wool		3621	Motors And Generators
	2241	Narrow Fabric Mills		3624	Carbon And Graphite Products
	2261	Finishing Plants, Cotton		3644	Noncurrent-carrying Wiring Devices
	2262	Finishing Plants, Manmade		3648	Lighting Equipment, Nec
	2273	Carpets And Rugs		3674	Semiconductors And Related Devices
	2281	Yarn Spinning Mills		3691	Storage Batteries
	2295	Coated Fabrics, Not Rubberized		3711	Motor Vehicles And Car Bodies
	2297	Nonwoven Fabrics		3713	Truck And Bus Bodies
	2392	Housefurnishings, Nec		3714	Motor Vehicle Parts And Accessories
	2421	Sawmills And Planing Mills, General		3715	Truck Trailers
	2426	Hardwood Dimension & Flooring Mills		3721	Aircraft
	2435	Hardwood Veneer And Plywood		3724	Aircraft Engines And Engine Parts
	2493	Reconstituted Wood Products		3728	Aircraft Parts And Equipment, Nec
	2499	Wood Products, Nec		3731	Ship Building And Repairing
	2522	Office Furniture, Except Wood		3799	Transportation Equipment, Nec
	2611	Pulp Mills		3841	Surgical And Medical Instruments
	2621	Paper Mills		3995	Burial Caskets
	2657	Folding Paperboard Boxes		3999	Manufacturing Industries, Nec
	2671	Paper Coated & Laminated, Packaging		4011	Railroads, Line-haul Operating
	2672	Paper Coated And Laminated, Nec		4111	Local And Suburban Transit
	2732	Book Printing		4221	Farm Product Warehousing And Storage
	2752	Commercial Printing, Lithographic		4226	Special Warehousing And Storage, Nec
	2819	Industrial Inorganic Chemicals, Nec		4953	Refuse Systems
	2821	Plastics Materials And Resins		5153	Grain And Field Beans
	2861	Gum And Wood Chemicals		5171	Petroleum Bulk Stations & Terminals
	2869	Industrial Organic Chemicals, Nec		5191	Farm Supplies
	2874	Phosphatic Fertilizers		7218	Industrial Launderers
	2951	Asphalt Paving Mixtures And Blocks		7389	Business Services, Nec
	3053	Gaskets, Packing And Sealing Devices		7694	Armature Rewinding Shops
	3081	Unsupported Plastics Film & Sheet		8062	General Medical & Surgical Hospitals
	3085	Plastics Bottles		8661	Religious Organizations
	3086	Plastics Foam Products		9511	Air, Water, & Solid Waste Management
	3089	Plastics Products, Nec		9711	National Security
	3111	Leather Tanning And Finishing			
	3259	Structural Clay Products, Nec			
	3275	Gypsum Products	3-90-012	<i>Industrial Processes: In-process Fuel Use - Solid Waste</i>	
	3291	Abrasive Products			
	3315	Steel Wire And Related Products		1499	Miscellaneous Nonmetallic Minerals
	3317	Steel Pipe And Tubes		2679	Converted Paper Products, Nec
	3321	Gray And Ductile Iron Foundries		2812	Alkalies And Chlorine
	3325	Steel Foundries, Nec		2833	Medicinals And Botanicals
	3339	Primary Nonferrous Metals, Nec		2869	Industrial Organic Chemicals, Nec
				2911	Petroleum Refining

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	3241	Cement, Hydraulic		1742	Plastering, Drywall, And Insulation
	3275	Gypsum Products		1751	Carpentry Work
	3334	Primary Aluminum		1761	Roofing, Siding, And Sheet Metal Work
	3559	Special Industry Machinery, Nec		1771	Concrete Work
	3764	Space Propulsion Units And Parts		1791	Structural Steel Erection
	4581	Airports, Flying Fields, & Services		1796	Installing Building Equipment, Nec
	4911	Electric Services		1799	Special Trade Contractors, Nec
	4952	Sewerage Systems		2026	Fluid Milk
	4953	Refuse Systems		2033	Canned Fruits And Vegetables
	5541	Gasoline Service Stations		2043	Cereal Breakfast Foods
	5812	Eating Places		2048	Prepared Feeds, Nec
	6553	Cemetery Subdividers And Developers		2051	Bread, Cake, And Related Products
	7261	Funeral Service And Crematories		2068	Salted And Roasted Nuts And Seeds
	8051	Skilled Nursing Care Facilities		2086	Bottled And Canned Soft Drinks
	8062	General Medical & Surgical Hospitals		2087	Flavoring Extracts And Syrups, Nec
	8063	Psychiatric Hospitals		2091	Canned And Cured Fish And Seafoods
	8221	Colleges And Universities		2096	Potato Chips And Similar Snacks
	8731	Commercial Physical Research		2099	Food Preparations, Nec
	9511	Air, Water, & Solid Waste Management		2211	Broadwoven Fabric Mills, Cotton
	9711	National Security		2231	Broadwoven Fabric Mills, Wool
3-90-013	<i>Industrial Processes: In-process Fuel Use - Liquid Waste</i>			2259	Knitting Mills, Nec
	1429	Crushed And Broken Stone, Nec		2261	Finishing Plants, Cotton
	1499	Miscellaneous Nonmetallic Minerals		2262	Finishing Plants, Manmade
	2023	Dry, Condensed, Evaporated Products		2269	Finishing Plants, Nec
	2653	Corrugated And Solid Fiber Boxes		2273	Carpets And Rugs
	2819	Industrial Inorganic Chemicals, Nec		2295	Coated Fabrics, Not Rubberized
	2821	Plastics Materials And Resins		2298	Cordage And Twine
	2824	Organic Fibers, Noncellulosic		2299	Textile Goods, Nec
	2843	Surface Active Agents		2331	Women's & Misses' Blouses & Shirts
	2865	Cyclic Crudes And Intermediates		2384	Robes And Dressing Gowns
	2869	Industrial Organic Chemicals, Nec		2387	Apparel Belts
	2951	Asphalt Paving Mixtures And Blocks		2392	Housefurnishings, Nec
	3089	Plastics Products, Nec		2394	Canvas And Related Products
	3241	Cement, Hydraulic		2395	Pleating And Stitching
	3274	Lime		2399	Fabricated Textile Products, Nec
	3295	Minerals, Ground Or Treated		2411	Logging
	3312	Blast Furnaces And Steel Mills		2421	Sawmills And Planing Mills, General
	3999	Manufacturing Industries, Nec		2426	Hardwood Dimension & Flooring Mills
	4953	Refuse Systems		2431	Millwork
4-02-001	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Surface Coating Application - General</i>			2434	Wood Kitchen Cabinets
	0711	Soil Preparation Services		2435	Hardwood Veneer And Plywood
	0782	Lawn And Garden Services		2441	Nailed Wood Boxes And Shook
	1021	Copper Ores		2449	Wood Containers, Nec
	1241	Coal Mining Services		2451	Mobile Homes
	1311	Crude Petroleum And Natural Gas		2452	Prefabricated Wood Buildings
	1382	Oil And Gas Exploration Services		2491	Wood Preserving
	1389	Oil And Gas Field Services, Nec		2493	Reconstituted Wood Products
	1422	Crushed And Broken Limestone		2499	Wood Products, Nec
	1522	Residential Construction, Nec		2511	Wood Household Furniture
	1541	Industrial Buildings And Warehouses		2512	Upholstered Household Furniture
	1542	Nonresidential Construction, Nec		2514	Metal Household Furniture
	1622	Bridge, Tunnel, & Elevated Highway		2515	Mattresses And Bedsprings
	1623	Water, Sewer, And Utility Lines		2519	Household Furniture, Nec
	1629	Heavy Construction, Nec		2521	Wood Office Furniture
	1711	Plumbing, Heating, Air-conditioning		2522	Office Furniture, Except Wood
	1721	Painting And Paper Hanging		2531	Public Building & Related Furniture
	1731	Electrical Work		2541	Wood Partitions And Fixtures
	1741	Masonry And Other Stonework		2542	Partitions And Fixtures, Except Wood
				2591	Drapery Hardware & Blinds & Shades
				2599	Furniture And Fixtures, Nec
				2621	Paper Mills
				2631	Paperboard Mills

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	2653	Corrugated And Solid Fiber Boxes		3255	Clay Refractories
	2655	Fiber Cans, Drums & Similar Products		3261	Vitreous Plumbing Fixtures
	2656	Sanitary Food Containers		3269	Pottery Products, Nec
	2657	Folding Paperboard Boxes		3272	Concrete Products, Nec
	2671	Paper Coated & Laminated, Packaging		3273	Ready-mixed Concrete
	2672	Paper Coated And Laminated, Nec		3275	Gypsum Products
	2673	Bags: Plastics, Laminated, & Coated		3281	Cut Stone And Stone Products
	2675	Die-cut Paper And Board		3291	Abrasive Products
	2676	Sanitary Paper Products		3292	Asbestos Products
	2711	Newspapers		3295	Minerals, Ground Or Treated
	2732	Book Printing		3296	Mineral Wool
	2752	Commercial Printing, Lithographic		3297	Nonclay Refractories
	2754	Commercial Printing, Gravure		3299	Nonmetallic Mineral Products, Nec
	2759	Commercial Printing, Nec		3312	Blast Furnaces And Steel Mills
	2782	Blankbooks And Looseleaf Binders		3315	Steel Wire And Related Products
	2796	Platemaking Services		3316	Cold Finishing Of Steel Shapes
	2813	Industrial Gases		3317	Steel Pipe And Tubes
	2816	Inorganic Pigments		3321	Gray And Ductile Iron Foundries
	2819	Industrial Inorganic Chemicals, Nec		3322	Malleable Iron Foundries
	2821	Plastics Materials And Resins		3325	Steel Foundries, Nec
	2822	Synthetic Rubber		3334	Primary Aluminum
	2823	Cellulosic Manmade Fibers		3339	Primary Nonferrous Metals, Nec
	2833	Medicinals And Botanicals		3341	Secondary Nonferrous Metals
	2834	Pharmaceutical Preparations		3354	Aluminum Extruded Products
	2841	Soap And Other Detergents		3356	Nonferrous Rolling And Drawing, Nec
	2842	Polishes And Sanitation Goods		3357	Nonferrous Wiredrawing & Insulating
	2843	Surface Active Agents		3363	Aluminum Die-castings
	2844	Toilet Preparations		3364	Nonferrous Die-casting Exc. Aluminum
	2851	Paints And Allied Products		3365	Aluminum Foundries
	2869	Industrial Organic Chemicals, Nec		3366	Copper Foundries
	2879	Agricultural Chemicals, Nec		3369	Nonferrous Foundries, Nec
	2891	Adhesives And Sealants		3399	Primary Metal Products, Nec
	2892	Explosives		3411	Metal Cans
	2893	Printing Ink		3412	Metal Barrels, Drums, And Pails
	2899	Chemical Preparations, Nec		3423	Hand And Edge Tools, Nec
	2911	Petroleum Refining		3429	Hardware, Nec
	2951	Asphalt Paving Mixtures And Blocks		3431	Metal Sanitary Ware
	2952	Asphalt Felts And Coatings		3432	Plumbing Fixture Fittings And Trim
	3011	Tires And Inner Tubes		3433	Heating Equipment, Except Electric
	3052	Rubber & Plastics Hose & Belting		3441	Fabricated Structural Metal
	3053	Gaskets, Packing And Sealing Devices		3442	Metal Doors, Sash, And Trim
	3061	Mechanical Rubber Goods		3443	Fabricated Plate Work (boiler Shops)
	3069	Fabricated Rubber Products, Nec		3444	Sheet Metalwork
	3081	Unsupported Plastics Film & Sheet		3446	Architectural Metal Work
	3082	Unsupported Plastics Profile Shapes		3448	Prefabricated Metal Buildings
	3083	Laminated Plastics Plate & Sheet		3449	Miscellaneous Metal Work
	3085	Plastics Bottles		3451	Screw Machine Products
	3086	Plastics Foam Products		3452	Bolts, Nuts, Rivets, And Washers
	3087	Custom Compound Purchased Resins		3462	Iron And Steel Forgings
	3088	Plastics Plumbing Fixtures		3465	Automotive Stampings
	3089	Plastics Products, Nec		3466	Crowns And Closures
	3111	Leather Tanning And Finishing		3469	Metal Stampings, Nec
	3131	Footwear Cut Stock		3471	Plating And Polishing
	3143	Men's Footwear, Except Athletic		3479	Metal Coating And Allied Services
	3161	Luggage		3482	Small Arms Ammunition
	3172	Personal Leather Goods, Nec		3483	Ammunition, Exc. For Small Arms, Nec
	3199	Leather Goods, Nec		3484	Small Arms
	3211	Flat Glass		3489	Ordnance And Accessories, Nec
	3229	Pressed And Blown Glass, Nec		3491	Industrial Valves
	3231	Products Of Purchased Glass		3492	Fluid Power Valves & Hose Fittings
	3241	Cement, Hydraulic		3493	Steel Springs, Except Wire
	3253	Ceramic Wall And Floor Tile		3494	Valves And Pipe Fittings, Nec

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	3495	Wire Springs		3643	Current-carrying Wiring Devices
	3496	Misc. Fabricated Wire Products		3644	Noncurrent-carrying Wiring Devices
	3497	Metal Foil And Leaf		3645	Residential Lighting Fixtures
	3498	Fabricated Pipe And Fittings		3646	Commercial Lighting Fixtures
	3499	Fabricated Metal Products, Nec		3647	Vehicular Lighting Equipment
	3511	Turbines And Turbine Generator Sets		3648	Lighting Equipment, Nec
	3519	Internal Combustion Engines, Nec		3651	Household Audio And Video Equipment
	3523	Farm Machinery And Equipment		3661	Telephone And Telegraph Apparatus
	3524	Lawn And Garden Equipment		3663	Radio & TV Communications Equipment
	3531	Construction Machinery		3669	Communications Equipment, Nec
	3532	Mining Machinery		3671	Electron Tubes
	3533	Oil And Gas Field Machinery		3674	Semiconductors And Related Devices
	3534	Elevators And Moving Stairways		3675	Electronic Capacitors
	3535	Conveyors And Conveying Equipment		3676	Electronic Resistors
	3536	Hoists, Cranes, And Monorails		3677	Electronic Coils And Transformers
	3537	Industrial Trucks And Tractors		3678	Electronic Connectors
	3541	Machine Tools, Metal Cutting Types		3679	Electronic Components, Nec
	3542	Machine Tools, Metal Forming Types		3691	Storage Batteries
	3543	Industrial Patterns		3692	Primary Batteries, Dry And Wet
	3544	Special Dies, Tools, Jigs & Fixtures		3694	Engine Electrical Equipment
	3545	Machine Tool Accessories		3695	Magnetic And Optical Recording Media
	3548	Welding Apparatus		3699	Electrical Equipment & Supplies, Nec
	3549	Metalworking Machinery, Nec		3711	Motor Vehicles And Car Bodies
	3552	Textile Machinery		3713	Truck And Bus Bodies
	3553	Woodworking Machinery		3714	Motor Vehicle Parts And Accessories
	3554	Paper Industries Machinery		3715	Truck Trailers
	3555	Printing Trades Machinery		3716	Motor Homes
	3556	Food Products Machinery		3721	Aircraft
	3559	Special Industry Machinery, Nec		3724	Aircraft Engines And Engine Parts
	3561	Pumps And Pumping Equipment		3728	Aircraft Parts And Equipment, Nec
	3562	Ball And Roller Bearings		3731	Ship Building And Repairing
	3563	Air And Gas Compressors		3732	Boat Building And Repairing
	3564	Blowers And Fans		3743	Railroad Equipment
	3566	Speed Changers, Drives, And Gears		3751	Motorcycles, Bicycles, And Parts
	3567	Industrial Furnaces And Ovens		3761	Guided Missiles And Space Vehicles
	3569	General Industrial Machinery, Nec		3764	Space Propulsion Units And Parts
	3571	Electronic Computers		3769	Space Vehicle Equipment, Nec
	3575	Computer Terminals		3792	Travel Trailers And Campers
	3577	Computer Peripheral Equipment, Nec		3795	Tanks And Tank Components
	3578	Calculating And Accounting Equipment		3799	Transportation Equipment, Nec
	3579	Office Machines, Nec		3812	Search And Navigation Equipment
	3581	Automatic Vending Machines		3821	Laboratory Apparatus And Furniture
	3582	Commercial Laundry Equipment		3822	Environmental Controls
	3585	Refrigeration And Heating Equipment		3823	Process Control Instruments
	3586	Measuring And Dispensing Pumps		3825	Instruments To Measure Electricity
	3589	Service Industry Machinery, Nec		3826	Analytical Instruments
	3592	Carburetors, Pistons, Rings, Valves		3827	Optical Instruments And Lenses
	3593	Fluid Power Cylinders & Actuators		3829	Measuring & Controlling Devices, Nec
	3594	Fluid Power Pumps And Motors		3841	Surgical And Medical Instruments
	3596	Scales And Balances, Exc. Laboratory		3842	Surgical Appliances And Supplies
	3599	Industrial Machinery, Nec		3843	Dental Equipment And Supplies
	3612	Transformers, Except Electronic		3844	X-ray Apparatus And Tubes
	3621	Motors And Generators		3851	Ophthalmic Goods
	3624	Carbon And Graphite Products		3861	Photographic Equipment And Supplies
	3625	Relays And Industrial Controls		3931	Musical Instruments
	3629	Electrical Industrial Apparatus, Nec		3942	Dolls And Stuffed Toys
	3631	Household Cooking Equipment		3944	Games, Toys, And Children's Vehicles
	3632	Household Refrigerators And Freezers		3949	Sporting And Athletic Goods, Nec
	3633	Household Laundry Equipment		3952	Lead Pencils And Art Goods
	3634	Electric Housewares And Fans		3955	Carbon Paper And Inked Ribbons
	3639	Household Appliances, Nec		3991	Brooms And Brushes
	3641	Electric Lamps		3993	Signs And Advertising Specialties

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	3995	Burial Caskets		5091	Sporting & Recreational Goods
	3996	Hard Surface Floor Coverings, Nec		5092	Toys And Hobby Goods And Supplies
	3999	Manufacturing Industries, Nec		5093	Scrap And Waste Materials
	4011	Railroads, Line-haul Operating		5099	Durable Goods, Nec
	4111	Local And Suburban Transit		5113	Industrial & Personal Service Paper
	4121	Taxicabs		5122	Drugs, Proprietaries, And Sundries
	4131	Intercity & Rural Bus Transportation		5131	Piece Goods & Notions
	4212	Local Trucking, Without Storage		5169	Chemicals & Allied Products, Nec
	4213	Trucking, Except Local		5171	Petroleum Bulk Stations & Terminals
	4215	Courier Services, Except By Air		5172	Petroleum Products, Nec
	4225	General Warehousing And Storage		5198	Paints, Varnishes, And Supplies
	4226	Special Warehousing And Storage, Nec		5199	Nondurable Goods, Nec
	4231	Trucking Terminal Facilities		5211	Lumber And Other Building Materials
	4311	U.S. Postal Service		5231	Paint, Glass, And Wallpaper Stores
	4424	Deep Sea Domestic Trans. Of Freight		5251	Hardware Stores
	4491	Marine Cargo Handling		5261	Retail Nurseries And Garden Stores
	4493	Marinas		5271	Mobile Home Dealers
	4512	Air Transportation, Scheduled		5311	Department Stores
	4581	Airports, Flying Fields, & Services		5399	Misc. General Merchandise Stores
	4729	Passenger Transport Arrangement, Nec		5411	Grocery Stores
	4741	Rental Of Railroad Cars		5511	New And Used Car Dealers
	4783	Packing And Crating		5521	Used Car Dealers
	4785	Inspection & Fixed Facilities		5531	Auto And Home Supply Stores
	4789	Transportation Services, Nec		5541	Gasoline Service Stations
	4813	Telephone Communications, Exc. Radio		5561	Recreational Vehicle Dealers
	4833	Television Broadcasting Stations		5571	Motorcycle Dealers
	4911	Electric Services		5599	Automotive Dealers, Nec
	4922	Natural Gas Transmission		5712	Furniture Stores
	4923	Gas Transmission And Distribution		5719	Misc. Homefurnishings Stores
	4925	Gas Production And/or Distribution		5722	Household Appliance Stores
	4931	Electric And Other Services Combined		5734	Computer And Software Stores
	4939	Combination Utilities, Nec		5736	Musical Instrument Stores
	4941	Water Supply		5812	Eating Places
	4952	Sewerage Systems		5932	Used Merchandise Stores
	4953	Refuse Systems		5941	Sporting Goods And Bicycle Shops
	4959	Sanitary Services, Nec		5943	Stationery Stores
	4961	Steam And Air-conditioning Supply		5994	News Dealers And Newsstands
	5012	Automobiles And Other Motor Vehicles		5999	Miscellaneous Retail Stores, Nec
	5015	Motor Vehicle Parts, Used		6021	National Commercial Banks
	5021	Furniture		6035	Federal Savings Institutions
	5023	Homefurnishings		6111	Federal & Fed.-sponsored Credit
	5031	Lumber, Plywood, And Millwork		6321	Accident And Health Insurance
	5032	Brick, Stone, & Related Materials		6512	Nonresidential Building Operators
	5033	Roofing, Siding, & Insulation		6552	Subdividers And Developers, Nec
	5039	Construction Materials, Nec		6553	Cemetery Subdividers And Developers
	5043	Photographic Equipment And Supplies		6719	Holding Companies, Nec
	5044	Office Equipment		6732	Educational, Religious, Etc. Trusts
	5045	Computers, Peripherals & Software		6799	Investors, Nec
	5046	Commercial Equipment, Nec		7011	Hotels And Motels
	5047	Medical And Hospital Equipment		7216	Drycleaning Plants, Except Rug
	5051	Metals Service Centers And Offices		7221	Photographic Studios, Portrait
	5064	Electrical Appliances, TV & Radios		7261	Funeral Service And Crematories
	5065	Electronic Parts And Equipment		7311	Advertising Agencies
	5074	Plumbing & Hydronic Heating Supplies		7335	Commercial Photography
	5075	Warm Air Heating & Air-conditioning		7336	Commercial Art And Graphic Design
	5078	Refrigeration Equipment And Supplies		7349	Building Maintenance Services, Nec
	5082	Construction And Mining Machinery		7352	Medical Equipment Rental
	5083	Farm And Garden Machinery		7359	Equipment Rental & Leasing, Nec
	5084	Industrial Machinery And Equipment		7371	Computer Programming Services
	5085	Industrial Supplies		7372	Prepackaged Software
	5087	Service Establishment Equipment		7373	Computer Integrated Systems Design
	5088	Transportation Equipment & Supplies		7377	Computer Rental & Leasing

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	7379	Computer Related Services, Nec		9711	National Security
	7381	Detective & Armored Car Services			
	7382	Security Systems Services	4-02-002		<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Surface Coating Application - General</i>
	7384	Photofinishing Laboratories		1241	Coal Mining Services
	7389	Business Services, Nec		1311	Crude Petroleum And Natural Gas
	7513	Truck Rental And Leasing, No Drivers		1721	Painting And Paper Hanging
	7514	Passenger Car Rental		2047	Dog And Cat Food
	7521	Automobile Parking		2295	Coated Fabrics, Not Rubberized
	7532	Top & Body Repair & Paint Shops		2326	Men's And Boys' Work Clothing
	7533	Auto Exhaust System Repair Shops		2421	Sawmills And Planing Mills, General
	7534	Tire Retreading And Repair Shops		2431	Millwork
	7538	General Automotive Repair Shops		2434	Wood Kitchen Cabinets
	7539	Automotive Repair Shops, Nec		2435	Hardwood Veneer And Plywood
	7542	Carwashes		2449	Wood Containers, Nec
	7549	Automotive Services, Nec		2451	Mobile Homes
	7629	Electrical Repair Shops, Nec		2493	Reconstituted Wood Products
	7641	Reupholstery And Furniture Repair		2499	Wood Products, Nec
	7692	Welding Repair		2519	Household Furniture, Nec
	7694	Armature Rewinding Shops		2531	Public Building & Related Furniture
	7699	Repair Services, Nec		2541	Wood Partitions And Fixtures
	7812	Motion Picture & Video Production		2542	Partitions And Fixtures, Except Wood
	7832	Motion Picture Theaters, Ex Drive-in		2599	Furniture And Fixtures, Nec
	7929	Entertainers & Entertainment Groups		2621	Paper Mills
	7948	Racing, Including Track Operation		2631	Paperboard Mills
	7991	Physical Fitness Facilities		2653	Corrugated And Solid Fiber Boxes
	7996	Amusement Parks		2655	Fiber Cans, Drums & Similar Products
	7999	Amusement And Recreation, Nec		2657	Folding Paperboard Boxes
	8011	Offices & Clinics Of Medical Doctors		2671	Paper Coated & Laminated, Packaging
	8049	Offices Of Health Practitioners, Nec		2672	Paper Coated And Laminated, Nec
	8062	General Medical & Surgical Hospitals		2675	Die-cut Paper And Board
	8063	Psychiatric Hospitals		2679	Converted Paper Products, Nec
	8093	Specialty Outpatient Clinics, Nec		2752	Commercial Printing, Lithographic
	8111	Legal Services		2821	Plastics Materials And Resins
	8211	Elementary And Secondary Schools		2834	Pharmaceutical Preparations
	8221	Colleges And Universities		2841	Soap And Other Detergents
	8222	Junior Colleges		2851	Paints And Allied Products
	8231	Libraries		2891	Adhesives And Sealants
	8249	Vocational Schools, Nec		2899	Chemical Preparations, Nec
	8299	Schools & Educational Services, Nec		3011	Tires And Inner Tubes
	8322	Individual And Family Services		3053	Gaskets, Packing And Sealing Devices
	8361	Residential Care		3069	Fabricated Rubber Products, Nec
	8412	Museums And Art Galleries		3085	Plastics Bottles
	8621	Professional Organizations		3087	Custom Compound Purchased Resins
	8711	Engineering Services		3089	Plastics Products, Nec
	8712	Architectural Services		3111	Leather Tanning And Finishing
	8731	Commercial Physical Research		3143	Men's Footwear, Except Athletic
	8732	Commercial Nonphysical Research		3172	Personal Leather Goods, Nec
	8733	Noncommercial Research Organizations		3229	Pressed And Blown Glass, Nec
	8734	Testing Laboratories		3255	Clay Refractories
	8741	Management Services		3272	Concrete Products, Nec
	8999	Services, Nec		3281	Cut Stone And Stone Products
	9111	Executive Offices		3296	Mineral Wool
	9199	General Government, Nec		3316	Cold Finishing Of Steel Shapes
	9221	Police Protection		3317	Steel Pipe And Tubes
	9223	Correctional Institutions		3321	Gray And Ductile Iron Foundries
	9411	Admin. Of Educational Programs		3322	Malleable Iron Foundries
	9441	Admin. Of Social & Manpower Programs		3325	Steel Foundries, Nec
	9511	Air, Water, & Solid Waste Management		3363	Aluminum Die-castings
	9531	Housing Programs		3365	Aluminum Foundries
	9621	Regulation, Admin. Of Transportation		3411	Metal Cans
	9631	Regulation, Admin. Of Utilities		3412	Metal Barrels, Drums, And Pails
	9661	Space Research And Technology			

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	3423	Hand And Edge Tools, Nec		3841	Surgical And Medical Instruments
	3429	Hardware, Nec		3861	Photographic Equipment And Supplies
	3442	Metal Doors, Sash, And Trim		3944	Games, Toys, And Children's Vehicles
	3443	Fabricated Plate Work (boiler Shops)		3949	Sporting And Athletic Goods, Nec
	3444	Sheet Metalwork		3996	Hard Surface Floor Coverings, Nec
	3448	Prefabricated Metal Buildings		3999	Manufacturing Industries, Nec
	3449	Miscellaneous Metal Work		4011	Railroads, Line-haul Operating
	3462	Iron And Steel Forgings		4581	Airports, Flying Fields, & Services
	3465	Automotive Stampings		4729	Passenger Transport Arrangement, Nec
	3469	Metal Stampings, Nec		4833	Television Broadcasting Stations
	3471	Plating And Polishing		4911	Electric Services
	3479	Metal Coating And Allied Services		4931	Electric And Other Services Combined
	3489	Ordnance And Accessories, Nec		4953	Refuse Systems
	3494	Valves And Pipe Fittings, Nec		5031	Lumber, Plywood, And Millwork
	3496	Misc. Fabricated Wire Products		5082	Construction And Mining Machinery
	3499	Fabricated Metal Products, Nec		5084	Industrial Machinery And Equipment
	3511	Turbines And Turbine Generator Sets		5141	Groceries, General Line
	3519	Internal Combustion Engines, Nec		5171	Petroleum Bulk Stations & Terminals
	3523	Farm Machinery And Equipment		5411	Grocery Stores
	3524	Lawn And Garden Equipment		5712	Furniture Stores
	3531	Construction Machinery		5912	Drug Stores And Proprietary Stores
	3532	Mining Machinery		6321	Accident And Health Insurance
	3535	Conveyors And Conveying Equipment		7011	Hotels And Motels
	3541	Machine Tools, Metal Cutting Types		7216	Drycleaning Plants, Except Rug
	3544	Special Dies, Tools, Jigs & Fixtures		7312	Outdoor Advertising Services
	3555	Printing Trades Machinery		7521	Automobile Parking
	3556	Food Products Machinery		7532	Top & Body Repair & Paint Shops
	3561	Pumps And Pumping Equipment		7534	Tire Retreading And Repair Shops
	3563	Air And Gas Compressors		7538	General Automotive Repair Shops
	3564	Blowers And Fans		7699	Repair Services, Nec
	3569	General Industrial Machinery, Nec		7812	Motion Picture & Video Production
	3571	Electronic Computers		7996	Amusement Parks
	3572	Computer Storage Devices		7999	Amusement And Recreation, Nec
	3577	Computer Peripheral Equipment, Nec		8062	General Medical & Surgical Hospitals
	3579	Office Machines, Nec		8063	Psychiatric Hospitals
	3581	Automatic Vending Machines		8069	Specialty Hospitals Exc. Psychiatric
	3585	Refrigeration And Heating Equipment		8211	Elementary And Secondary Schools
	3589	Service Industry Machinery, Nec		8221	Colleges And Universities
	3599	Industrial Machinery, Nec		8361	Residential Care
	3612	Transformers, Except Electronic		8731	Commercial Physical Research
	3621	Motors And Generators		8741	Management Services
	3625	Relays And Industrial Controls		9199	General Government, Nec
	3634	Electric Housewares And Fans		9223	Correctional Institutions
	3639	Household Appliances, Nec		9621	Regulation, Admin. Of Transportation
	3641	Electric Lamps		9661	Space Research And Technology
	3645	Residential Lighting Fixtures		9711	National Security
	3651	Household Audio And Video Equipment			
	3661	Telephone And Telegraph Apparatus	4-02-003	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Surface Coating Application - General</i>	
	3669	Communications Equipment, Nec		1061	Ferroalloy Ores, Except Vanadium
	3679	Electronic Components, Nec		1721	Painting And Paper Hanging
	3699	Electrical Equipment & Supplies, Nec		2426	Hardwood Dimension & Flooring Mills
	3711	Motor Vehicles And Car Bodies		2431	Millwork
	3713	Truck And Bus Bodies		2434	Wood Kitchen Cabinets
	3714	Motor Vehicle Parts And Accessories		2435	Hardwood Veneer And Plywood
	3715	Truck Trailers		2493	Reconstituted Wood Products
	3724	Aircraft Engines And Engine Parts		2499	Wood Products, Nec
	3728	Aircraft Parts And Equipment, Nec		2511	Wood Household Furniture
	3731	Ship Building And Repairing		2512	Upholstered Household Furniture
	3732	Boat Building And Repairing		2517	Wood Tv And Radio Cabinets
	3743	Railroad Equipment		2521	Wood Office Furniture
	3799	Transportation Equipment, Nec		2522	Office Furniture, Except Wood
	3812	Search And Navigation Equipment			



## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	2531	Public Building & Related Furniture		3844	X-ray Apparatus And Tubes
	2541	Wood Partitions And Fixtures		3845	Electromedical Equipment
	2599	Furniture And Fixtures, Nec		3931	Musical Instruments
	2621	Paper Mills		3944	Games, Toys, And Children's Vehicles
	2655	Fiber Cans, Drums & Similar Products		3949	Sporting And Athletic Goods, Nec
	2656	Sanitary Food Containers		3955	Carbon Paper And Inked Ribbons
	2672	Paper Coated And Laminated, Nec		3991	Brooms And Brushes
	2732	Book Printing		3993	Signs And Advertising Specialties
	2752	Commercial Printing, Lithographic		3995	Burial Caskets
	2759	Commercial Printing, Nec		3999	Manufacturing Industries, Nec
	2875	Fertilizers, Mixing Only		4013	Switching And Terminal Services
	3069	Fabricated Rubber Products, Nec		5065	Electronic Parts And Equipment
	3083	Laminated Plastics Plate & Sheet		5083	Farm And Garden Machinery
	3087	Custom Compound Purchased Resins		5511	New And Used Car Dealers
	3089	Plastics Products, Nec		7216	Drycleaning Plants, Except Rug
	3271	Concrete Block And Brick		7389	Business Services, Nec
	3281	Cut Stone And Stone Products		7532	Top & Body Repair & Paint Shops
	3292	Asbestos Products		7629	Electrical Repair Shops, Nec
	3312	Blast Furnaces And Steel Mills		7641	Reupholstery And Furniture Repair
	3317	Steel Pipe And Tubes		7694	Armature Rewinding Shops
	3357	Nonferrous Wiredrawing & Insulating		8062	General Medical & Surgical Hospitals
	3411	Metal Cans		9199	General Government, Nec
	3412	Metal Barrels, Drums, And Pails		9223	Correctional Institutions
	3429	Hardware, Nec		9711	National Security
	3444	Sheet Metalwork			
	3465	Automotive Stampings	4-02-004	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Surface Coating Application - General</i>	
	3466	Crowns And Closures		1311	Crude Petroleum And Natural Gas
	3469	Metal Stampings, Nec		1521	Single-family Housing Construction
	3471	Plating And Polishing		1799	Special Trade Contractors, Nec
	3479	Metal Coating And Allied Services		2353	Hats, Caps, And Millinery
	3491	Industrial Valves		2411	Logging
	3498	Fabricated Pipe And Fittings		2421	Sawmills And Planing Mills, General
	3499	Fabricated Metal Products, Nec		2426	Hardwood Dimension & Flooring Mills
	3523	Farm Machinery And Equipment		2431	Millwork
	3536	Hoists, Cranes, And Monorails		2434	Wood Kitchen Cabinets
	3542	Machine Tools, Metal Forming Types		2435	Hardwood Veneer And Plywood
	3545	Machine Tool Accessories		2452	Prefabricated Wood Buildings
	3548	Welding Apparatus		2491	Wood Preserving
	3559	Special Industry Machinery, Nec		2499	Wood Products, Nec
	3561	Pumps And Pumping Equipment		2511	Wood Household Furniture
	3599	Industrial Machinery, Nec		2512	Upholstered Household Furniture
	3612	Transformers, Except Electronic		2514	Metal Household Furniture
	3621	Motors And Generators		2517	Wood Tv And Radio Cabinets
	3625	Relays And Industrial Controls		2519	Household Furniture, Nec
	3629	Electrical Industrial Apparatus, Nec		2521	Wood Office Furniture
	3634	Electric Housewares And Fans		2522	Office Furniture, Except Wood
	3674	Semiconductors And Related Devices		2531	Public Building & Related Furniture
	3677	Electronic Coils And Transformers		2541	Wood Partitions And Fixtures
	3679	Electronic Components, Nec		2542	Partitions And Fixtures, Except Wood
	3694	Engine Electrical Equipment		2599	Furniture And Fixtures, Nec
	3699	Electrical Equipment & Supplies, Nec		2655	Fiber Cans, Drums & Similar Products
	3714	Motor Vehicle Parts And Accessories		2671	Paper Coated & Laminated, Packaging
	3715	Truck Trailers		2732	Book Printing
	3716	Motor Homes		2741	Miscellaneous Publishing
	3721	Aircraft		2752	Commercial Printing, Lithographic
	3728	Aircraft Parts And Equipment, Nec		2754	Commercial Printing, Gravure
	3731	Ship Building And Repairing		2759	Commercial Printing, Nec
	3732	Boat Building And Repairing		2771	Greeting Cards
	3743	Railroad Equipment		2821	Plastics Materials And Resins
	3792	Travel Trailers And Campers		2834	Pharmaceutical Preparations
	3825	Instruments To Measure Electricity		2851	Paints And Allied Products
	3841	Surgical And Medical Instruments			

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	2891	Adhesives And Sealants		3632	Household Refrigerators And Freezers
	2911	Petroleum Refining		3634	Electric Housewares And Fans
	3053	Gaskets, Packing And Sealing Devices		3641	Electric Lamps
	3069	Fabricated Rubber Products, Nec		3645	Residential Lighting Fixtures
	3085	Plastics Bottles		3647	Vehicular Lighting Equipment
	3086	Plastics Foam Products		3648	Lighting Equipment, Nec
	3087	Custom Compound Purchased Resins		3651	Household Audio And Video Equipment
	3088	Plastics Plumbing Fixtures		3661	Telephone And Telegraph Apparatus
	3089	Plastics Products, Nec		3663	Radio & TV Communications Equipment
	3111	Leather Tanning And Finishing		3671	Electron Tubes
	3143	Men's Footwear, Except Athletic		3679	Electronic Components, Nec
	3211	Flat Glass		3694	Engine Electrical Equipment
	3261	Vitreous Plumbing Fixtures		3711	Motor Vehicles And Car Bodies
	3269	Pottery Products, Nec		3714	Motor Vehicle Parts And Accessories
	3281	Cut Stone And Stone Products		3715	Truck Trailers
	3291	Abrasive Products		3721	Aircraft
	3312	Blast Furnaces And Steel Mills		3724	Aircraft Engines And Engine Parts
	3321	Gray And Ductile Iron Foundries		3732	Boat Building And Repairing
	3325	Steel Foundries, Nec		3743	Railroad Equipment
	3365	Aluminum Foundries		3792	Travel Trailers And Campers
	3411	Metal Cans		3795	Tanks And Tank Components
	3412	Metal Barrels, Drums, And Pails		3799	Transportation Equipment, Nec
	3423	Hand And Edge Tools, Nec		3812	Search And Navigation Equipment
	3429	Hardware, Nec		3842	Surgical Appliances And Supplies
	3433	Heating Equipment, Except Electric		3844	X-ray Apparatus And Tubes
	3441	Fabricated Structural Metal		3861	Photographic Equipment And Supplies
	3443	Fabricated Plate Work (boiler Shops)		3873	Watches, Clocks, Watchcases & Parts
	3444	Sheet Metalwork		3911	Jewelry, Precious Metal
	3446	Architectural Metal Work		3931	Musical Instruments
	3452	Bolts, Nuts, Rivets, And Washers		3949	Sporting And Athletic Goods, Nec
	3469	Metal Stampings, Nec		3952	Lead Pencils And Art Goods
	3471	Plating And Polishing		3961	Costume Jewelry
	3479	Metal Coating And Allied Services		3991	Brooms And Brushes
	3482	Small Arms Ammunition		3993	Signs And Advertising Specialties
	3484	Small Arms		3995	Burial Caskets
	3494	Valves And Pipe Fittings, Nec		3999	Manufacturing Industries, Nec
	3496	Misc. Fabricated Wire Products		4173	Bus Terminal And Service Facilities
	3497	Metal Foil And Leaf		4213	Trucking, Except Local
	3499	Fabricated Metal Products, Nec		4311	U.S. Postal Service
	3519	Internal Combustion Engines, Nec		4512	Air Transportation, Scheduled
	3531	Construction Machinery		4581	Airports, Flying Fields, & Services
	3532	Mining Machinery		4931	Electric And Other Services Combined
	3534	Elevators And Moving Stairways		4941	Water Supply
	3535	Conveyors And Conveying Equipment		4961	Steam And Air-conditioning Supply
	3541	Machine Tools, Metal Cutting Types		5021	Furniture
	3544	Special Dies, Tools, Jigs & Fixtures		5046	Commercial Equipment, Nec
	3545	Machine Tool Accessories		5092	Toys And Hobby Goods And Supplies
	3548	Welding Apparatus		5211	Lumber And Other Building Materials
	3549	Metalworking Machinery, Nec		5231	Paint, Glass, And Wallpaper Stores
	3553	Woodworking Machinery		5511	New And Used Car Dealers
	3554	Paper Industries Machinery		5561	Recreational Vehicle Dealers
	3559	Special Industry Machinery, Nec		5712	Furniture Stores
	3561	Pumps And Pumping Equipment		5912	Drug Stores And Proprietary Stores
	3562	Ball And Roller Bearings		5932	Used Merchandise Stores
	3566	Speed Changers, Drives, And Gears		5943	Stationery Stores
	3569	General Industrial Machinery, Nec		6553	Cemetery Subdividers And Developers
	3585	Refrigeration And Heating Equipment		7011	Hotels And Motels
	3589	Service Industry Machinery, Nec		7216	Drycleaning Plants, Except Rug
	3592	Carburetors, Pistons, Rings, Valves		7261	Funeral Service And Crematories
	3599	Industrial Machinery, Nec		7312	Outdoor Advertising Services
	3612	Transformers, Except Electronic		7319	Advertising, Nec
	3621	Motors And Generators		7389	Business Services, Nec

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	7514	Passenger Car Rental		3089	Plastics Products, Nec
	7532	Top & Body Repair & Paint Shops		3221	Glass Containers
	7539	Automotive Repair Shops, Nec		3229	Pressed And Blown Glass, Nec
	7542	Carwashes		3231	Products Of Purchased Glass
	7641	Reupholstery And Furniture Repair		3264	Porcelain Electrical Supplies
	7699	Repair Services, Nec		3269	Pottery Products, Nec
	7812	Motion Picture & Video Production		3272	Concrete Products, Nec
	8062	General Medical & Surgical Hospitals		3281	Cut Stone And Stone Products
	8063	Psychiatric Hospitals		3312	Blast Furnaces And Steel Mills
	8069	Specialty Hospitals Exc. Psychiatric		3315	Steel Wire And Related Products
	8221	Colleges And Universities		3316	Cold Finishing Of Steel Shapes
	8222	Junior Colleges		3317	Steel Pipe And Tubes
	8249	Vocational Schools, Nec		3321	Gray And Ductile Iron Foundries
	8322	Individual And Family Services		3341	Secondary Nonferrous Metals
	8733	Noncommercial Research Organizations		3354	Aluminum Extruded Products
	8999	Services, Nec		3355	Aluminum Rolling And Drawing, Nec
	9199	General Government, Nec		3356	Nonferrous Rolling And Drawing, Nec
	9223	Correctional Institutions		3357	Nonferrous Wire Drawing & Insulating
	9711	National Security		3365	Aluminum Foundries
				3366	Copper Foundries
4-02-005	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Surface Coating Application - General</i>			3399	Primary Metal Products, Nec
	1221	Bituminous Coal And Lignite Surface		3411	Metal Cans
	1311	Crude Petroleum And Natural Gas		3412	Metal Barrels, Drums, And Pails
	1531	Operative Builders		3423	Hand And Edge Tools, Nec
	1611	Highway And Street Construction		3429	Hardware, Nec
	1721	Painting And Paper Hanging		3431	Metal Sanitary Ware
	1791	Structural Steel Erection		3441	Fabricated Structural Metal
	1799	Special Trade Contractors, Nec		3442	Metal Doors, Sash, And Trim
	2033	Canned Fruits And Vegetables		3443	Fabricated Plate Work (boiler Shops)
	2052	Cookies And Crackers		3444	Sheet Metalwork
	2111	Cigarettes		3446	Architectural Metal Work
	2421	Sawmills And Planing Mills, General		3448	Prefabricated Metal Buildings
	2431	Millwork		3449	Miscellaneous Metal Work
	2434	Wood Kitchen Cabinets		3452	Bolts, Nuts, Rivets, And Washers
	2441	Nailed Wood Boxes And Shook		3462	Iron And Steel Forgings
	2499	Wood Products, Nec		3469	Metal Stampings, Nec
	2511	Wood Household Furniture		3471	Plating And Polishing
	2512	Upholstered Household Furniture		3479	Metal Coating And Allied Services
	2514	Metal Household Furniture		3489	Ordnance And Accessories, Nec
	2521	Wood Office Furniture		3494	Valves And Pipe Fittings, Nec
	2522	Office Furniture, Except Wood		3495	Wire Springs
	2531	Public Building & Related Furniture		3496	Misc. Fabricated Wire Products
	2541	Wood Partitions And Fixtures		3498	Fabricated Pipe And Fittings
	2542	Partitions And Fixtures, Except Wood		3499	Fabricated Metal Products, Nec
	2599	Furniture And Fixtures, Nec		3519	Internal Combustion Engines, Nec
	2621	Paper Mills		3523	Farm Machinery And Equipment
	2752	Commercial Printing, Lithographic		3524	Lawn And Garden Equipment
	2812	Alkalies And Chlorine		3531	Construction Machinery
	2813	Industrial Gases		3532	Mining Machinery
	2821	Plastics Materials And Resins		3533	Oil And Gas Field Machinery
	2824	Organic Fibers, Noncellulosic		3535	Conveyors And Conveying Equipment
	2834	Pharmaceutical Preparations		3536	Hoists, Cranes, And Monorails
	2851	Paints And Allied Products		3537	Industrial Trucks And Tractors
	2865	Cyclic Crudes And Intermediates		3542	Machine Tools, Metal Forming Types
	2869	Industrial Organic Chemicals, Nec		3545	Machine Tool Accessories
	2891	Adhesives And Sealants		3549	Metalworking Machinery, Nec
	2892	Explosives		3552	Textile Machinery
	2899	Chemical Preparations, Nec		3554	Paper Industries Machinery
	2911	Petroleum Refining		3555	Printing Trades Machinery
	3069	Fabricated Rubber Products, Nec		3556	Food Products Machinery
	3087	Custom Compound Purchased Resins		3559	Special Industry Machinery, Nec
				3561	Pumps And Pumping Equipment

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	3563	Air And Gas Compressors		3995	Burial Caskets
	3564	Blowers And Fans		3996	Hard Surface Floor Coverings, Nec
	3566	Speed Changers, Drives, And Gears		3999	Manufacturing Industries, Nec
	3567	Industrial Furnaces And Ovens		4011	Railroads, Line-haul Operating
	3569	General Industrial Machinery, Nec		4013	Switching And Terminal Services
	3579	Office Machines, Nec		4111	Local And Suburban Transit
	3585	Refrigeration And Heating Equipment		4173	Bus Terminal And Service Facilities
	3586	Measuring And Dispensing Pumps		4212	Local Trucking, Without Storage
	3589	Service Industry Machinery, Nec		4213	Trucking, Except Local
	3596	Scales And Balances, Exc. Laboratory		4231	Trucking Terminal Facilities
	3599	Industrial Machinery, Nec		4512	Air Transportation, Scheduled
	3612	Transformers, Except Electronic		4581	Airports, Flying Fields, & Services
	3621	Motors And Generators		4613	Refined Petroleum Pipelines
	3625	Relays And Industrial Controls		4741	Rental Of Railroad Cars
	3629	Electrical Industrial Apparatus, Nec		4911	Electric Services
	3631	Household Cooking Equipment		4923	Gas Transmission And Distribution
	3632	Household Refrigerators And Freezers		4931	Electric And Other Services Combined
	3633	Household Laundry Equipment		4941	Water Supply
	3634	Electric Housewares And Fans		4953	Refuse Systems
	3639	Household Appliances, Nec		4961	Steam And Air-conditioning Supply
	3641	Electric Lamps		5012	Automobiles And Other Motor Vehicles
	3643	Current-carrying Wiring Devices		5015	Motor Vehicle Parts, Used
	3644	Noncurrent-carrying Wiring Devices		5082	Construction And Mining Machinery
	3645	Residential Lighting Fixtures		5085	Industrial Supplies
	3646	Commercial Lighting Fixtures		5093	Scrap And Waste Materials
	3648	Lighting Equipment, Nec		5113	Industrial & Personal Service Paper
	3663	Radio & TV Communications Equipment		5169	Chemicals & Allied Products, Nec
	3669	Communications Equipment, Nec		5171	Petroleum Bulk Stations & Terminals
	3671	Electron Tubes		5211	Lumber And Other Building Materials
	3674	Semiconductors And Related Devices		5231	Paint, Glass, And Wallpaper Stores
	3676	Electronic Resistors		5511	New And Used Car Dealers
	3679	Electronic Components, Nec		5521	Used Car Dealers
	3694	Engine Electrical Equipment		5541	Gasoline Service Stations
	3711	Motor Vehicles And Car Bodies		5712	Furniture Stores
	3713	Truck And Bus Bodies		5943	Stationery Stores
	3714	Motor Vehicle Parts And Accessories		6531	Real Estate Agents And Managers
	3715	Truck Trailers		7011	Hotels And Motels
	3721	Aircraft		7216	Drycleaning Plants, Except Rug
	3724	Aircraft Engines And Engine Parts		7312	Outdoor Advertising Services
	3728	Aircraft Parts And Equipment, Nec		7389	Business Services, Nec
	3731	Ship Building And Repairing		7514	Passenger Car Rental
	3732	Boat Building And Repairing		7521	Automobile Parking
	3743	Railroad Equipment		7532	Top & Body Repair & Paint Shops
	3761	Guided Missiles And Space Vehicles		7538	General Automotive Repair Shops
	3764	Space Propulsion Units And Parts		7549	Automotive Services, Nec
	3792	Travel Trailers And Campers		7629	Electrical Repair Shops, Nec
	3795	Tanks And Tank Components		7641	Reupholstery And Furniture Repair
	3799	Transportation Equipment, Nec		7699	Repair Services, Nec
	3812	Search And Navigation Equipment		7812	Motion Picture & Video Production
	3822	Environmental Controls		7999	Amusement And Recreation, Nec
	3823	Process Control Instruments		8059	Nursing And Personal Care, Nec
	3824	Fluid Meters And Counting Devices		8062	General Medical & Surgical Hospitals
	3841	Surgical And Medical Instruments		8211	Elementary And Secondary Schools
	3842	Surgical Appliances And Supplies		8221	Colleges And Universities
	3843	Dental Equipment And Supplies		8249	Vocational Schools, Nec
	3844	X-ray Apparatus And Tubes		8322	Individual And Family Services
	3845	Electromedical Equipment		8731	Commercial Physical Research
	3851	Ophthalmic Goods		8733	Noncommercial Research Organizations
	3861	Photographic Equipment And Supplies		8734	Testing Laboratories
	3949	Sporting And Athletic Goods, Nec		8999	Services, Nec
	3991	Brooms And Brushes		9199	General Government, Nec
	3993	Signs And Advertising Specialities		9223	Correctional Institutions

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	9611	Admin. Of General Economic Programs		3431	Metal Sanitary Ware
	9711	National Security		3432	Plumbing Fixture Fittings And Trim
4-02-006		<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Surface Coating Application - General</i>		3441	Fabricated Structural Metal
	1221	Bituminous Coal And Lignite Surface		3442	Metal Doors, Sash, And Trim
	1311	Crude Petroleum And Natural Gas		3443	Fabricated Plate Work (boiler Shops)
	1531	Operative Builders		3444	Sheet Metalwork
	1721	Painting And Paper Hanging		3446	Architectural Metal Work
	1791	Structural Steel Erection		3448	Prefabricated Metal Buildings
	1799	Special Trade Contractors, Nec		3449	Miscellaneous Metal Work
	2052	Cookies And Crackers		3452	Bolts, Nuts, Rivets, And Washers
	2426	Hardwood Dimension & Flooring Mills		3465	Automotive Stampings
	2431	Millwork		3469	Metal Stampings, Nec
	2434	Wood Kitchen Cabinets		3471	Plating And Polishing
	2435	Hardwood Veneer And Plywood		3479	Metal Coating And Allied Services
	2493	Reconstituted Wood Products		3484	Small Arms
	2499	Wood Products, Nec		3489	Ordnance And Accessories, Nec
	2511	Wood Household Furniture		3494	Valves And Pipe Fittings, Nec
	2512	Upholstered Household Furniture		3496	Misc. Fabricated Wire Products
	2514	Metal Household Furniture		3497	Metal Foil And Leaf
	2517	Wood Tv And Radio Cabinets		3499	Fabricated Metal Products, Nec
	2519	Household Furniture, Nec		3519	Internal Combustion Engines, Nec
	2521	Wood Office Furniture		3523	Farm Machinery And Equipment
	2522	Office Furniture, Except Wood		3524	Lawn And Garden Equipment
	2531	Public Building & Related Furniture		3531	Construction Machinery
	2541	Wood Partitions And Fixtures		3532	Mining Machinery
	2542	Partitions And Fixtures, Except Wood		3533	Oil And Gas Field Machinery
	2599	Furniture And Fixtures, Nec		3535	Conveyors And Conveying Equipment
	2631	Paperboard Mills		3536	Hoists, Cranes, And Monorails
	2671	Paper Coated & Laminated, Packaging		3537	Industrial Trucks And Tractors
	2672	Paper Coated And Laminated, Nec		3542	Machine Tools, Metal Forming Types
	2752	Commercial Printing, Lithographic		3545	Machine Tool Accessories
	2754	Commercial Printing, Gravure		3548	Welding Apparatus
	2771	Greeting Cards		3553	Woodworking Machinery
	2824	Organic Fibers, Noncellulosic		3556	Food Products Machinery
	2834	Pharmaceutical Preparations		3559	Special Industry Machinery, Nec
	2851	Paints And Allied Products		3561	Pumps And Pumping Equipment
	2891	Adhesives And Sealants		3563	Air And Gas Compressors
	2899	Chemical Preparations, Nec		3566	Speed Changers, Drives, And Gears
	2911	Petroleum Refining		3567	Industrial Furnaces And Ovens
	3011	Tires And Inner Tubes		3569	General Industrial Machinery, Nec
	3053	Gaskets, Packing And Sealing Devices		3581	Automatic Vending Machines
	3069	Fabricated Rubber Products, Nec		3585	Refrigeration And Heating Equipment
	3085	Plastics Bottles		3589	Service Industry Machinery, Nec
	3089	Plastics Products, Nec		3596	Scales And Balances, Exc. Laboratory
	3143	Men's Footwear, Except Athletic		3599	Industrial Machinery, Nec
	3231	Products Of Purchased Glass		3612	Transformers, Except Electronic
	3272	Concrete Products, Nec		3621	Motors And Generators
	3275	Gypsum Products		3624	Carbon And Graphite Products
	3292	Asbestos Products		3632	Household Refrigerators And Freezers
	3312	Blast Furnaces And Steel Mills		3633	Household Laundry Equipment
	3321	Gray And Ductile Iron Foundries		3634	Electric Housewares And Fans
	3325	Steel Foundries, Nec		3639	Household Appliances, Nec
	3341	Secondary Nonferrous Metals		3645	Residential Lighting Fixtures
	3354	Aluminum Extruded Products		3663	Radio & TV Communications Equipment
	3356	Nonferrous Rolling And Drawing, Nec		3674	Semiconductors And Related Devices
	3366	Copper Foundries		3675	Electronic Capacitors
	3369	Nonferrous Foundries, Nec		3679	Electronic Components, Nec
	3411	Metal Cans		3711	Motor Vehicles And Car Bodies
	3423	Hand And Edge Tools, Nec		3713	Truck And Bus Bodies
	3429	Hardware, Nec		3714	Motor Vehicle Parts And Accessories
				3715	Truck Trailers
				3716	Motor Homes

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

Six-Digit SCC	SIC Code	SIC Description	Six-Digit SCC	SIC Code	SIC Description
	3721	Aircraft		8322	Individual And Family Services
	3724	Aircraft Engines And Engine Parts		8733	Noncommercial Research Organizations
	3728	Aircraft Parts And Equipment, Nec		9111	Executive Offices
	3731	Ship Building And Repairing		9199	General Government, Nec
	3732	Boat Building And Repairing		9223	Correctional Institutions
	3743	Railroad Equipment		9711	National Security
	3764	Space Propulsion Units And Parts			
	3792	Travel Trailers And Campers	4-02-007	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Surface Coating Application - General</i>	
	3795	Tanks And Tank Components		1021	Copper Ores
	3799	Transportation Equipment, Nec		1311	Crude Petroleum And Natural Gas
	3812	Search And Navigation Equipment		1799	Special Trade Contractors, Nec
	3826	Analytical Instruments		2047	Dog And Cat Food
	3842	Surgical Appliances And Supplies		2241	Narrow Fabric Mills
	3844	X-ray Apparatus And Tubes		2261	Finishing Plants, Cotton
	3845	Electromedical Equipment		2281	Yarn Spinning Mills
	3861	Photographic Equipment And Supplies		2295	Coated Fabrics, Not Rubberized
	3949	Sporting And Athletic Goods, Nec		2296	Tire Cord And Fabrics
	3993	Signs And Advertising Specialties		2299	Textile Goods, Nec
	3995	Burial Caskets		2396	Automotive And Apparel Trimmings
	3999	Manufacturing Industries, Nec		2426	Hardwood Dimension & Flooring Mills
	4011	Railroads, Line-haul Operating		2431	Millwork
	4013	Switching And Terminal Services		2434	Wood Kitchen Cabinets
	4111	Local And Suburban Transit		2435	Hardwood Veneer And Plywood
	4173	Bus Terminal And Service Facilities		2436	Softwood Veneer And Plywood
	4231	Trucking Terminal Facilities		2451	Mobile Homes
	4311	U.S. Postal Service		2493	Reconstituted Wood Products
	4512	Air Transportation, Scheduled		2499	Wood Products, Nec
	4581	Airports, Flying Fields, & Services		2511	Wood Household Furniture
	4789	Transportation Services, Nec		2512	Upholstered Household Furniture
	4911	Electric Services		2514	Metal Household Furniture
	4931	Electric And Other Services Combined		2515	Mattresses And Bedsprings
	4953	Refuse Systems		2517	Wood Tv And Radio Cabinets
	4961	Steam And Air-conditioning Supply		2521	Wood Office Furniture
	5012	Automobiles And Other Motor Vehicles		2522	Office Furniture, Except Wood
	5021	Furniture		2531	Public Building & Related Furniture
	5051	Metals Service Centers And Offices		2541	Wood Partitions And Fixtures
	5113	Industrial & Personal Service Paper		2542	Partitions And Fixtures, Except Wood
	5171	Petroleum Bulk Stations & Terminals		2599	Furniture And Fixtures, Nec
	5211	Lumber And Other Building Materials		2621	Paper Mills
	5511	New And Used Car Dealers		2631	Paperboard Mills
	5521	Used Car Dealers		2653	Corrugated And Solid Fiber Boxes
	5541	Gasoline Service Stations		2655	Fiber Cans, Drums & Similar Products
	5599	Automotive Dealers, Nec		2656	Sanitary Food Containers
	5712	Furniture Stores		2657	Folding Paperboard Boxes
	5932	Used Merchandise Stores		2671	Paper Coated & Laminated, Packaging
	6553	Cemetery Subdividers And Developers		2672	Paper Coated And Laminated, Nec
	7216	Drycleaning Plants, Except Rug		2673	Bags: Plastics, Laminated, & Coated
	7389	Business Services, Nec		2674	Bags: Uncoated Paper & Multiwall
	7514	Passenger Car Rental		2675	Die-cut Paper And Board
	7521	Automobile Parking		2676	Sanitary Paper Products
	7532	Top & Body Repair & Paint Shops		2677	Envelopes
	7538	General Automotive Repair Shops		2679	Converted Paper Products, Nec
	7539	Automotive Repair Shops, Nec		2711	Newspapers
	7629	Electrical Repair Shops, Nec		2721	Periodicals
	7641	Reupholstery And Furniture Repair		2732	Book Printing
	7694	Armature Rewinding Shops		2752	Commercial Printing, Lithographic
	7699	Repair Services, Nec		2754	Commercial Printing, Gravure
	7812	Motion Picture & Video Production		2759	Commercial Printing, Nec
	7999	Amusement And Recreation, Nec		2761	Manifold Business Forms
	8062	General Medical & Surgical Hospitals		2771	Greeting Cards
	8211	Elementary And Secondary Schools		2782	Blankbooks And Looseleaf Binders
	8221	Colleges And Universities			

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	2816	Inorganic Pigments		3489	Ordnance And Accessories, Nec
	2819	Industrial Inorganic Chemicals, Nec		3491	Industrial Valves
	2821	Plastics Materials And Resins		3499	Fabricated Metal Products, Nec
	2822	Synthetic Rubber		3523	Farm Machinery And Equipment
	2823	Cellulosic Manmade Fibers		3531	Construction Machinery
	2824	Organic Fibers, Noncellulosic		3533	Oil And Gas Field Machinery
	2834	Pharmaceutical Preparations		3534	Elevators And Moving Stairways
	2841	Soap And Other Detergents		3541	Machine Tools, Metal Cutting Types
	2842	Polishes And Sanitation Goods		3555	Printing Trades Machinery
	2851	Paints And Allied Products		3559	Special Industry Machinery, Nec
	2865	Cyclic Crudes And Intermediates		3561	Pumps And Pumping Equipment
	2869	Industrial Organic Chemicals, Nec		3564	Blowers And Fans
	2891	Adhesives And Sealants		3568	Power Transmission Equipment, Nec
	2911	Petroleum Refining		3569	General Industrial Machinery, Nec
	2952	Asphalt Felts And Coatings		3577	Computer Peripheral Equipment, Nec
	3011	Tires And Inner Tubes		3585	Refrigeration And Heating Equipment
	3021	Rubber And Plastics Footwear		3589	Service Industry Machinery, Nec
	3052	Rubber & Plastics Hose & Belting		3599	Industrial Machinery, Nec
	3053	Gaskets, Packing And Sealing Devices		3612	Transformers, Except Electronic
	3061	Mechanical Rubber Goods		3621	Motors And Generators
	3069	Fabricated Rubber Products, Nec		3625	Relays And Industrial Controls
	3081	Unsupported Plastics Film & Sheet		3633	Household Laundry Equipment
	3082	Unsupported Plastics Profile Shapes		3641	Electric Lamps
	3085	Plastics Bottles		3643	Current-carrying Wiring Devices
	3086	Plastics Foam Products		3645	Residential Lighting Fixtures
	3087	Custom Compound Purchased Resins		3651	Household Audio And Video Equipment
	3088	Plastics Plumbing Fixtures		3663	Radio & TV Communications Equipment
	3089	Plastics Products, Nec		3674	Semiconductors And Related Devices
	3111	Leather Tanning And Finishing		3675	Electronic Capacitors
	3131	Footwear Cut Stock		3679	Electronic Components, Nec
	3143	Men's Footwear, Except Athletic		3694	Engine Electrical Equipment
	3144	Women's Footwear, Except Athletic		3711	Motor Vehicles And Car Bodies
	3149	Footwear, Except Rubber, Nec		3713	Truck And Bus Bodies
	3172	Personal Leather Goods, Nec		3714	Motor Vehicle Parts And Accessories
	3221	Glass Containers		3715	Truck Trailers
	3231	Products Of Purchased Glass		3716	Motor Homes
	3291	Abrasive Products		3721	Aircraft
	3292	Asbestos Products		3724	Aircraft Engines And Engine Parts
	3296	Mineral Wool		3728	Aircraft Parts And Equipment, Nec
	3315	Steel Wire And Related Products		3731	Ship Building And Repairing
	3316	Cold Finishing Of Steel Shapes		3732	Boat Building And Repairing
	3321	Gray And Ductile Iron Foundries		3743	Railroad Equipment
	3354	Aluminum Extruded Products		3751	Motorcycles, Bicycles, And Parts
	3357	Nonferrous Wiredrawing & Insulating		3761	Guided Missiles And Space Vehicles
	3411	Metal Cans		3792	Travel Trailers And Campers
	3412	Metal Barrels, Drums, And Pails		3799	Transportation Equipment, Nec
	3421	Cutlery		3812	Search And Navigation Equipment
	3423	Hand And Edge Tools, Nec		3822	Environmental Controls
	3429	Hardware, Nec		3841	Surgical And Medical Instruments
	3433	Heating Equipment, Except Electric		3842	Surgical Appliances And Supplies
	3441	Fabricated Structural Metal		3844	X-ray Apparatus And Tubes
	3442	Metal Doors, Sash, And Trim		3861	Photographic Equipment And Supplies
	3443	Fabricated Plate Work (boiler Shops)		3931	Musical Instruments
	3444	Sheet Metalwork		3949	Sporting And Athletic Goods, Nec
	3446	Architectural Metal Work		3952	Lead Pencils And Art Goods
	3448	Prefabricated Metal Buildings		3991	Brooms And Brushes
	3449	Miscellaneous Metal Work		3993	Signs And Advertising Specialities
	3452	Bolts, Nuts, Rivets, And Washers		3995	Burial Caskets
	3465	Automotive Stampings		3996	Hard Surface Floor Coverings, Nec
	3469	Metal Stampings, Nec		3999	Manufacturing Industries, Nec
	3471	Plating And Polishing		4581	Airports, Flying Fields, & Services
	3479	Metal Coating And Allied Services		4931	Electric And Other Services Combined

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	5087	Service Establishment Equipment		2759	Commercial Printing, Nec
	5113	Industrial & Personal Service Paper		2796	Platemaking Services
	5171	Petroleum Bulk Stations & Terminals		2816	Inorganic Pigments
	5511	New And Used Car Dealers		2821	Plastics Materials And Resins
	5561	Recreational Vehicle Dealers		2834	Pharmaceutical Preparations
	5712	Furniture Stores		2844	Toilet Preparations
	5912	Drug Stores And Proprietary Stores		2851	Paints And Allied Products
	6321	Accident And Health Insurance		2865	Cyclic Crudes And Intermediates
	7389	Business Services, Nec		2891	Adhesives And Sealants
	7532	Top & Body Repair & Paint Shops		2892	Explosives
	7534	Tire Retreading And Repair Shops		2893	Printing Ink
	7538	General Automotive Repair Shops		2899	Chemical Preparations, Nec
	8062	General Medical & Surgical Hospitals		2911	Petroleum Refining
	8734	Testing Laboratories		2951	Asphalt Paving Mixtures And Blocks
	9199	General Government, Nec		3011	Tires And Inner Tubes
	9223	Correctional Institutions		3053	Gaskets, Packing And Sealing Devices
	9711	National Security		3061	Mechanical Rubber Goods
4-02-008	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Coating Oven - General</i>			3069	Fabricated Rubber Products, Nec
	1389	Oil And Gas Field Services, Nec		3081	Unsupported Plastics Film & Sheet
	1721	Painting And Paper Hanging		3085	Plastics Bottles
	1761	Roofing, Siding, And Sheet Metal Work		3088	Plastics Plumbing Fixtures
	1795	Wrecking And Demolition Work		3089	Plastics Products, Nec
	2035	Pickles, Sauces, And Salad Dressings		3111	Leather Tanning And Finishing
	2041	Flour And Other Grain Mill Products		3143	Men's Footwear, Except Athletic
	2241	Narrow Fabric Mills		3221	Glass Containers
	2261	Finishing Plants, Cotton		3231	Products Of Purchased Glass
	2262	Finishing Plants, Manmade		3263	Semivitreous Table & Kitchenware
	2269	Finishing Plants, Nec		3281	Cut Stone And Stone Products
	2281	Yarn Spinning Mills		3291	Abrasive Products
	2295	Coated Fabrics, Not Rubberized		3292	Asbestos Products
	2297	Nonwoven Fabrics		3299	Nonmetallic Mineral Products, Nec
	2299	Textile Goods, Nec		3312	Blast Furnaces And Steel Mills
	2396	Automotive And Apparel Trimmings		3316	Cold Finishing Of Steel Shapes
	2399	Fabricated Textile Products, Nec		3317	Steel Pipe And Tubes
	2426	Hardwood Dimension & Flooring Mills		3321	Gray And Ductile Iron Foundries
	2431	Millwork		3322	Malleable Iron Foundries
	2434	Wood Kitchen Cabinets		3341	Secondary Nonferrous Metals
	2435	Hardwood Veneer And Plywood		3353	Aluminum Sheet, Plate, And Foil
	2491	Wood Preserving		3354	Aluminum Extruded Products
	2499	Wood Products, Nec		3356	Nonferrous Rolling And Drawing, Nec
	2511	Wood Household Furniture		3357	Nonferrous Wiredrawing & Insulating
	2514	Metal Household Furniture		3366	Copper Foundries
	2517	Wood Tv And Radio Cabinets		3369	Nonferrous Foundries, Nec
	2521	Wood Office Furniture		3399	Primary Metal Products, Nec
	2522	Office Furniture, Except Wood		3411	Metal Cans
	2531	Public Building & Related Furniture		3412	Metal Barrels, Drums, And Pails
	2541	Wood Partitions And Fixtures		3423	Hand And Edge Tools, Nec
	2542	Partitions And Fixtures, Except Wood		3429	Hardware, Nec
	2599	Furniture And Fixtures, Nec		3431	Metal Sanitary Ware
	2621	Paper Mills		3433	Heating Equipment, Except Electric
	2655	Fiber Cans, Drums & Similar Products		3441	Fabricated Structural Metal
	2656	Sanitary Food Containers		3442	Metal Doors, Sash, And Trim
	2671	Paper Coated & Laminated, Packaging		3443	Fabricated Plate Work (boiler Shops)
	2672	Paper Coated And Laminated, Nec		3444	Sheet Metalwork
	2673	Bags: Plastics, Laminated, & Coated		3446	Architectural Metal Work
	2679	Converted Paper Products, Nec		3448	Prefabricated Metal Buildings
	2731	Book Publishing		3449	Miscellaneous Metal Work
	2732	Book Printing		3462	Iron And Steel Forgings
	2752	Commercial Printing, Lithographic		3465	Automotive Stampings
	2754	Commercial Printing, Gravure		3466	Crowns And Closures
				3469	Metal Stampings, Nec
				3471	Plating And Polishing



## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	3479	Metal Coating And Allied Services		3743	Railroad Equipment
	3483	Ammunition, Exc. For Small Arms, Nec		3751	Motorcycles, Bicycles, And Parts
	3489	Ordnance And Accessories, Nec		3761	Guided Missiles And Space Vehicles
	3496	Misc. Fabricated Wire Products		3795	Tanks And Tank Components
	3497	Metal Foil And Leaf		3799	Transportation Equipment, Nec
	3499	Fabricated Metal Products, Nec		3812	Search And Navigation Equipment
	3519	Internal Combustion Engines, Nec		3821	Laboratory Apparatus And Furniture
	3523	Farm Machinery And Equipment		3822	Environmental Controls
	3524	Lawn And Garden Equipment		3826	Analytical Instruments
	3531	Construction Machinery		3829	Measuring & Controlling Devices, Nec
	3532	Mining Machinery		3841	Surgical And Medical Instruments
	3534	Elevators And Moving Stairways		3842	Surgical Appliances And Supplies
	3541	Machine Tools, Metal Cutting Types		3844	X-ray Apparatus And Tubes
	3542	Machine Tools, Metal Forming Types		3845	Electromedical Equipment
	3544	Special Dies, Tools, Jigs & Fixtures		3861	Photographic Equipment And Supplies
	3546	Power-driven Handtools		3873	Watches, Clocks, Watchcases & Parts
	3555	Printing Trades Machinery		3911	Jewelry, Precious Metal
	3559	Special Industry Machinery, Nec		3931	Musical Instruments
	3561	Pumps And Pumping Equipment		3944	Games, Toys, And Children's Vehicles
	3563	Air And Gas Compressors		3949	Sporting And Athletic Goods, Nec
	3564	Blowers And Fans		3955	Carbon Paper And Inked Ribbons
	3567	Industrial Furnaces And Ovens		3965	Fasteners, Buttons, Needles, & Pins
	3569	General Industrial Machinery, Nec		3993	Signs And Advertising Specialities
	3571	Electronic Computers		3995	Burial Caskets
	3579	Office Machines, Nec		3996	Hard Surface Floor Coverings, Nec
	3581	Automatic Vending Machines		3999	Manufacturing Industries, Nec
	3585	Refrigeration And Heating Equipment		4581	Airports, Flying Fields, & Services
	3589	Service Industry Machinery, Nec		4789	Transportation Services, Nec
	3596	Scales And Balances, Exc. Laboratory		4953	Refuse Systems
	3599	Industrial Machinery, Nec		5082	Construction And Mining Machinery
	3612	Transformers, Except Electronic		5085	Industrial Supplies
	3621	Motors And Generators		5511	New And Used Car Dealers
	3625	Relays And Industrial Controls		5712	Furniture Stores
	3629	Electrical Industrial Apparatus, Nec		5984	Liquefied Petroleum Gas Dealers
	3631	Household Cooking Equipment		6512	Nonresidential Building Operators
	3632	Household Refrigerators And Freezers		6513	Apartment Building Operators
	3633	Household Laundry Equipment		7216	Drycleaning Plants, Except Rug
	3634	Electric Housewares And Fans		7389	Business Services, Nec
	3639	Household Appliances, Nec		7532	Top & Body Repair & Paint Shops
	3641	Electric Lamps		7641	Reupholstery And Furniture Repair
	3643	Current-carrying Wiring Devices		7694	Armature Rewinding Shops
	3645	Residential Lighting Fixtures		7699	Repair Services, Nec
	3646	Commercial Lighting Fixtures		8062	General Medical & Surgical Hospitals
	3647	Vehicular Lighting Equipment		8733	Noncommercial Research Organizations
	3648	Lighting Equipment, Nec		8734	Testing Laboratories
	3651	Household Audio And Video Equipment		9223	Correctional Institutions
	3661	Telephone And Telegraph Apparatus		9611	Admin. Of General Economic Programs
	3663	Radio & TV Communications Equipment		9661	Space Research And Technology
	3669	Communications Equipment, Nec		9711	National Security
	3671	Electron Tubes			
	3674	Semiconductors And Related Devices	4-02-009	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Thinning Solvents - General</i>	
	3679	Electronic Components, Nec		0181	Ornamental Nursery Products
	3691	Storage Batteries		0723	Crop Preparation Services For Market
	3694	Engine Electrical Equipment		1221	Bituminous Coal And Lignite Surface
	3699	Electrical Equipment & Supplies, Nec		1311	Crude Petroleum And Natural Gas
	3711	Motor Vehicles And Car Bodies		1382	Oil And Gas Exploration Services
	3713	Truck And Bus Bodies		1389	Oil And Gas Field Services, Nec
	3714	Motor Vehicle Parts And Accessories		1521	Single-family Housing Construction
	3721	Aircraft		1531	Operative Builders
	3724	Aircraft Engines And Engine Parts		1611	Highway And Street Construction
	3728	Aircraft Parts And Equipment, Nec		1629	Heavy Construction, Nec
	3731	Ship Building And Repairing			

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	1721	Painting And Paper Hanging		2653	Corrugated And Solid Fiber Boxes
	1761	Roofing, Siding, And Sheet Metal Work		2655	Fiber Cans, Drums & Similar Products
	1791	Structural Steel Erection		2656	Sanitary Food Containers
	1799	Special Trade Contractors, Nec		2657	Folding Paperboard Boxes
	2011	Meat Packing Plants		2671	Paper Coated & Laminated, Packaging
	2033	Canned Fruits And Vegetables		2672	Paper Coated And Laminated, Nec
	2041	Flour And Other Grain Mill Products		2673	Bags: Plastics, Laminated, & Coated
	2051	Bread, Cake, And Related Products		2677	Envelopes
	2052	Cookies And Crackers		2679	Converted Paper Products, Nec
	2075	Soybean Oil Mills		2711	Newspapers
	2076	Vegetable Oil Mills, Nec		2732	Book Printing
	2082	Malt Beverages		2752	Commercial Printing, Lithographic
	2085	Distilled And Blended Liquors		2754	Commercial Printing, Gravure
	2096	Potato Chips And Similar Snacks		2759	Commercial Printing, Nec
	2211	Broadwoven Fabric Mills, Cotton		2761	Manifold Business Forms
	2221	Broadwoven Fabric Mills, Manmade		2771	Greeting Cards
	2231	Broadwoven Fabric Mills, Wool		2782	Blankbooks And Looseleaf Binders
	2253	Knit Outerwear Mills		2789	Bookbinding And Related Work
	2258	Lace & Warp Knit Fabric Mills		2796	Platemaking Services
	2261	Finishing Plants, Cotton		2812	Alkalies And Chlorine
	2262	Finishing Plants, Manmade		2813	Industrial Gases
	2269	Finishing Plants, Nec		2819	Industrial Inorganic Chemicals, Nec
	2273	Carpets And Rugs		2821	Plastics Materials And Resins
	2281	Yarn Spinning Mills		2822	Synthetic Rubber
	2282	Throwing And Winding Mills		2823	Cellulosic Manmade Fibers
	2284	Thread Mills		2824	Organic Fibers, Noncellulosic
	2295	Coated Fabrics, Not Rubberized		2833	Medicinals And Botanicals
	2296	Tire Cord And Fabrics		2834	Pharmaceutical Preparations
	2297	Nonwoven Fabrics		2841	Soap And Other Detergents
	2298	Cordage And Twine		2842	Polishes And Sanitation Goods
	2299	Textile Goods, Nec		2843	Surface Active Agents
	2329	Men's And Boys' Clothing, Nec		2844	Toilet Preparations
	2392	Housefurnishings, Nec		2851	Paints And Allied Products
	2394	Canvas And Related Products		2865	Cyclic Crudes And Intermediates
	2396	Automotive And Apparel Trimmings		2869	Industrial Organic Chemicals, Nec
	2399	Fabricated Textile Products, Nec		2891	Adhesives And Sealants
	2421	Sawmills And Planing Mills, General		2892	Explosives
	2426	Hardwood Dimension & Flooring Mills		2893	Printing Ink
	2431	Millwork		2899	Chemical Preparations, Nec
	2434	Wood Kitchen Cabinets		2911	Petroleum Refining
	2435	Hardwood Veneer And Plywood		2951	Asphalt Paving Mixtures And Blocks
	2436	Softwood Veneer And Plywood		2992	Lubricating Oils And Greases
	2439	Structural Wood Members, Nec		3011	Tires And Inner Tubes
	2441	Nailed Wood Boxes And Shook		3052	Rubber & Plastics Hose & Belting
	2451	Mobile Homes		3053	Gaskets, Packing And Sealing Devices
	2452	Prefabricated Wood Buildings		3061	Mechanical Rubber Goods
	2493	Reconstituted Wood Products		3069	Fabricated Rubber Products, Nec
	2499	Wood Products, Nec		3081	Unsupported Plastics Film & Sheet
	2511	Wood Household Furniture		3082	Unsupported Plastics Profile Shapes
	2512	Upholstered Household Furniture		3083	Laminated Plastics Plate & Sheet
	2514	Metal Household Furniture		3084	Plastics Pipe
	2517	Wood Tv And Radio Cabinets		3085	Plastics Bottles
	2519	Household Furniture, Nec		3086	Plastics Foam Products
	2521	Wood Office Furniture		3087	Custom Compound Purchased Resins
	2522	Office Furniture, Except Wood		3088	Plastics Plumbing Fixtures
	2531	Public Building & Related Furniture		3089	Plastics Products, Nec
	2541	Wood Partitions And Fixtures		3111	Leather Tanning And Finishing
	2542	Partitions And Fixtures, Except Wood		3143	Men's Footwear, Except Athletic
	2599	Furniture And Fixtures, Nec		3144	Women's Footwear, Except Athletic
	2611	Pulp Mills		3221	Glass Containers
	2621	Paper Mills		3229	Pressed And Blown Glass, Nec
	2631	Paperboard Mills		3231	Products Of Purchased Glass

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	3251	Brick And Structural Clay Tile		3497	Metal Foil And Leaf
	3255	Clay Refractories		3498	Fabricated Pipe And Fittings
	3261	Vitreous Plumbing Fixtures		3499	Fabricated Metal Products, Nec
	3264	Porcelain Electrical Supplies		3511	Turbines And Turbine Generator Sets
	3269	Pottery Products, Nec		3519	Internal Combustion Engines, Nec
	3272	Concrete Products, Nec		3523	Farm Machinery And Equipment
	3275	Gypsum Products		3524	Lawn And Garden Equipment
	3281	Cut Stone And Stone Products		3531	Construction Machinery
	3291	Abrasive Products		3532	Mining Machinery
	3292	Asbestos Products		3533	Oil And Gas Field Machinery
	3295	Minerals, Ground Or Treated		3534	Elevators And Moving Stairways
	3296	Mineral Wool		3535	Conveyors And Conveying Equipment
	3299	Nonmetallic Mineral Products, Nec		3536	Hoists, Cranes, And Monorails
	3312	Blast Furnaces And Steel Mills		3537	Industrial Trucks And Tractors
	3315	Steel Wire And Related Products		3541	Machine Tools, Metal Cutting Types
	3317	Steel Pipe And Tubes		3542	Machine Tools, Metal Forming Types
	3321	Gray And Ductile Iron Foundries		3545	Machine Tool Accessories
	3324	Steel Investment Foundries		3548	Welding Apparatus
	3325	Steel Foundries, Nec		3549	Metalworking Machinery, Nec
	3331	Primary Copper		3552	Textile Machinery
	3339	Primary Nonferrous Metals, Nec		3553	Woodworking Machinery
	3341	Secondary Nonferrous Metals		3554	Paper Industries Machinery
	3351	Copper Rolling And Drawing		3555	Printing Trades Machinery
	3353	Aluminum Sheet, Plate, And Foil		3556	Food Products Machinery
	3354	Aluminum Extruded Products		3559	Special Industry Machinery, Nec
	3356	Nonferrous Rolling And Drawing, Nec		3561	Pumps And Pumping Equipment
	3357	Nonferrous Wiredrawing & Insulating		3562	Ball And Roller Bearings
	3363	Aluminum Die-castings		3563	Air And Gas Compressors
	3365	Aluminum Foundries		3564	Blowers And Fans
	3366	Copper Foundries		3566	Speed Changers, Drives, And Gears
	3398	Metal Heat Treating		3567	Industrial Furnaces And Ovens
	3399	Primary Metal Products, Nec		3569	General Industrial Machinery, Nec
	3411	Metal Cans		3571	Electronic Computers
	3412	Metal Barrels, Drums, And Pails		3572	Computer Storage Devices
	3421	Cutlery		3577	Computer Peripheral Equipment, Nec
	3423	Hand And Edge Tools, Nec		3579	Office Machines, Nec
	3429	Hardware, Nec		3581	Automatic Vending Machines
	3431	Metal Sanitary Ware		3582	Commercial Laundry Equipment
	3432	Plumbing Fixture Fittings And Trim		3585	Refrigeration And Heating Equipment
	3433	Heating Equipment, Except Electric		3586	Measuring And Dispensing Pumps
	3441	Fabricated Structural Metal		3589	Service Industry Machinery, Nec
	3442	Metal Doors, Sash, And Trim		3592	Carburetors, Pistons, Rings, Valves
	3443	Fabricated Plate Work (boiler Shops)		3596	Scales And Balances, Exc. Laboratory
	3444	Sheet Metalwork		3599	Industrial Machinery, Nec
	3446	Architectural Metal Work		3612	Transformers, Except Electronic
	3448	Prefabricated Metal Buildings		3621	Motors And Generators
	3449	Miscellaneous Metal Work		3624	Carbon And Graphite Products
	3452	Bolts, Nuts, Rivets, And Washers		3625	Relays And Industrial Controls
	3462	Iron And Steel Forgings		3629	Electrical Industrial Apparatus, Nec
	3465	Automotive Stampings		3632	Household Refrigerators And Freezers
	3466	Crowns And Closures		3633	Household Laundry Equipment
	3469	Metal Stampings, Nec		3634	Electric Housewares And Fans
	3471	Plating And Polishing		3639	Household Appliances, Nec
	3479	Metal Coating And Allied Services		3641	Electric Lamps
	3482	Small Arms Ammunition		3643	Current-carrying Wiring Devices
	3483	Ammunition, Exc. For Small Arms, Nec		3644	Noncurrent-carrying Wiring Devices
	3484	Small Arms		3645	Residential Lighting Fixtures
	3489	Ordnance And Accessories, Nec		3646	Commercial Lighting Fixtures
	3491	Industrial Valves		3648	Lighting Equipment, Nec
	3494	Valves And Pipe Fittings, Nec		3651	Household Audio And Video Equipment
	3495	Wire Springs		3661	Telephone And Telegraph Apparatus
	3496	Misc. Fabricated Wire Products		3663	Radio & TV Communications Equipment

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	3671	Electron Tubes		4226	Special Warehousing And Storage, Nec
	3674	Semiconductors And Related Devices		4311	U.S. Postal Service
	3675	Electronic Capacitors		4449	Water Transportation Of Freight, Nec
	3676	Electronic Resistors		4493	Marinas
	3677	Electronic Coils And Transformers		4512	Air Transportation, Scheduled
	3678	Electronic Connectors		4581	Airports, Flying Fields, & Services
	3679	Electronic Components, Nec		4613	Refined Petroleum Pipelines
	3691	Storage Batteries		4741	Rental Of Railroad Cars
	3694	Engine Electrical Equipment		4789	Transportation Services, Nec
	3695	Magnetic And Optical Recording Media		4833	Television Broadcasting Stations
	3699	Electrical Equipment & Supplies, Nec		4911	Electric Services
	3711	Motor Vehicles And Car Bodies		4923	Gas Transmission And Distribution
	3713	Truck And Bus Bodies		4931	Electric And Other Services Combined
	3714	Motor Vehicle Parts And Accessories		4932	Gas And Other Services Combined
	3715	Truck Trailers		4939	Combination Utilities, Nec
	3716	Motor Homes		4941	Water Supply
	3721	Aircraft		4953	Refuse Systems
	3724	Aircraft Engines And Engine Parts		4959	Sanitary Services, Nec
	3728	Aircraft Parts And Equipment, Nec		5012	Automobiles And Other Motor Vehicles
	3731	Ship Building And Repairing		5015	Motor Vehicle Parts, Used
	3732	Boat Building And Repairing		5023	Homefurnishings
	3743	Railroad Equipment		5031	Lumber, Plywood, And Millwork
	3751	Motorcycles, Bicycles, And Parts		5033	Roofing, Siding, & Insulation
	3761	Guided Missiles And Space Vehicles		5039	Construction Materials, Nec
	3764	Space Propulsion Units And Parts		5045	Computers, Peripherals & Software
	3769	Space Vehicle Equipment, Nec		5046	Commercial Equipment, Nec
	3792	Travel Trailers And Campers		5051	Metals Service Centers And Offices
	3795	Tanks And Tank Components		5065	Electronic Parts And Equipment
	3799	Transportation Equipment, Nec		5082	Construction And Mining Machinery
	3812	Search And Navigation Equipment		5083	Farm And Garden Machinery
	3822	Environmental Controls		5084	Industrial Machinery And Equipment
	3823	Process Control Instruments		5085	Industrial Supplies
	3825	Instruments To Measure Electricity		5088	Transportation Equipment & Supplies
	3826	Analytical Instruments		5092	Toys And Hobby Goods And Supplies
	3827	Optical Instruments And Lenses		5093	Scrap And Waste Materials
	3829	Measuring & Controlling Devices, Nec		5113	Industrial & Personal Service Paper
	3841	Surgical And Medical Instruments		5122	Drugs, Proprietaries, And Sundries
	3842	Surgical Appliances And Supplies		5169	Chemicals & Allied Products, Nec
	3843	Dental Equipment And Supplies		5171	Petroleum Bulk Stations & Terminals
	3844	X-ray Apparatus And Tubes		5172	Petroleum Products, Nec
	3845	Electromedical Equipment		5211	Lumber And Other Building Materials
	3861	Photographic Equipment And Supplies		5231	Paint, Glass, And Wallpaper Stores
	3873	Watches, Clocks, Watchcases & Parts		5411	Grocery Stores
	3911	Jewelry, Precious Metal		5511	New And Used Car Dealers
	3931	Musical Instruments		5521	Used Car Dealers
	3944	Games, Toys, And Children's Vehicles		5541	Gasoline Service Stations
	3949	Sporting And Athletic Goods, Nec		5599	Automotive Dealers, Nec
	3951	Pens And Mechanical Pencils		5712	Furniture Stores
	3952	Lead Pencils And Art Goods		5912	Drug Stores And Proprietary Stores
	3955	Carbon Paper And Inked Ribbons		5932	Used Merchandise Stores
	3961	Costume Jewelry		5943	Stationery Stores
	3991	Brooms And Brushes		6512	Nonresidential Building Operators
	3993	Signs And Advertising Specialities		7011	Hotels And Motels
	3995	Burial Caskets		7216	Drycleaning Plants, Except Rug
	3999	Manufacturing Industries, Nec		7261	Funeral Service And Crematories
	4011	Railroads, Line-haul Operating		7312	Outdoor Advertising Services
	4013	Switching And Terminal Services		7359	Equipment Rental & Leasing, Nec
	4111	Local And Suburban Transit		7373	Computer Integrated Systems Design
	4173	Bus Terminal And Service Facilities		7389	Business Services, Nec
	4212	Local Trucking, Without Storage		7514	Passenger Car Rental
	4213	Trucking, Except Local		7519	Utility Trailer Rental
	4215	Courier Services, Except By Air		7532	Top & Body Repair & Paint Shops

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

Six-Digit SCC	SIC Code	SIC Description	Six-Digit SCC	SIC Code	SIC Description
	7534	Tire Retreading And Repair Shops		2392	Housefurnishings, Nec
	7538	General Automotive Repair Shops		2396	Automotive And Apparel Trimmings
	7539	Automotive Repair Shops, Nec		2399	Fabricated Textile Products, Nec
	7542	Carwashes		2426	Hardwood Dimension & Flooring Mills
	7629	Electrical Repair Shops, Nec		2431	Millwork
	7641	Reupholstery And Furniture Repair		2434	Wood Kitchen Cabinets
	7692	Welding Repair		2435	Hardwood Veneer And Plywood
	7694	Armature Rewinding Shops		2451	Mobile Homes
	7699	Repair Services, Nec		2493	Reconstituted Wood Products
	7812	Motion Picture & Video Production		2499	Wood Products, Nec
	7819	Services Allied To Motion Pictures		2511	Wood Household Furniture
	7996	Amusement Parks		2512	Upholstered Household Furniture
	7999	Amusement And Recreation, Nec		2514	Metal Household Furniture
	8011	Offices & Clinics Of Medical Doctors		2515	Mattresses And Bedsprings
	8059	Nursing And Personal Care, Nec		2517	Wood Tv And Radio Cabinets
	8062	General Medical & Surgical Hospitals		2519	Household Furniture, Nec
	8063	Psychiatric Hospitals		2521	Wood Office Furniture
	8069	Specialty Hospitals Exc. Psychiatric		2522	Office Furniture, Except Wood
	8211	Elementary And Secondary Schools		2531	Public Building & Related Furniture
	8221	Colleges And Universities		2541	Wood Partitions And Fixtures
	8222	Junior Colleges		2542	Partitions And Fixtures, Except Wood
	8249	Vocational Schools, Nec		2591	Drapery Hardware & Blinds & Shades
	8711	Engineering Services		2599	Furniture And Fixtures, Nec
	8731	Commercial Physical Research		2621	Paper Mills
	8734	Testing Laboratories		2631	Paperboard Mills
	8999	Services, Nec		2652	Setup Paperboard Boxes
	9111	Executive Offices		2653	Corrugated And Solid Fiber Boxes
	9199	General Government, Nec		2655	Fiber Cans, Drums & Similar Products
	9223	Correctional Institutions		2671	Paper Coated & Laminated, Packaging
	9511	Air, Water, & Solid Waste Management		2672	Paper Coated And Laminated, Nec
	9611	Admin. Of General Economic Programs		2673	Bags: Plastics, Laminated, & Coated
	9621	Regulation, Admin. Of Transportation		2679	Converted Paper Products, Nec
	9661	Space Research And Technology		2711	Newspapers
	9711	National Security		2731	Book Publishing
				2752	Commercial Printing, Lithographic
				2754	Commercial Printing, Gravure
				2759	Commercial Printing, Nec
				2771	Greeting Cards
				2782	Blankbooks And Looseleaf Binders
				2789	Bookbinding And Related Work
				2791	Typesetting
				2796	Platemaking Services
				2819	Industrial Inorganic Chemicals, Nec
				2821	Plastics Materials And Resins
				2834	Pharmaceutical Preparations
				2841	Soap And Other Detergents
				2842	Polishes And Sanitation Goods
				2844	Toilet Preparations
				2851	Paints And Allied Products
				2865	Cyclic Crudes And Intermediates
				2869	Industrial Organic Chemicals, Nec
				2891	Adhesives And Sealants
				2893	Printing Ink
				2899	Chemical Preparations, Nec
				2911	Petroleum Refining
				2951	Asphalt Paving Mixtures And Blocks
				2952	Asphalt Felts And Coatings
				2992	Lubricating Oils And Greases
				3052	Rubber & Plastics Hose & Belting
				3053	Gaskets, Packing And Sealing Devices
				3069	Fabricated Rubber Products, Nec
				3081	Unsupported Plastics Film & Sheet
4-02-010	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Coating Oven Heater</i>				
	0182	Food Crops Grown Under Cover			
	1311	Crude Petroleum And Natural Gas			
	1711	Plumbing, Heating, Air-conditioning			
	1721	Painting And Paper Hanging			
	1799	Special Trade Contractors, Nec			
	2033	Canned Fruits And Vegetables			
	2035	Pickles, Sauces, And Salad Dressings			
	2041	Flour And Other Grain Mill Products			
	2052	Cookies And Crackers			
	2091	Canned And Cured Fish And Seafoods			
	2096	Potato Chips And Similar Snacks			
	2099	Food Preparations, Nec			
	2211	Broadwoven Fabric Mills, Cotton			
	2241	Narrow Fabric Mills			
	2251	Women's Hosiery, Except Socks			
	2253	Knit Outerwear Mills			
	2261	Finishing Plants, Cotton			
	2262	Finishing Plants, Manmade			
	2269	Finishing Plants, Nec			
	2273	Carpets And Rugs			
	2295	Coated Fabrics, Not Rubberized			
	2296	Tire Cord And Fabrics			
	2298	Cordage And Twine			
	2299	Textile Goods, Nec			
	2329	Men's And Boys' Clothing, Nec			

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	3082	Unsupported Plastics Profile Shapes		3492	Fluid Power Valves & Hose Fittings
	3083	Laminated Plastics Plate & Sheet		3496	Misc. Fabricated Wire Products
	3084	Plastics Pipe		3499	Fabricated Metal Products, Nec
	3085	Plastics Bottles		3511	Turbines And Turbine Generator Sets
	3086	Plastics Foam Products		3519	Internal Combustion Engines, Nec
	3087	Custom Compound Purchased Resins		3523	Farm Machinery And Equipment
	3088	Plastics Plumbing Fixtures		3524	Lawn And Garden Equipment
	3089	Plastics Products, Nec		3531	Construction Machinery
	3149	Footwear, Except Rubber, Nec		3532	Mining Machinery
	3221	Glass Containers		3533	Oil And Gas Field Machinery
	3229	Pressed And Blown Glass, Nec		3534	Elevators And Moving Stairways
	3231	Products Of Purchased Glass		3535	Conveyors And Conveying Equipment
	3255	Clay Refractories		3537	Industrial Trucks And Tractors
	3259	Structural Clay Products, Nec		3541	Machine Tools, Metal Cutting Types
	3272	Concrete Products, Nec		3544	Special Dies, Tools, Jigs & Fixtures
	3275	Gypsum Products		3548	Welding Apparatus
	3281	Cut Stone And Stone Products		3552	Textile Machinery
	3291	Abrasive Products		3555	Printing Trades Machinery
	3292	Asbestos Products		3556	Food Products Machinery
	3295	Minerals, Ground Or Treated		3559	Special Industry Machinery, Nec
	3296	Mineral Wool		3561	Pumps And Pumping Equipment
	3299	Nonmetallic Mineral Products, Nec		3566	Speed Changers, Drives, And Gears
	3312	Blast Furnaces And Steel Mills		3569	General Industrial Machinery, Nec
	3315	Steel Wire And Related Products		3577	Computer Peripheral Equipment, Nec
	3316	Cold Finishing Of Steel Shapes		3579	Office Machines, Nec
	3317	Steel Pipe And Tubes		3581	Automatic Vending Machines
	3321	Gray And Ductile Iron Foundries		3582	Commercial Laundry Equipment
	3324	Steel Investment Foundries		3585	Refrigeration And Heating Equipment
	3325	Steel Foundries, Nec		3589	Service Industry Machinery, Nec
	3334	Primary Aluminum		3594	Fluid Power Pumps And Motors
	3351	Copper Rolling And Drawing		3596	Scales And Balances, Exc. Laboratory
	3353	Aluminum Sheet, Plate, And Foil		3599	Industrial Machinery, Nec
	3354	Aluminum Extruded Products		3612	Transformers, Except Electronic
	3357	Nonferrous Wiredrawing & Insulating		3621	Motors And Generators
	3365	Aluminum Foundries		3624	Carbon And Graphite Products
	3366	Copper Foundries		3625	Relays And Industrial Controls
	3369	Nonferrous Foundries, Nec		3629	Electrical Industrial Apparatus, Nec
	3398	Metal Heat Treating		3631	Household Cooking Equipment
	3399	Primary Metal Products, Nec		3632	Household Refrigerators And Freezers
	3411	Metal Cans		3634	Electric Housewares And Fans
	3412	Metal Barrels, Drums, And Pails		3639	Household Appliances, Nec
	3429	Hardware, Nec		3641	Electric Lamps
	3431	Metal Sanitary Ware		3643	Current-carrying Wiring Devices
	3432	Plumbing Fixture Fittings And Trim		3645	Residential Lighting Fixtures
	3433	Heating Equipment, Except Electric		3646	Commercial Lighting Fixtures
	3441	Fabricated Structural Metal		3647	Vehicular Lighting Equipment
	3442	Metal Doors, Sash, And Trim		3648	Lighting Equipment, Nec
	3443	Fabricated Plate Work (boiler Shops)		3651	Household Audio And Video Equipment
	3444	Sheet Metalwork		3652	Prerecorded Records And Tapes
	3446	Architectural Metal Work		3663	Radio & TV Communications Equipment
	3448	Prefabricated Metal Buildings		3669	Communications Equipment, Nec
	3449	Miscellaneous Metal Work		3671	Electron Tubes
	3452	Bolts, Nuts, Rivets, And Washers		3674	Semiconductors And Related Devices
	3462	Iron And Steel Forgings		3675	Electronic Capacitors
	3465	Automotive Stampings		3677	Electronic Coils And Transformers
	3466	Crowns And Closures		3679	Electronic Components, Nec
	3469	Metal Stampings, Nec		3694	Engine Electrical Equipment
	3471	Plating And Polishing		3699	Electrical Equipment & Supplies, Nec
	3479	Metal Coating And Allied Services		3711	Motor Vehicles And Car Bodies
	3482	Small Arms Ammunition		3713	Truck And Bus Bodies
	3483	Ammunition, Exc. For Small Arms, Nec		3714	Motor Vehicle Parts And Accessories
	3489	Ordnance And Accessories, Nec		3715	Truck Trailers

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	3721	Aircraft		5912	Drug Stores And Proprietary Stores
	3728	Aircraft Parts And Equipment, Nec		5932	Used Merchandise Stores
	3732	Boat Building And Repairing		6021	National Commercial Banks
	3743	Railroad Equipment		6512	Nonresidential Building Operators
	3751	Motorcycles, Bicycles, And Parts		6513	Apartment Building Operators
	3761	Guided Missiles And Space Vehicles		6552	Subdividers And Developers, Nec
	3764	Space Propulsion Units And Parts		7011	Hotels And Motels
	3769	Space Vehicle Equipment, Nec		7216	Drycleaning Plants, Except Rug
	3799	Transportation Equipment, Nec		7336	Commercial Art And Graphic Design
	3812	Search And Navigation Equipment		7389	Business Services, Nec
	3821	Laboratory Apparatus And Furniture		7515	Passenger Car Leasing
	3822	Environmental Controls		7532	Top & Body Repair & Paint Shops
	3825	Instruments To Measure Electricity		7534	Tire Retreading And Repair Shops
	3827	Optical Instruments And Lenses		7536	Automotive Glass Replacement Shops
	3829	Measuring & Controlling Devices, Nec		7538	General Automotive Repair Shops
	3841	Surgical And Medical Instruments		7539	Automotive Repair Shops, Nec
	3842	Surgical Appliances And Supplies		7629	Electrical Repair Shops, Nec
	3843	Dental Equipment And Supplies		7694	Armature Rewinding Shops
	3845	Electromedical Equipment		7699	Repair Services, Nec
	3851	Ophthalmic Goods		7812	Motion Picture & Video Production
	3861	Photographic Equipment And Supplies		7819	Services Allied To Motion Pictures
	3914	Silverware And Plated Ware		7999	Amusement And Recreation, Nec
	3931	Musical Instruments		8062	General Medical & Surgical Hospitals
	3942	Dolls And Stuffed Toys		8211	Elementary And Secondary Schools
	3944	Games, Toys, And Children's Vehicles		8221	Colleges And Universities
	3949	Sporting And Athletic Goods, Nec		8222	Junior Colleges
	3965	Fasteners, Buttons, Needles, & Pins		8711	Engineering Services
	3991	Brooms And Brushes		8999	Services, Nec
	3993	Signs And Advertising Specialities		9199	General Government, Nec
	3995	Burial Caskets		9223	Correctional Institutions
	3996	Hard Surface Floor Coverings, Nec		9611	Admin. Of General Economic Programs
	3999	Manufacturing Industries, Nec		9711	National Security
	4491	Marine Cargo Handling			
	4581	Airports, Flying Fields, & Services	4-02-025	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Miscellaneous Metal Parts</i>	
	4741	Rental Of Railroad Cars		0111	Wheat
	4789	Transportation Services, Nec		1021	Copper Ores
	4833	Television Broadcasting Stations		1311	Crude Petroleum And Natural Gas
	4911	Electric Services		1611	Highway And Street Construction
	5015	Motor Vehicle Parts, Used		1623	Water, Sewer, And Utility Lines
	5031	Lumber, Plywood, And Millwork		1721	Painting And Paper Hanging
	5044	Office Equipment		1799	Special Trade Contractors, Nec
	5051	Metals Service Centers And Offices		2052	Cookies And Crackers
	5064	Electrical Appliances, TV & Radios		2068	Salted And Roasted Nuts And Seeds
	5065	Electronic Parts And Equipment		2082	Malt Beverages
	5072	Hardware		2295	Coated Fabrics, Not Rubberized
	5078	Refrigeration Equipment And Supplies		2299	Textile Goods, Nec
	5082	Construction And Mining Machinery		2399	Fabricated Textile Products, Nec
	5084	Industrial Machinery And Equipment		2431	Millwork
	5085	Industrial Supplies		2434	Wood Kitchen Cabinets
	5088	Transportation Equipment & Supplies		2439	Structural Wood Members, Nec
	5092	Toys And Hobby Goods And Supplies		2451	Mobile Homes
	5093	Scrap And Waste Materials		2511	Wood Household Furniture
	5099	Durable Goods, Nec		2514	Metal Household Furniture
	5111	Printing And Writing Paper		2517	Wood Tv And Radio Cabinets
	5112	Stationery And Office Supplies		2522	Office Furniture, Except Wood
	5113	Industrial & Personal Service Paper		2531	Public Building & Related Furniture
	5199	Nondurable Goods, Nec		2542	Partitions And Fixtures, Except Wood
	5211	Lumber And Other Building Materials		2591	Drapery Hardware & Blinds & Shades
	5311	Department Stores		2599	Furniture And Fixtures, Nec
	5411	Grocery Stores		2656	Sanitary Food Containers
	5511	New And Used Car Dealers		2671	Paper Coated & Laminated, Packaging
	5712	Furniture Stores			

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	2672	Paper Coated And Laminated, Nec		3449	Miscellaneous Metal Work
	2752	Commercial Printing, Lithographic		3452	Bolts, Nuts, Rivets, And Washers
	2759	Commercial Printing, Nec		3462	Iron And Steel Forgings
	2796	Platemaking Services		3465	Automotive Stampings
	2821	Plastics Materials And Resins		3466	Crowns And Closures
	2842	Polishes And Sanitation Goods		3469	Metal Stampings, Nec
	2844	Toilet Preparations		3471	Plating And Polishing
	2851	Paints And Allied Products		3479	Metal Coating And Allied Services
	2869	Industrial Organic Chemicals, Nec		3482	Small Arms Ammunition
	2892	Explosives		3483	Ammunition, Exc. For Small Arms, Nec
	2899	Chemical Preparations, Nec		3484	Small Arms
	2951	Asphalt Paving Mixtures And Blocks		3489	Ordnance And Accessories, Nec
	2992	Lubricating Oils And Greases		3491	Industrial Valves
	3011	Tires And Inner Tubes		3492	Fluid Power Valves & Hose Fittings
	3052	Rubber & Plastics Hose & Belting		3493	Steel Springs, Except Wire
	3053	Gaskets, Packing And Sealing Devices		3494	Valves And Pipe Fittings, Nec
	3069	Fabricated Rubber Products, Nec		3495	Wire Springs
	3082	Unsupported Plastics Profile Shapes		3496	Misc. Fabricated Wire Products
	3083	Laminated Plastics Plate & Sheet		3498	Fabricated Pipe And Fittings
	3085	Plastics Bottles		3499	Fabricated Metal Products, Nec
	3086	Plastics Foam Products		3511	Turbines And Turbine Generator Sets
	3089	Plastics Products, Nec		3519	Internal Combustion Engines, Nec
	3221	Glass Containers		3523	Farm Machinery And Equipment
	3231	Products Of Purchased Glass		3524	Lawn And Garden Equipment
	3264	Porcelain Electrical Supplies		3531	Construction Machinery
	3272	Concrete Products, Nec		3532	Mining Machinery
	3275	Gypsum Products		3533	Oil And Gas Field Machinery
	3281	Cut Stone And Stone Products		3534	Elevators And Moving Stairways
	3292	Asbestos Products		3535	Conveyors And Conveying Equipment
	3295	Minerals, Ground Or Treated		3536	Hoists, Cranes, And Monorails
	3312	Blast Furnaces And Steel Mills		3537	Industrial Trucks And Tractors
	3313	Electrometallurgical Products		3541	Machine Tools, Metal Cutting Types
	3315	Steel Wire And Related Products		3542	Machine Tools, Metal Forming Types
	3316	Cold Finishing Of Steel Shapes		3543	Industrial Patterns
	3317	Steel Pipe And Tubes		3544	Special Dies, Tools, Jigs & Fixtures
	3321	Gray And Ductile Iron Foundries		3545	Machine Tool Accessories
	3322	Malleable Iron Foundries		3548	Welding Apparatus
	3325	Steel Foundries, Nec		3549	Metalworking Machinery, Nec
	3341	Secondary Nonferrous Metals		3552	Textile Machinery
	3351	Copper Rolling And Drawing		3553	Woodworking Machinery
	3353	Aluminum Sheet, Plate, And Foil		3554	Paper Industries Machinery
	3354	Aluminum Extruded Products		3555	Printing Trades Machinery
	3355	Aluminum Rolling And Drawing, Nec		3556	Food Products Machinery
	3357	Nonferrous Wiredrawing & Insulating		3559	Special Industry Machinery, Nec
	3365	Aluminum Foundries		3561	Pumps And Pumping Equipment
	3369	Nonferrous Foundries, Nec		3563	Air And Gas Compressors
	3398	Metal Heat Treating		3564	Blowers And Fans
	3399	Primary Metal Products, Nec		3566	Speed Changers, Drives, And Gears
	3411	Metal Cans		3567	Industrial Furnaces And Ovens
	3412	Metal Barrels, Drums, And Pails		3568	Power Transmission Equipment, Nec
	3421	Cutlery		3569	General Industrial Machinery, Nec
	3423	Hand And Edge Tools, Nec		3571	Electronic Computers
	3425	Saw Blades And Handsaws		3577	Computer Peripheral Equipment, Nec
	3429	Hardware, Nec		3579	Office Machines, Nec
	3432	Plumbing Fixture Fittings And Trim		3581	Automatic Vending Machines
	3433	Heating Equipment, Except Electric		3585	Refrigeration And Heating Equipment
	3441	Fabricated Structural Metal		3586	Measuring And Dispensing Pumps
	3442	Metal Doors, Sash, And Trim		3589	Service Industry Machinery, Nec
	3443	Fabricated Plate Work (boiler Shops)		3592	Carburetors, Pistons, Rings, Valves
	3444	Sheet Metalwork		3593	Fluid Power Cylinders & Actuators
	3446	Architectural Metal Work		3594	Fluid Power Pumps And Motors
	3448	Prefabricated Metal Buildings		3596	Scales And Balances, Exc. Laboratory



## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	3599	Industrial Machinery, Nec		3955	Carbon Paper And Inked Ribbons
	3612	Transformers, Except Electronic		3961	Costume Jewelry
	3621	Motors And Generators		3965	Fasteners, Buttons, Needles, & Pins
	3625	Relays And Industrial Controls		3993	Signs And Advertising Specialities
	3629	Electrical Industrial Apparatus, Nec		3995	Burial Caskets
	3631	Household Cooking Equipment		3996	Hard Surface Floor Coverings, Nec
	3632	Household Refrigerators And Freezers		3999	Manufacturing Industries, Nec
	3633	Household Laundry Equipment		4011	Railroads, Line-haul Operating
	3634	Electric Housewares And Fans		4111	Local And Suburban Transit
	3639	Household Appliances, Nec		4226	Special Warehousing And Storage, Nec
	3641	Electric Lamps		4231	Trucking Terminal Facilities
	3643	Current-carrying Wiring Devices		4512	Air Transportation, Scheduled
	3644	Noncurrent-carrying Wiring Devices		4581	Airports, Flying Fields, & Services
	3645	Residential Lighting Fixtures		4741	Rental Of Railroad Cars
	3646	Commercial Lighting Fixtures		4789	Transportation Services, Nec
	3647	Vehicular Lighting Equipment		4911	Electric Services
	3648	Lighting Equipment, Nec		4931	Electric And Other Services Combined
	3651	Household Audio And Video Equipment		5012	Automobiles And Other Motor Vehicles
	3661	Telephone And Telegraph Apparatus		5015	Motor Vehicle Parts, Used
	3663	Radio & TV Communications Equipment		5045	Computers, Peripherals & Software
	3671	Electron Tubes		5051	Metals Service Centers And Offices
	3674	Semiconductors And Related Devices		5072	Hardware
	3675	Electronic Capacitors		5082	Construction And Mining Machinery
	3676	Electronic Resistors		5083	Farm And Garden Machinery
	3677	Electronic Coils And Transformers		5084	Industrial Machinery And Equipment
	3679	Electronic Components, Nec		5085	Industrial Supplies
	3694	Engine Electrical Equipment		5092	Toys And Hobby Goods And Supplies
	3699	Electrical Equipment & Supplies, Nec		5093	Scrap And Waste Materials
	3711	Motor Vehicles And Car Bodies		5169	Chemicals & Allied Products, Nec
	3713	Truck And Bus Bodies		5712	Furniture Stores
	3714	Motor Vehicle Parts And Accessories		6021	National Commercial Banks
	3715	Truck Trailers		6512	Nonresidential Building Operators
	3721	Aircraft		6513	Apartment Building Operators
	3724	Aircraft Engines And Engine Parts		7216	Drycleaning Plants, Except Rug
	3728	Aircraft Parts And Equipment, Nec		7389	Business Services, Nec
	3731	Ship Building And Repairing		7532	Top & Body Repair & Paint Shops
	3743	Railroad Equipment		7538	General Automotive Repair Shops
	3751	Motorcycles, Bicycles, And Parts		7539	Automotive Repair Shops, Nec
	3761	Guided Missiles And Space Vehicles		7629	Electrical Repair Shops, Nec
	3764	Space Propulsion Units And Parts		7692	Welding Repair
	3769	Space Vehicle Equipment, Nec		7694	Armature Rewinding Shops
	3792	Travel Trailers And Campers		7699	Repair Services, Nec
	3795	Tanks And Tank Components		7812	Motion Picture & Video Production
	3799	Transportation Equipment, Nec		8011	Offices & Clinics Of Medical Doctors
	3812	Search And Navigation Equipment		8062	General Medical & Surgical Hospitals
	3821	Laboratory Apparatus And Furniture		8211	Elementary And Secondary Schools
	3822	Environmental Controls		8711	Engineering Services
	3823	Process Control Instruments		8731	Commercial Physical Research
	3824	Fluid Meters And Counting Devices		8734	Testing Laboratories
	3825	Instruments To Measure Electricity		9199	General Government, Nec
	3826	Analytical Instruments		9223	Correctional Institutions
	3827	Optical Instruments And Lenses		9511	Air, Water, & Solid Waste Management
	3829	Measuring & Controlling Devices, Nec		9661	Space Research And Technology
	3841	Surgical And Medical Instruments		9711	National Security
	3842	Surgical Appliances And Supplies			
	3843	Dental Equipment And Supplies			
	3844	X-ray Apparatus And Tubes			
	3845	Electromedical Equipment			
	3861	Photographic Equipment And Supplies			
	3914	Silverware And Plated Ware			
	3944	Games, Toys, And Children's Vehicles			
	3949	Sporting And Athletic Goods, Nec			
			4-02-040	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Fabric Printing</i>	
				2211	Broadwoven Fabric Mills, Cotton
				2221	Broadwoven Fabric Mills, Manmade
				2231	Broadwoven Fabric Mills, Wool
				2251	Women's Hosiery, Except Socks
				2252	Hosiery, Nec

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	2258	Lace & Warp Knit Fabric Mills		2299	Textile Goods, Nec
	2259	Knitting Mills, Nec			
	2261	Finishing Plants, Cotton	4-02-044	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Fabric Coating, Transfer Coating</i>	
	2262	Finishing Plants, Manmade		2211	Broadwoven Fabric Mills, Cotton
	2269	Finishing Plants, Nec		2221	Broadwoven Fabric Mills, Manmade
	2273	Carpets And Rugs		2231	Broadwoven Fabric Mills, Wool
	2281	Yarn Spinning Mills		2251	Women's Hosiery, Except Socks
	2282	Throwing And Winding Mills		2252	Hosiery, Nec
	2297	Nonwoven Fabrics		2258	Lace & Warp Knit Fabric Mills
	2299	Textile Goods, Nec		2259	Knitting Mills, Nec
4-02-041	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Fabric Coating, Knife Coating</i>			2261	Finishing Plants, Cotton
	2211	Broadwoven Fabric Mills, Cotton		2262	Finishing Plants, Manmade
	2221	Broadwoven Fabric Mills, Manmade		2269	Finishing Plants, Nec
	2231	Broadwoven Fabric Mills, Wool		2273	Carpets And Rugs
	2251	Women's Hosiery, Except Socks		2281	Yarn Spinning Mills
	2252	Hosiery, Nec		2282	Throwing And Winding Mills
	2258	Lace & Warp Knit Fabric Mills		2297	Nonwoven Fabrics
	2259	Knitting Mills, Nec		2299	Textile Goods, Nec
	2261	Finishing Plants, Cotton	4-02-045	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Fabric Coating, Extrusion Coating</i>	
	2262	Finishing Plants, Manmade		2211	Broadwoven Fabric Mills, Cotton
	2269	Finishing Plants, Nec		2221	Broadwoven Fabric Mills, Manmade
	2273	Carpets And Rugs		2231	Broadwoven Fabric Mills, Wool
	2281	Yarn Spinning Mills		2251	Women's Hosiery, Except Socks
	2282	Throwing And Winding Mills		2252	Hosiery, Nec
	2297	Nonwoven Fabrics		2258	Lace & Warp Knit Fabric Mills
	2299	Textile Goods, Nec		2259	Knitting Mills, Nec
4-02-042	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Fabric Coating, Roller Coating</i>			2261	Finishing Plants, Cotton
	2211	Broadwoven Fabric Mills, Cotton		2262	Finishing Plants, Manmade
	2221	Broadwoven Fabric Mills, Manmade		2269	Finishing Plants, Nec
	2231	Broadwoven Fabric Mills, Wool		2273	Carpets And Rugs
	2251	Women's Hosiery, Except Socks		2281	Yarn Spinning Mills
	2252	Hosiery, Nec		2282	Throwing And Winding Mills
	2258	Lace & Warp Knit Fabric Mills		2297	Nonwoven Fabrics
	2259	Knitting Mills, Nec		2299	Textile Goods, Nec
	2261	Finishing Plants, Cotton	4-02-046	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Fabric Coating, Melt Roll Coating</i>	
	2262	Finishing Plants, Manmade		2211	Broadwoven Fabric Mills, Cotton
	2269	Finishing Plants, Nec		2221	Broadwoven Fabric Mills, Manmade
	2273	Carpets And Rugs		2231	Broadwoven Fabric Mills, Wool
	2281	Yarn Spinning Mills		2251	Women's Hosiery, Except Socks
	2282	Throwing And Winding Mills		2252	Hosiery, Nec
	2297	Nonwoven Fabrics		2258	Lace & Warp Knit Fabric Mills
	2299	Textile Goods, Nec		2259	Knitting Mills, Nec
4-02-043	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Fabric Coating, Dip Coating</i>			2261	Finishing Plants, Cotton
	2211	Broadwoven Fabric Mills, Cotton		2262	Finishing Plants, Manmade
	2221	Broadwoven Fabric Mills, Manmade		2269	Finishing Plants, Nec
	2231	Broadwoven Fabric Mills, Wool		2273	Carpets And Rugs
	2251	Women's Hosiery, Except Socks		2281	Yarn Spinning Mills
	2252	Hosiery, Nec		2282	Throwing And Winding Mills
	2258	Lace & Warp Knit Fabric Mills		2297	Nonwoven Fabrics
	2259	Knitting Mills, Nec		2299	Textile Goods, Nec
	2261	Finishing Plants, Cotton	4-02-047	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Fabric Coating, Coagulation Coating</i>	
	2262	Finishing Plants, Manmade		2211	Broadwoven Fabric Mills, Cotton
	2269	Finishing Plants, Nec		2221	Broadwoven Fabric Mills, Manmade
	2273	Carpets And Rugs		2231	Broadwoven Fabric Mills, Wool
	2281	Yarn Spinning Mills		2251	Women's Hosiery, Except Socks
	2282	Throwing And Winding Mills		2252	Hosiery, Nec
	2297	Nonwoven Fabrics			

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

Six-Digit SCC	SIC Code	SIC Description	Six-Digit SCC	SIC Code	SIC Description
	2258	Lace & Warp Knit Fabric Mills		3053	Gaskets, Packing And Sealing Devices
	2259	Knitting Mills, Nec		3069	Fabricated Rubber Products, Nec
	2261	Finishing Plants, Cotton		3081	Unsupported Plastics Film & Sheet
	2262	Finishing Plants, Manmade		3083	Laminated Plastics Plate & Sheet
	2269	Finishing Plants, Nec		3085	Plastics Bottles
	2273	Carpets And Rugs		3086	Plastics Foam Products
	2281	Yarn Spinning Mills		3089	Plastics Products, Nec
	2282	Throwing And Winding Mills		3111	Leather Tanning And Finishing
	2297	Nonwoven Fabrics		3131	Footwear Cut Stock
	2299	Textile Goods, Nec		3144	Women's Footwear, Except Athletic
4-02-060	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Fabric Dyeing</i>			3211	Flat Glass
	2211	Broadwoven Fabric Mills, Cotton		3229	Pressed And Blown Glass, Nec
	2221	Broadwoven Fabric Mills, Manmade		3231	Products Of Purchased Glass
	2231	Broadwoven Fabric Mills, Wool		3291	Abrasive Products
	2251	Women's Hosiery, Except Socks		3292	Asbestos Products
	2252	Hosiery, Nec		3296	Mineral Wool
	2258	Lace & Warp Knit Fabric Mills		3299	Nonmetallic Mineral Products, Nec
	2259	Knitting Mills, Nec		3312	Blast Furnaces And Steel Mills
	2261	Finishing Plants, Cotton		3315	Steel Wire And Related Products
	2262	Finishing Plants, Manmade		3317	Steel Pipe And Tubes
	2269	Finishing Plants, Nec		3354	Aluminum Extruded Products
	2273	Carpets And Rugs		3357	Nonferrous Wire Drawing & Insulating
	2281	Yarn Spinning Mills		3399	Primary Metal Products, Nec
	2282	Throwing And Winding Mills		3411	Metal Cans
	2297	Nonwoven Fabrics		3412	Metal Barrels, Drums, And Pails
	2299	Textile Goods, Nec		3441	Fabricated Structural Metal
				3442	Metal Doors, Sash, And Trim
				3443	Fabricated Plate Work (boiler Shops)
				3448	Prefabricated Metal Buildings
4-02-888	<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Fugitive Emissions</i>			3462	Iron And Steel Forgings
	1721	Painting And Paper Hanging		3471	Plating And Polishing
	2062	Cane Sugar Refining		3479	Metal Coating And Allied Services
	2221	Broadwoven Fabric Mills, Manmade		3496	Misc. Fabricated Wire Products
	2262	Finishing Plants, Manmade		3499	Fabricated Metal Products, Nec
	2281	Yarn Spinning Mills		3523	Farm Machinery And Equipment
	2295	Coated Fabrics, Not Rubberized		3542	Machine Tools, Metal Forming Types
	2298	Cordage And Twine		3559	Special Industry Machinery, Nec
	2396	Automotive And Apparel Trimmings		3561	Pumps And Pumping Equipment
	2434	Wood Kitchen Cabinets		3569	General Industrial Machinery, Nec
	2499	Wood Products, Nec		3575	Computer Terminals
	2511	Wood Household Furniture		3585	Refrigeration And Heating Equipment
	2519	Household Furniture, Nec		3589	Service Industry Machinery, Nec
	2522	Office Furniture, Except Wood		3599	Industrial Machinery, Nec
	2531	Public Building & Related Furniture		3612	Transformers, Except Electronic
	2541	Wood Partitions And Fixtures		3621	Motors And Generators
	2542	Partitions And Fixtures, Except Wood		3625	Relays And Industrial Controls
	2599	Furniture And Fixtures, Nec		3631	Household Cooking Equipment
	2621	Paper Mills		3632	Household Refrigerators And Freezers
	2631	Paperboard Mills		3641	Electric Lamps
	2653	Corrugated And Solid Fiber Boxes		3661	Telephone And Telegraph Apparatus
	2671	Paper Coated & Laminated, Packaging		3671	Electron Tubes
	2672	Paper Coated And Laminated, Nec		3679	Electronic Components, Nec
	2679	Converted Paper Products, Nec		3711	Motor Vehicles And Car Bodies
	2752	Commercial Printing, Lithographic		3714	Motor Vehicle Parts And Accessories
	2754	Commercial Printing, Gravure		3715	Truck Trailers
	2816	Inorganic Pigments		3721	Aircraft
	2822	Synthetic Rubber		3724	Aircraft Engines And Engine Parts
	2869	Industrial Organic Chemicals, Nec		3732	Boat Building And Repairing
	2891	Adhesives And Sealants		3743	Railroad Equipment
	2899	Chemical Preparations, Nec		3761	Guided Missiles And Space Vehicles
	2911	Petroleum Refining		3764	Space Propulsion Units And Parts
				3795	Tanks And Tank Components

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

Six-Digit SCC	SIC Code	SIC Description	Six-Digit SCC	SIC Code	SIC Description
	3841	Surgical And Medical Instruments		5171	Petroleum Bulk Stations & Terminals
	3842	Surgical Appliances And Supplies		8062	General Medical & Surgical Hospitals
	3843	Dental Equipment And Supplies			
	3844	X-ray Apparatus And Tubes	4-02-999		<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Miscellaneous</i>
	3861	Photographic Equipment And Supplies		0181	Ornamental Nursery Products
	3931	Musical Instruments		1021	Copper Ores
	3951	Pens And Mechanical Pencils		1311	Crude Petroleum And Natural Gas
	3965	Fasteners, Buttons, Needles, & Pins		1442	Construction Sand And Gravel
	3993	Signs And Advertising Specialities		1446	Industrial Sand
	3999	Manufacturing Industries, Nec		1479	Chemical And Fertilizer Mining, Nec
	4226	Special Warehousing And Storage, Nec		1522	Residential Construction, Nec
	4581	Airports, Flying Fields, & Services		1622	Bridge, Tunnel, & Elevated Highway
	4612	Crude Petroleum Pipelines		1629	Heavy Construction, Nec
	4741	Rental Of Railroad Cars		1721	Painting And Paper Hanging
	4789	Transportation Services, Nec		1751	Carpentry Work
	4911	Electric Services		1771	Concrete Work
	5052	Coal And Other Minerals And Ores		1791	Structural Steel Erection
	6512	Nonresidential Building Operators		1799	Special Trade Contractors, Nec
	7319	Advertising, Nec		2011	Meat Packing Plants
	7532	Top & Body Repair & Paint Shops		2047	Dog And Cat Food
	7999	Amusement And Recreation, Nec		2051	Bread, Cake, And Related Products
	9711	National Security		2052	Cookies And Crackers
4-02-900		<i>Petroleum and Solvent Evaporation: Surface Coating Operations - Fuel Fired Equipment</i>		2076	Vegetable Oil Mills, Nec
	1321	Natural Gas Liquids		2082	Malt Beverages
	2435	Hardwood Veneer And Plywood		2086	Bottled And Canned Soft Drinks
	2652	Setup Paperboard Boxes		2091	Canned And Cured Fish And Seafoods
	2657	Folding Paperboard Boxes		2099	Food Preparations, Nec
	2671	Paper Coated & Laminated, Packaging		2211	Broadwoven Fabric Mills, Cotton
	2672	Paper Coated And Laminated, Nec		2221	Broadwoven Fabric Mills, Manmade
	2679	Converted Paper Products, Nec		2241	Narrow Fabric Mills
	2752	Commercial Printing, Lithographic		2251	Women's Hosiery, Except Socks
	2759	Commercial Printing, Nec		2259	Knitting Mills, Nec
	2851	Paints And Allied Products		2261	Finishing Plants, Cotton
	2865	Cyclic Crudes And Intermediates		2269	Finishing Plants, Nec
	2869	Industrial Organic Chemicals, Nec		2281	Yarn Spinning Mills
	2891	Adhesives And Sealants		2284	Thread Mills
	2911	Petroleum Refining		2295	Coated Fabrics, Not Rubberized
	3083	Laminated Plastics Plate & Sheet		2297	Nonwoven Fabrics
	3089	Plastics Products, Nec		2298	Cordage And Twine
	3231	Products Of Purchased Glass		2299	Textile Goods, Nec
	3264	Porcelain Electrical Supplies		2335	Women's, Junior's, & Misses' Dresses
	3411	Metal Cans		2396	Automotive And Apparel Trimmings
	3412	Metal Barrels, Drums, And Pails		2426	Hardwood Dimension & Flooring Mills
	3429	Hardware, Nec		2429	Special Product Sawmills, Nec
	3444	Sheet Metalwork		2431	Millwork
	3469	Metal Stampings, Nec		2434	Wood Kitchen Cabinets
	3471	Plating And Polishing		2435	Hardwood Veneer And Plywood
	3479	Metal Coating And Allied Services		2441	Nailed Wood Boxes And Shook
	3585	Refrigeration And Heating Equipment		2451	Mobile Homes
	3599	Industrial Machinery, Nec		2491	Wood Preserving
	3612	Transformers, Except Electronic		2499	Wood Products, Nec
	3624	Carbon And Graphite Products		2511	Wood Household Furniture
	3711	Motor Vehicles And Car Bodies		2512	Upholstered Household Furniture
	3713	Truck And Bus Bodies		2514	Metal Household Furniture
	3714	Motor Vehicle Parts And Accessories		2515	Mattresses And Bedsprings
	3721	Aircraft		2517	Wood Tv And Radio Cabinets
	3861	Photographic Equipment And Supplies		2519	Household Furniture, Nec
	3965	Fasteners, Buttons, Needles, & Pins		2521	Wood Office Furniture
	3999	Manufacturing Industries, Nec		2522	Office Furniture, Except Wood
	4226	Special Warehousing And Storage, Nec		2531	Public Building & Related Furniture
				2541	Wood Partitions And Fixtures

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	2542	Partitions And Fixtures, Except Wood		3149	Footwear, Except Rubber, Nec
	2591	Drapery Hardware & Blinds & Shades		3172	Personal Leather Goods, Nec
	2599	Furniture And Fixtures, Nec		3211	Flat Glass
	2621	Paper Mills		3221	Glass Containers
	2631	Paperboard Mills		3229	Pressed And Blown Glass, Nec
	2652	Setup Paperboard Boxes		3231	Products Of Purchased Glass
	2653	Corrugated And Solid Fiber Boxes		3241	Cement, Hydraulic
	2655	Fiber Cans, Drums & Similar Products		3251	Brick And Structural Clay Tile
	2656	Sanitary Food Containers		3255	Clay Refractories
	2657	Folding Paperboard Boxes		3261	Vitreous Plumbing Fixtures
	2671	Paper Coated & Laminated, Packaging		3264	Porcelain Electrical Supplies
	2672	Paper Coated And Laminated, Nec		3269	Pottery Products, Nec
	2673	Bags: Plastics, Laminated, & Coated		3272	Concrete Products, Nec
	2675	Die-cut Paper And Board		3273	Ready-mixed Concrete
	2679	Converted Paper Products, Nec		3281	Cut Stone And Stone Products
	2711	Newspapers		3291	Abrasive Products
	2731	Book Publishing		3292	Asbestos Products
	2732	Book Printing		3295	Minerals, Ground Or Treated
	2752	Commercial Printing, Lithographic		3296	Mineral Wool
	2754	Commercial Printing, Gravure		3299	Nonmetallic Mineral Products, Nec
	2759	Commercial Printing, Nec		3312	Blast Furnaces And Steel Mills
	2782	Blankbooks And Looseleaf Binders		3315	Steel Wire And Related Products
	2789	Bookbinding And Related Work		3316	Cold Finishing Of Steel Shapes
	2796	Platemaking Services		3317	Steel Pipe And Tubes
	2813	Industrial Gases		3321	Gray And Ductile Iron Foundries
	2816	Inorganic Pigments		3324	Steel Investment Foundries
	2819	Industrial Inorganic Chemicals, Nec		3341	Secondary Nonferrous Metals
	2821	Plastics Materials And Resins		3354	Aluminum Extruded Products
	2822	Synthetic Rubber		3357	Nonferrous Wiredrawing & Insulating
	2823	Cellulosic Manmade Fibers		3365	Aluminum Foundries
	2833	Medicinals And Botanicals		3366	Copper Foundries
	2834	Pharmaceutical Preparations		3398	Metal Heat Treating
	2841	Soap And Other Detergents		3399	Primary Metal Products, Nec
	2842	Polishes And Sanitation Goods		3411	Metal Cans
	2843	Surface Active Agents		3412	Metal Barrels, Drums, And Pails
	2844	Toilet Preparations		3423	Hand And Edge Tools, Nec
	2851	Paints And Allied Products		3425	Saw Blades And Handsaws
	2865	Cyclic Crudes And Intermediates		3429	Hardware, Nec
	2869	Industrial Organic Chemicals, Nec		3432	Plumbing Fixture Fittings And Trim
	2873	Nitrogenous Fertilizers		3433	Heating Equipment, Except Electric
	2891	Adhesives And Sealants		3441	Fabricated Structural Metal
	2892	Explosives		3442	Metal Doors, Sash, And Trim
	2899	Chemical Preparations, Nec		3443	Fabricated Plate Work (boiler Shops)
	2911	Petroleum Refining		3444	Sheet Metalwork
	2951	Asphalt Paving Mixtures And Blocks		3446	Architectural Metal Work
	2952	Asphalt Felts And Coatings		3448	Prefabricated Metal Buildings
	3011	Tires And Inner Tubes		3449	Miscellaneous Metal Work
	3021	Rubber And Plastics Footwear		3451	Screw Machine Products
	3052	Rubber & Plastics Hose & Belting		3452	Bolts, Nuts, Rivets, And Washers
	3053	Gaskets, Packing And Sealing Devices		3462	Iron And Steel Forgings
	3061	Mechanical Rubber Goods		3465	Automotive Stampings
	3069	Fabricated Rubber Products, Nec		3469	Metal Stampings, Nec
	3081	Unsupported Plastics Film & Sheet		3471	Plating And Polishing
	3082	Unsupported Plastics Profile Shapes		3479	Metal Coating And Allied Services
	3083	Laminated Plastics Plate & Sheet		3489	Ordnance And Accessories, Nec
	3085	Plastics Bottles		3491	Industrial Valves
	3086	Plastics Foam Products		3492	Fluid Power Valves & Hose Fittings
	3088	Plastics Plumbing Fixtures		3493	Steel Springs, Except Wire
	3089	Plastics Products, Nec		3494	Valves And Pipe Fittings, Nec
	3111	Leather Tanning And Finishing		3496	Misc. Fabricated Wire Products
	3131	Footwear Cut Stock		3497	Metal Foil And Leaf
	3143	Men's Footwear, Except Athletic		3499	Fabricated Metal Products, Nec

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	3511	Turbines And Turbine Generator Sets		3695	Magnetic And Optical Recording Media
	3519	Internal Combustion Engines, Nec		3711	Motor Vehicles And Car Bodies
	3523	Farm Machinery And Equipment		3713	Truck And Bus Bodies
	3524	Lawn And Garden Equipment		3714	Motor Vehicle Parts And Accessories
	3531	Construction Machinery		3715	Truck Trailers
	3532	Mining Machinery		3716	Motor Homes
	3533	Oil And Gas Field Machinery		3721	Aircraft
	3535	Conveyors And Conveying Equipment		3724	Aircraft Engines And Engine Parts
	3536	Hoists, Cranes, And Monorails		3728	Aircraft Parts And Equipment, Nec
	3537	Industrial Trucks And Tractors		3731	Ship Building And Repairing
	3541	Machine Tools, Metal Cutting Types		3732	Boat Building And Repairing
	3544	Special Dies, Tools, Jigs & Fixtures		3743	Railroad Equipment
	3548	Welding Apparatus		3751	Motorcycles, Bicycles, And Parts
	3549	Metalworking Machinery, Nec		3761	Guided Missiles And Space Vehicles
	3552	Textile Machinery		3764	Space Propulsion Units And Parts
	3555	Printing Trades Machinery		3769	Space Vehicle Equipment, Nec
	3559	Special Industry Machinery, Nec		3792	Travel Trailers And Campers
	3561	Pumps And Pumping Equipment		3795	Tanks And Tank Components
	3562	Ball And Roller Bearings		3799	Transportation Equipment, Nec
	3563	Air And Gas Compressors		3812	Search And Navigation Equipment
	3564	Blowers And Fans		3821	Laboratory Apparatus And Furniture
	3566	Speed Changers, Drives, And Gears		3822	Environmental Controls
	3567	Industrial Furnaces And Ovens		3823	Process Control Instruments
	3568	Power Transmission Equipment, Nec		3824	Fluid Meters And Counting Devices
	3569	General Industrial Machinery, Nec		3825	Instruments To Measure Electricity
	3571	Electronic Computers		3826	Analytical Instruments
	3572	Computer Storage Devices		3827	Optical Instruments And Lenses
	3577	Computer Peripheral Equipment, Nec		3829	Measuring & Controlling Devices, Nec
	3579	Office Machines, Nec		3841	Surgical And Medical Instruments
	3581	Automatic Vending Machines		3842	Surgical Appliances And Supplies
	3585	Refrigeration And Heating Equipment		3843	Dental Equipment And Supplies
	3589	Service Industry Machinery, Nec		3844	X-ray Apparatus And Tubes
	3596	Scales And Balances, Exc. Laboratory		3861	Photographic Equipment And Supplies
	3599	Industrial Machinery, Nec		3931	Musical Instruments
	3612	Transformers, Except Electronic		3942	Dolls And Stuffed Toys
	3621	Motors And Generators		3944	Games, Toys, And Children's Vehicles
	3625	Relays And Industrial Controls		3949	Sporting And Athletic Goods, Nec
	3629	Electrical Industrial Apparatus, Nec		3951	Pens And Mechanical Pencils
	3631	Household Cooking Equipment		3955	Carbon Paper And Inked Ribbons
	3632	Household Refrigerators And Freezers		3961	Costume Jewelry
	3633	Household Laundry Equipment		3991	Brooms And Brushes
	3639	Household Appliances, Nec		3993	Signs And Advertising Specialties
	3641	Electric Lamps		3995	Burial Caskets
	3643	Current-carrying Wiring Devices		3996	Hard Surface Floor Coverings, Nec
	3644	Noncurrent-carrying Wiring Devices		3999	Manufacturing Industries, Nec
	3645	Residential Lighting Fixtures		4011	Railroads, Line-haul Operating
	3646	Commercial Lighting Fixtures		4013	Switching And Terminal Services
	3647	Vehicular Lighting Equipment		4142	Bus Charter Service, Except Local
	3648	Lighting Equipment, Nec		4212	Local Trucking, Without Storage
	3651	Household Audio And Video Equipment		4213	Trucking, Except Local
	3652	Prerecorded Records And Tapes		4225	General Warehousing And Storage
	3661	Telephone And Telegraph Apparatus		4449	Water Transportation Of Freight, Nec
	3663	Radio & TV Communications Equipment		4491	Marine Cargo Handling
	3669	Communications Equipment, Nec		4493	Marinas
	3671	Electron Tubes		4512	Air Transportation, Scheduled
	3674	Semiconductors And Related Devices		4581	Airports, Flying Fields, & Services
	3676	Electronic Resistors		4612	Crude Petroleum Pipelines
	3677	Electronic Coils And Transformers		4741	Rental Of Railroad Cars
	3678	Electronic Connectors		4789	Transportation Services, Nec
	3679	Electronic Components, Nec		4911	Electric Services
	3692	Primary Batteries, Dry And Wet		4931	Electric And Other Services Combined
	3694	Engine Electrical Equipment		4932	Gas And Other Services Combined

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>	<u>Six-Digit SCC</u>	<u>SIC Code</u>	<u>SIC Description</u>
	4939	Combination Utilities, Nec		7999	Amusement And Recreation, Nec
	4941	Water Supply		8011	Offices & Clinics Of Medical Doctors
	4952	Sewerage Systems		8062	General Medical & Surgical Hospitals
	4953	Refuse Systems		8069	Specialty Hospitals Exc. Psychiatric
	4959	Sanitary Services, Nec		8211	Elementary And Secondary Schools
	4961	Steam And Air-conditioning Supply		8221	Colleges And Universities
	5015	Motor Vehicle Parts, Used		8222	Junior Colleges
	5031	Lumber, Plywood, And Millwork		8711	Engineering Services
	5033	Roofing, Siding, & Insulation		8712	Architectural Services
	5039	Construction Materials, Nec		8731	Commercial Physical Research
	5046	Commercial Equipment, Nec		8734	Testing Laboratories
	5047	Medical And Hospital Equipment		8741	Management Services
	5051	Metals Service Centers And Offices		8999	Services, Nec
	5078	Refrigeration Equipment And Supplies		9199	General Government, Nec
	5082	Construction And Mining Machinery		9223	Correctional Institutions
	5084	Industrial Machinery And Equipment		9511	Air, Water, & Solid Waste Management
	5085	Industrial Supplies		9621	Regulation, Admin. Of Transportation
	5087	Service Establishment Equipment		9661	Space Research And Technology
	5088	Transportation Equipment & Supplies		9711	National Security
	5092	Toys And Hobby Goods And Supplies			
	5093	Scrap And Waste Materials			
	5141	Groceries, General Line			
	5169	Chemicals & Allied Products, Nec			
	5171	Petroleum Bulk Stations & Terminals			
	5172	Petroleum Products, Nec			
	5181	Beer And Ale			
	5199	Nondurable Goods, Nec			
	5211	Lumber And Other Building Materials			
	5311	Department Stores			
	5411	Grocery Stores			
	5511	New And Used Car Dealers			
	5541	Gasoline Service Stations			
	5712	Furniture Stores			
	5719	Misc. Homefurnishings Stores			
	5731	Radio, Tv, & Electronic Stores			
	5812	Eating Places			
	5999	Miscellaneous Retail Stores, Nec			
	6111	Federal & Fed.-sponsored Credit			
	6512	Nonresidential Building Operators			
	6513	Apartment Building Operators			
	7011	Hotels And Motels			
	7216	Drycleaning Plants, Except Rug			
	7261	Funeral Service And Crematories			
	7312	Outdoor Advertising Services			
	7359	Equipment Rental & Leasing, Nec			
	7372	Prepackaged Software			
	7373	Computer Integrated Systems Design			
	7382	Security Systems Services			
	7384	Photofinishing Laboratories			
	7389	Business Services, Nec			
	7532	Top & Body Repair & Paint Shops			
	7534	Tire Retreading And Repair Shops			
	7538	General Automotive Repair Shops			
	7539	Automotive Repair Shops, Nec			
	7629	Electrical Repair Shops, Nec			
	7641	Reupholstery And Furniture Repair			
	7692	Welding Repair			
	7694	Armature Rewinding Shops			
	7699	Repair Services, Nec			
	7812	Motion Picture & Video Production			
	7941	Sports Clubs, Managers, & Promoters			
	7996	Amusement Parks			
			4-03-001	<i>Petroleum and Solvent Evaporation: Petroleum Product Storage at Refineries - Deleted - Do Not Use (See 4-03-010 and 4-07)</i>	
				0723	Crop Preparation Services For Market
				1021	Copper Ores
				1311	Crude Petroleum And Natural Gas
				1321	Natural Gas Liquids
				1382	Oil And Gas Exploration Services
				1422	Crushed And Broken Limestone
				1429	Crushed And Broken Stone, Nec
				1795	Wrecking And Demolition Work
				2013	Sausages And Other Prepared Meats
				2074	Cottonseed Oil Mills
				2075	Soybean Oil Mills
				2421	Sawmills And Planing Mills, General
				2621	Paper Mills
				2671	Paper Coated & Laminated, Packaging
				2673	Bags: Plastics, Laminated, & Coated
				2731	Book Publishing
				2732	Book Printing
				2759	Commercial Printing, Nec
				2812	Alkalies And Chlorine
				2819	Industrial Inorganic Chemicals, Nec
				2821	Plastics Materials And Resins
				2822	Synthetic Rubber
				2841	Soap And Other Detergents
				2843	Surface Active Agents
				2851	Paints And Allied Products
				2861	Gum And Wood Chemicals
				2869	Industrial Organic Chemicals, Nec
				2879	Agricultural Chemicals, Nec
				2891	Adhesives And Sealants
				2892	Explosives
				2895	Carbon Black
				2899	Chemical Preparations, Nec
				2911	Petroleum Refining
				2951	Asphalt Paving Mixtures And Blocks
				2952	Asphalt Felts And Coatings
				2992	Lubricating Oils And Greases
				3085	Plastics Bottles
				3241	Cement, Hydraulic
				3255	Clay Refractories
				3295	Minerals, Ground Or Treated

## Appendix D: Six-Digit SCCs With Multiple SIC Code Linkings

Six-Digit SCC	SIC Code	SIC Description	Six-Digit SCC	SIC Code	SIC Description
	3312	Blast Furnaces And Steel Mills		2821	Plastics Materials And Resins
	3331	Primary Copper		2824	Organic Fibers, Noncellulosic
	3353	Aluminum Sheet, Plate, And Foil		2833	Medicinals And Botanicals
	3479	Metal Coating And Allied Services		2841	Soap And Other Detergents
	3483	Ammunition, Exc. For Small Arms, Nec		2851	Paints And Allied Products
	3572	Computer Storage Devices		2869	Industrial Organic Chemicals, Nec
	3612	Transformers, Except Electronic		2899	Chemical Preparations, Nec
	3647	Vehicular Lighting Equipment		2911	Petroleum Refining
	3674	Semiconductors And Related Devices		2951	Asphalt Paving Mixtures And Blocks
	3679	Electronic Components, Nec		2992	Lubricating Oils And Greases
	3711	Motor Vehicles And Car Bodies		3069	Fabricated Rubber Products, Nec
	3721	Aircraft		3312	Blast Furnaces And Steel Mills
	3731	Ship Building And Repairing		3661	Telephone And Telegraph Apparatus
	3743	Railroad Equipment		3711	Motor Vehicles And Car Bodies
	4011	Railroads, Line-haul Operating		3724	Aircraft Engines And Engine Parts
	4226	Special Warehousing And Storage, Nec		4226	Special Warehousing And Storage, Nec
	4581	Airports, Flying Fields, & Services		4911	Electric Services
	4612	Crude Petroleum Pipelines		5169	Chemicals & Allied Products, Nec
	4613	Refined Petroleum Pipelines		5171	Petroleum Bulk Stations & Terminals
	4789	Transportation Services, Nec		5191	Farm Supplies
	4911	Electric Services		5541	Gasoline Service Stations
	4922	Natural Gas Transmission		8062	General Medical & Surgical Hospitals
	4923	Gas Transmission And Distribution			
	4953	Refuse Systems	4-05-008	<i>Petroleum and Solvent Evaporation: Printing/Publishing - General</i>	
	5171	Petroleum Bulk Stations & Terminals		2396	Automotive And Apparel Trimmings
	5191	Farm Supplies		2759	Commercial Printing, Nec
	5541	Gasoline Service Stations		2893	Printing Ink
	5999	Miscellaneous Retail Stores, Nec		3479	Metal Coating And Allied Services
	7216	Drycleaning Plants, Except Rug		3661	Telephone And Telegraph Apparatus
	7538	General Automotive Repair Shops		3671	Electron Tubes
	7694	Armature Rewinding Shops		3714	Motor Vehicle Parts And Accessories
	8062	General Medical & Surgical Hospitals		3829	Measuring & Controlling Devices, Nec
	9661	Space Research And Technology		3993	Signs And Advertising Specialities
	9711	National Security		9711	National Security
4-03-002	<i>Petroleum and Solvent Evaporation: Petroleum Product Storage at Refineries - Deleted - Do Not Use (See 4-03-011 and 4-07)</i>		4-07-146	<i>Petroleum and Solvent Evaporation: Organic Chemical Storage - Fixed Roof Tanks - Miscellaneous</i>	
	1311	Crude Petroleum And Natural Gas		2077	Animal And Marine Fats And Oils
	2821	Plastics Materials And Resins		2819	Industrial Inorganic Chemicals, Nec
	2822	Synthetic Rubber		2821	Plastics Materials And Resins
	2869	Industrial Organic Chemicals, Nec		2833	Medicinals And Botanicals
	2891	Adhesives And Sealants		2834	Pharmaceutical Preparations
	2911	Petroleum Refining		2842	Polishes And Sanitation Goods
	3255	Clay Refractories		2844	Toilet Preparations
	3273	Ready-mixed Concrete		2851	Paints And Allied Products
	4226	Special Warehousing And Storage, Nec		2869	Industrial Organic Chemicals, Nec
	4491	Marine Cargo Handling		2899	Chemical Preparations, Nec
	4612	Crude Petroleum Pipelines		2951	Asphalt Paving Mixtures And Blocks
	4613	Refined Petroleum Pipelines		2952	Asphalt Felts And Coatings
	4789	Transportation Services, Nec		3086	Plastics Foam Products
	4911	Electric Services		3412	Metal Barrels, Drums, And Pails
	5171	Petroleum Bulk Stations & Terminals		3569	General Industrial Machinery, Nec
	7538	General Automotive Repair Shops		3711	Motor Vehicles And Car Bodies
	8062	General Medical & Surgical Hospitals		4225	General Warehousing And Storage
	9661	Space Research And Technology		4226	Special Warehousing And Storage, Nec
	9711	National Security		4491	Marine Cargo Handling
				4922	Natural Gas Transmission
4-03-999	<i>Petroleum and Solvent Evaporation: Petroleum Product Storage at Refineries - Other Not Classified</i>			4923	Gas Transmission And Distribution
	1311	Crude Petroleum And Natural Gas		5171	Petroleum Bulk Stations & Terminals
	2621	Paper Mills		5172	Petroleum Products, Nec
	2819	Industrial Inorganic Chemicals, Nec		8062	General Medical & Surgical Hospitals



# **APPENDIX E**

## **MACT SOURCE CLASSIFICATION CODES (SCC)**

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## *Appendix E - MACT Source Classification Codes (SCC)*

<i>SCC</i>	<i>Description</i>
<b>Cellulose Food Casing Manufacture</b>	
6-25-400-01	Cellulose Food Casing
6-25-400-10	Cellulose Xanthate Formation: Barattees
6-25-400-20	Viscose Processing
6-25-400-21	Viscose Processing: Viscose Holding Tanks
6-25-400-22	Viscose Processing: Extrusion and Coagulation
6-25-400-23	Viscose Processing: Regeneration
6-25-400-24	Viscose Processing: Water Washing
6-25-400-25	Drying and Humidification
6-25-400-30	MP Operation
6-25-400-40	Acid Bath System And Evaporators
6-25-400-41	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> Acid Bath System and Evaporator
6-25-400-42	Na <sub>2</sub> SO <sub>4</sub> Acid Bath System and Evaporator
6-25-400-50	End Product Storage: Cellulose Casing
6-25-800-01	Equipment Leaks
6-25-820-01	Process Area Drains
6-25-820-02	Process Equipment Drains
6-25-825-01	Viscose Filtering
6-25-825-02	Water Washing
6-25-825-03	Acid Bath Evaporator
6-25-825-99	Specify Point of Generation

### **2,4-D Salts and Esters Production**

6-31-110-01	2,4-D Salts and Esters Production
6-31-110-10	Process Vents: 2,4-D Salts and Esters Production
6-31-110-11	Process Vents, Chlorophenol Unit: Chlorination Reactor
6-31-110-12	Process Vents, Chlorophenol Unit: Distillation
6-31-110-20	Process Vents, Chloroacetic Acid Plant
6-31-110-21	Process Vents, Chloroacetic Acid Plant: Neutralizer
6-31-110-30	Process Vents, Chlorine Plant
6-31-110-40	Process Vents, 2,4-D: Neutralizer (Chlorine and Phenoxyacetic Acid)
6-31-110-41	Process Vents, 2,4-D: Condensation Reactor
6-31-110-42	Process Vents: 2,4-D Recovery
6-31-110-43	Process Vents, 2,4-D Recovery: Vessel
6-31-110-44	Process Vents, 2,4-D Recovery: Filtration

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<i><b>SCC</b></i>	<i><b>Description</b></i>
6-31-110-45	Process Vents, 2,4-D: Dryer (For Wet 2,4-D)
6-31-110-50	Process Vents: 2,4-D Product Storage
6-31-110-70	Waste Products
6-31-110-71	Waste Products: Filter Cakes
6-31-110-72	Waste Products: Still Bottoms
6-31-250-01	Captan Production
6-31-250-10	Process Vents: Captan Unit
6-31-250-11	Process Vents: PMM/THPI Reactor
6-31-250-12	Process Vents: Captan Unit, Holding Vessel
6-31-250-13	Process Vents: Captan Unit, Filtration
6-31-250-14	Process Vents: Captan Unit, Washing
6-31-250-15	Process Vents: Captan Unit, Drying
6-31-250-30	Process Vents: THPI Production
6-31-250-31	Process Vents: THPI Reactor
6-31-250-32	Process Vents: THPI Flaker
6-31-250-40	Process Vents: PMM Production
6-31-250-41	Process Vents: PMM Chlorinator
6-31-250-42	Process Vents: PMM Distillation
6-31-250-80	Process Vents: Captan Unit, Product Storage and Packaging
6-31-310-01	Chlorothalonil Production
6-31-310-10	Process Vents: Chlorothalonil Production
6-31-310-11	Process Vents: IPN Feed Bin
6-31-310-12	Process Vents: IPN Melt Pot
6-31-310-13	Process Vents: Reactor
6-31-310-14	Process Vents: Desublimer
6-31-310-15	Process Vents: Desublimer Feed Tank
6-31-310-16	Process Vents: Converters
6-31-310-17	Process Vents: Blender
6-31-310-18	Process Vents: Product Packaging
6-31-310-30	Process Vents, Chlorine (Cl) Recovery System
6-31-310-31	Process Vents, Cl Recovery System: Knockout Pots
6-31-310-32	Process Vents, Cl Recovery System: HCl Absorber
6-31-310-33	Process Vents, By-product Purification: CCl <sub>4</sub> Evaporator
6-31-310-34	Process Vents, Cl Recovery System: Bottom Drumming System
6-31-310-38	Process Vents: CCl <sub>4</sub> Collection System
6-31-310-80	Process Vents: End Product Storage
6-31-340-01	Dacthal Production

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<i><b>SCC</b></i>	<i><b>Description</b></i>
6-31-340-10	Process Vents: Dacthal Production
6-31-340-11	Process Vents: Photochlorination Reactor
6-31-340-12	Process Vents: Fusion Reactor
6-31-340-13	Process Vents: Thermal Chlorination Reactor
6-31-340-14	Process Vents, Esterification Reaction: Reactors
6-31-340-15	Process Vents: Still Pot Meoh Reflux Drum
6-31-340-16	Process Vents, Separation: Centrifuge
6-31-340-17	Process Vents: Xylol/Stripper Decanter
6-31-340-18	Process Vents: Flash Distillation
6-31-340-19	Process Vents: Organic Fume Scrubber System
6-31-340-20	Process Vents: Dacthal Flaking
6-31-340-21	Process Vents: Dacthal Hold Bin
6-31-340-22	Process Vents: Dacthal Formulation
6-31-340-23	Process Vents: Dacthal Packaging
6-31-340-24	Process Vents, Formulation: Solid Additives Feeders
6-31-340-25	Process Vents, Formulation: Feed Hoppers
6-31-340-26	Process Vents, Formulation: Adjusting Batch Tank
6-31-340-27	Process Vents, Formulation: Grinding Tanks
6-31-340-28	Process Vents, Formulation: Digester
6-31-340-29	Process Vents, Formulation: Adjusting Tanks
6-31-340-30	Process Vents, Formulation: Spray Dryers
6-31-340-31	Process Vents, Formulation: Surge Bins
6-31-340-32	Process Vents, Formulation: Packaging, Flowables
6-31-340-33	Process Vents, Formulation: Rework Tank
6-31-340-34	Process Vents, Formulation: Conveyor Transport Bin
6-31-340-35	Process Vents, Formulation: Product Silos
6-31-340-36	Process Vents, Formulation: Packaging Surge Bins
6-31-340-37	Process Vents, Formulation: Packaging (Solids)
6-31-340-38	Process Vents: Solid Antifoam Feeder
6-31-340-39	Process Vents, Formulation: Central Vacuum System
6-31-340-40	Process Vents: 2 Phase Separator
6-31-340-61	Process Tanks: CCl4 Coolant System Surge Tank
6-31-340-62	Process Tanks: MeOH Drying Column Water Hold Tank
6-31-340-63	Process Tanks: Fume Scrubber Hold Tank
6-31-340-64	Process Tanks: Xylol Still Receiver Tank
6-31-340-65	Process Tanks: Crude Xylol Hold Tank
6-31-340-66	Process Tanks: Hot Xylol Wash Tank

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<i><b>SCC</b></i>	<i><b>Description</b></i>
6-31-340-67	Process Tanks: Chilled Xylol Hold Tank
6-31-340-68	Process Tanks: Centrifuge Product Tanks
6-31-340-69	Process Tanks: Still Pot Surge Tank
6-31-340-70	Process Tanks: Mill Feed Tank
6-31-340-71	Process Tanks: Mill Receiver Tank
6-31-340-72	Process Tanks: MeOH Storage Chilled Water Hold Tank
6-31-340-73	Process Tanks: Xylol Mechanical Seal Tank
6-31-340-74	Process Tanks: MeOH Drying Column Receiver Tank
6-31-340-75	Process Tanks: Light Organic Slops Tank
6-31-340-76	Process Tanks: Sump Surge Tank
6-31-340-77	Process Tanks: Product Packaging Tanks
6-31-340-78	Process Tanks: Flash Feed Tanks
6-31-340-79	Process Tanks: Distillation Feed Tanks
6-31-340-80	Process Tanks: Flaker Feed Tanks
6-31-340-81	Process Tanks: Xylol Stripper Feed Tank
6-31-340-82	Process Tanks: Centrifuge Feed Tanks
6-31-340-83	Process Tanks: MeOH Drying Feed Tanks
6-31-340-84	Process Tanks: Spray Dryer Feed Tanks
6-31-340-85	Process Tanks: Small Media Mill Surge Tanks
6-31-420-01	Sodium Pentachlorophenate: Chlorination Process
6-31-420-10	Process Vents: Chlorination Process
6-31-420-11	Process Vents: Primary Reactor
6-31-420-12	Process Vents: Distillation
6-31-420-13	Process Vents: Secondary Reactor
6-31-420-14	Process Vents: Dryer
6-31-420-15	Process Vents: Prill Tower
6-31-420-30	Process Vents: End Product Storage
6-31-420-31	Process Vents, End Product Storage: Prilled Product
6-31-420-32	Process Vents, End Product Storage: Crystallized Product
6-31-430-01	Sodium Pentachlorophenate: Hydrolyzation Process
6-31-430-10	Process Vents: Hydrolyzation Process
6-31-430-11	Process Vents: Hydrolysis Reactor
6-31-430-12	Process Vents: Evaporation
6-31-430-13	Process Vents: Filter, Alcohol
6-31-430-14	Process Vents: Residue Dissolution in Water
6-31-430-15	Process Vents: Filtration of Alkali Insoluble Material
6-31-430-16	Process Vents: Acidification of Filtrate, Partial

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<i><b>SCC</b></i>	<i><b>Description</b></i>
6-31-430-17	Process Vents: Acidification of Filtrate, Full
6-31-430-18	Process Vents: Acidification Filter
6-31-430-19	Process Vents: Water Wash of Product
6-31-430-20	Process Vents: Dryer
6-31-430-30	Process Vents: End Product Storage
6-31-800-01	Equipment Leaks
6-31-820-01	Process Area Drain
6-31-820-02	Process Equipment Drains
6-31-825-01	2,4-D Recovery
6-31-825-07	Dacthal Condensate
6-31-825-08	Spent Scrubber Liquor Tank
6-31-825-09	2 Phase Separator
6-31-825-37	Captan Unit, Washing
6-31-825-38	THPI Reactor Scrubber
6-31-825-39	THPI Flaker Scrubber
6-31-825-40	PMM Chlorinator Scrubber
6-31-825-41	PMM Distillation Scrubber
6-31-825-42	PMM Storage Scrubber
6-31-825-73	Separator
6-31-825-80	Filtrate, Partial Evaporation of Alcohol
6-31-825-81	Filtrate, Acidification of Filtrate
6-31-825-82	Dissolve Residue in Water
6-31-825-99	Specify Point of Generation

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### **Polymethyl Methacrylate Prod - Bulk Polymerization, Batch-cell Method**

6-41-300-01	Polymethyl Methacrylate Resins: Bulk, Batch Cell Process
6-41-300-10	Process Vents: Bulk, Batch Cell Process
6-41-300-11	Process Vents: Reactor
6-41-300-25	Process Vents: End Product Storage
6-41-301-01	Polymethyl Methacrylate Resins: Bulk, Continuous Process
6-41-301-10	Process Vents: Bulk, Continuous Process
6-41-301-11	Process Vents, Reactor: Curing Zone
6-41-301-12	Process Vents, Reactor: Annealing Zone
6-41-301-25	Process Vents: End Product Storage
6-41-302-01	Polymethyl Methacrylate Resins: Bulk, Centrifugal Process
6-41-302-10	Process Vents: Bulk, Centrifugal Process
6-41-302-11	Process Vents: Reactor

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<i><b>SCC</b></i>	<i><b>Description</b></i>
6-41-302-25	Process Vents: End Product Storage
6-41-310-01	Polymethyl Methacrylate Resins: Solvent Process
6-41-310-10	Process Vents: Solvent Process
6-41-310-11	Process Vents: Reactor
6-41-310-15	Process Vents: Separation/Filtration
6-41-310-20	Process Vents: Dryer
6-41-310-25	Process Vents: Product Filters
6-41-310-30	Process Vents: End Product Storage
6-41-320-01	Polymethyl Methacrylate Resins: Emulsion Process
6-41-320-10	Process Vents: Emulsion Process
6-41-320-11	Process Vents: Reactor
6-41-320-20	Process Vents: Separation/Filtration
6-41-320-25	Process Vents: Dryer
6-41-320-30	Process Vents: Product Storage
6-41-330-01	Polymethyl Methacrylate Resins: Suspension Process
6-41-330-10	Process Vents: Suspension Process
6-41-330-11	Process Vents: Reactor
6-41-330-20	Process Vents: Separation/Filtration
6-41-330-25	Process Vents: Dryer
6-41-330-30	Process Vents: Product Storage
6-41-800-01	Equipment Leaks
6-41-820-01	Process Area Drains
6-41-820-02	Process Equipment Drains
6-41-825-99	Specify Point of Generation

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## **Carboxymethylcellulose Production**

6-44-200-01	Carboxymethylcellulose Production
6-44-200-10	Cellulose Preparation
6-44-200-11	Cellulose Preparation: Sodium Chloroacetate Reagent, Conventional
6-44-200-12	Cellulose Preparation: Chloroacetic Acid Reagent, Conventional
6-44-200-13	Cellulose Preparation: Sodium Chloroacetate Reagent, Aqueous Solution
6-44-200-14	Cellulose Prep: Chloroacetic Acid Reagent, Aqueous Solution Spraying
6-44-200-15	Cellulose Preparation: Sodium Chloroacetate Reagent, Aqueous Solution
6-44-200-16	Cellulose Prep: Chloroacetic Acid Reagent, Aqueous Solution Steeping
6-44-200-20	Etherification Reaction
6-44-200-21	Etherification Reaction: Wet Reaction Mass
6-44-200-22	Etherification Reaction: Slurry Process



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<i><b>SCC</b></i>	<i><b>Description</b></i>
6-44-200-30	Product Finishing
6-44-200-31	Product Finishing: Mill
6-44-200-32	Product Finishing: Neutralization
6-44-200-33	Product Finishing: Purification/Extraction
6-44-200-34	Product Finishing: Drying
6-44-200-40	End Product Storage
6-44-200-41	End Product Storage: Cyclones
6-44-200-42	End Product Storage: Bins, Containers, Etc.
6-44-300-01	Methyl Cellulose: Gaseous Methyl Chloride Process
6-44-300-10	Process Vents: Gaseous Methyl Chloride Process
6-44-300-11	Process Vents: Methylation Reactor
6-44-300-12	Process Vents: Neutralization
6-44-300-13	Process Vents: Salt Extraction/Washing
6-44-300-14	Process Vents: Drying
6-44-300-15	Process Vents: Acid Treatment
6-44-300-16	Process Vents: Glyoxal Reaction
6-44-300-17	Process Vents: Solvent Recovery
6-44-300-30	Process Vents: End Product Storage
6-44-310-01	Methyl Cellulose: Liquid Methyl Chloride Process
6-44-310-10	Process Vents: Liquid Methyl Chloride Process
6-44-310-11	Process Vents: Slurrying Vessel
6-44-310-12	Process Vents: Reactor Vessel/Tube
6-44-310-13	Process Vents: Evaporation
6-44-310-14	Process Vents: Drying
6-44-310-15	Process Vents: Acid Treatment
6-44-310-16	Process Vents: Glyoxal Reaction
6-44-310-17	Process Vents: Solvent Recovery
6-44-310-30	Process Vents: End Product Storage
6-44-500-01	Cellulose Ethers Production
6-44-500-10	Alkalization
6-44-500-11	Alkalization: Sodium Hydroxide Bath
6-44-500-12	Alkalization: NaOH Solution Spray
6-44-500-13	Alkalization: Inert Organic Solvent Impregnation
6-44-500-14	Alkalization: Vessels with Organic Solvent
6-44-500-20	Etherification and Neutralization
6-44-500-21	Etherification: Autoclaves
6-44-500-22	Neutralization

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<i><b>SCC</b></i>	<i><b>Description</b></i>
6-44-500-30	Product Purification
6-44-500-31	Purification: Washing, Hot Water
6-44-500-32	Purification: Salt Extraction, Step by Step
6-44-500-33	Purification: Salt Extraction, Continuous
6-44-500-34	Purification: Salt Extraction, Cascade Extraction w/ Organic Solvents
6-44-500-35	Isolation of Purified Products: Centrifuge
6-44-500-36	Isolation of Purified Products: Filtration
6-44-500-40	Material Recovery
6-44-500-41	Solvent Removal (Prior to Drying)
6-44-500-42	Solvent Recycle: Distillation
6-44-500-50	End Product Finishing
6-44-500-51	End Product Finishing: Drying
6-44-500-52	End Product Finishing: Milling and Sifting
6-44-500-53	End Product Finishing: Blending
6-44-500-60	End Product Storage
6-44-500-61	End Product Storage: Packaging
6-44-500-62	End Product Storage: Containers
6-44-700-01	Cellophane Manufacturing
6-44-700-10	Production of Viscose Solution
6-44-700-11	Viscose Solution Production: Mechanical Churn
6-44-700-12	Viscose Solution Production: Mixing Tank
6-44-700-13	Viscose Solution Production: Aging Tank
6-44-700-20	Cellophane Formation
6-44-700-21	Cellophane Formation: Coagulation Bath
6-44-700-22	Cellophane Formation: Acid Removal Water Wash Bath
6-44-700-23	Cellophane Formation: Bleach Bath
6-44-700-24	Cellophane Formation: Wash Tanks (After Bleach Bath)
6-44-700-25	Cellophane Formation: Glycerin Bath
6-44-700-26	Cellophane Formation: Drying/Dryer
6-44-700-40	Coating Operations
6-44-800-01	Equipment Leaks
6-44-820-01	Process Area Drains
6-44-820-02	Process Equipment Drains
6-44-825-99	Specify Point of Generation

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## **Alkyd Resin Production, Solvent Process**

6-45-200-01	Alkyd Production: Solvent Process
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<i><b>SCC</b></i>	<i><b>Description</b></i>
6-45-200-10	Polymerization Reaction
6-45-200-11	Polymerization Reaction: Kettle
6-45-200-20	Product Finishing
6-45-200-21	Product Finishing: Thinning Vessels
6-45-200-22	Product Finishing: Filter
6-45-200-23	Product Finishing: Intermediate Storage
6-45-200-30	Solvent Recovery
6-45-200-31	Solvent Recovery: Decanter
6-45-200-32	Solvent Recovery: Water Tank
6-45-200-40	End Product Storage
6-45-200-41	End Product Storage: Drum and Bulk Loading
6-45-210-01	Alkyd Production: Fusion Process
6-45-210-10	Polymerization Reaction
6-45-210-11	Polymerization Reaction: Kettle
6-45-210-20	Product Finishing
6-45-210-21	Product Finishing: Thinning Vessels
6-45-210-22	Product Finishing: Filter
6-45-210-23	Product Finishing: Intermediate Storage
6-45-210-40	End Product Storage
6-45-210-41	End Product Storage: Drum and Bulk Loading
6-45-800-01	Equipment Leaks
6-45-820-01	Process Area Drains
6-45-820-02	Process Equipment Drains
6-45-825-01	Solvent Recovery, Water Tank
6-45-825-02	Solvent Recovery, Fume Scrubber
6-45-825-99	Specify Point of Generation

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### **Polymerized Vinylidene Chloride Production - Emulsion, Latex Prod.**

6-46-100-01	Emulsion Polymerization: Latex Production
6-46-100-10	Raw Material Preparation
6-46-100-11	Raw Material Preparation: Raw Weighing and Holding Tanks
6-46-100-12	Raw Material Preparation: Raw Material Loading Lines
6-46-100-20	Polymerization
6-46-100-21	Polymerization: Reactor Opening Loss
6-46-100-22	Polymerization: Reactor Relief Value
6-46-100-30	Material Recovery
6-46-100-31	Material Recovery: Stripping Vessel

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<i><b>SCC</b></i>	<i><b>Description</b></i>
6-46-100-32	Material Recovery: Monomer Recovery Sys. Exhaust Vents & Knockout Pots
6-46-100-40	Product Finishing
6-46-100-41	Product Finishing: Polymer Holding Tanks
6-46-100-50	End Product Storage
6-46-101-01	Emulsion Polymerization: Dried Resin
6-46-101-10	Raw Material Preparation
6-46-101-11	Raw Material Preparation: Raw Weighing and Holding Tanks
6-46-101-12	Raw Material Preparation: Raw Material Loading Lines
6-46-101-20	Polymerization
6-46-101-21	Polymerization: Reactor Opening Loss
6-46-101-22	Polymerization: Reactor Relief Value
6-46-101-30	Material Recovery
6-46-101-31	Material Recovery: Stripping Vessel
6-46-101-32	Material Recovery: Monomer Recovery Sys. Exhaust Vents & Knockout Pots
6-46-101-40	Product Finishing
6-46-101-41	Product Finishing: Polymer Holding Tanks
6-46-101-42	Product Finishing: Dewatering and Centrifuge
6-46-101-43	Product Finishing: Dryer
6-46-101-50	End Product Storage
6-46-102-01	Polymerized Vinylidene Chloride Production: Suspension Polymerization
6-46-102-10	Raw Material Preparation
6-46-102-11	Raw Material Preparation: Raw Weighing and Holding Tanks
6-46-102-12	Raw Material Preparation: Raw Material Loading Lines
6-46-102-20	Polymerization
6-46-102-21	Polymerization: Reactor Opening Loss
6-46-102-22	Polymerization: Reactor Relief Value
6-46-102-30	Material Recovery
6-46-102-31	Material Recovery: Stripping Vessel
6-46-102-32	Material Recovery: Monomer Recovery Sys. Exhaust Vents & Knockout Pots
6-46-102-40	Product Finishing
6-46-102-41	Product Finishing: Polymer Holding Tanks
6-46-102-42	Product Finishing: Dryer
6-46-102-50	End Product Storage
6-46-103-01	Solution Polymerization: Batch Process
6-46-103-10	Raw Material Preparation
6-46-103-11	Raw Material Preparation: Raw Weighing and Holding Tanks
6-46-103-12	Raw Material Preparation: Raw Material Loading Lines

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<i><b>SCC</b></i>	<i><b>Description</b></i>
6-46-103-20	Polymerization
6-46-103-21	Polymerization: Reactor Opening Loss
6-46-103-22	Polymerization: Reactor Relief Value
6-46-103-30	Material Recovery
6-46-103-31	Material Recovery: Stripping Vessel
6-46-103-32	Material Recovery: Monomer Recovery Sys. Exhaust Vents & Knockout Pots
6-46-103-40	Product Finishing
6-46-103-50	End Product Storage
6-46-150-01	Polyvinyl Acetate Emulsions Production
6-46-150-10	Polymerization
6-46-150-11	Polymerization: Reactor Safety Valve
6-46-150-12	Polymerization: Reactor Vacuum System
6-46-150-20	Material Recovery
6-46-150-21	Material Recovery: Stripping Vessel (If Not Stripped in Reactor)
6-46-150-22	Material Recovery: Residual Monomer Removal, Sparging
6-46-150-23	Material Recovery: Residual Monomer Removal, Distillation
6-46-150-30	End Product Storage
6-46-200-01	Polyvinyl Alcohol Production: Solution Polymerization
6-46-200-11	Raw Material Preparation
6-46-200-12	Raw Mat Prep: Vinyl Acetate Monomer Purification (Deinhibiting) Column
6-46-200-13	Raw Material Preparation: Purified, Uninhibited VAM Day Storage Tank
6-46-200-15	Polymerization and Hydrolysis
6-46-200-16	Polymeriz'n/Hydrolysis: Vinyl Acetate Monomer Polymerization Reactors
6-46-200-17	Polymeriz'n/Hydrlysis: Intrmed Prc Stor Tks, Varnish - Polymer in CH <sub>3</sub> OH
6-46-200-18	Polymerization/Hydrolysis: Hydrolysis Reactors
6-46-200-20	Product Finishing
6-46-200-21	Product Finishing: Centrifuge
6-46-200-22	Product Finishing: Dryer
6-46-200-25	Product Storage
6-46-200-26	Product Storage: Powder Storage and Conveying
6-46-200-27	Product Storage: Packaging: Loading and Unloading
6-46-200-30	Material Recovery
6-46-200-31	Vinyl Acetate Monomer Recovery Column
6-46-200-32	Solvent Separation: Crude Solvent Storage
6-46-200-33	Solvent Recovery: Overall
6-46-200-34	Solvent Recovery: Mixed Solvent Column
6-46-200-35	Solvent Recovery: MeOH Column

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<i><b>SCC</b></i>	<i><b>Description</b></i>
6-46-200-36	Solvent Recovery: Acetic Acid Column
6-46-200-37	Solvent Recovery: Ester Hydrolizer
6-46-200-38	Solvent Recovery: Crude Solvent Recovery
6-46-300-01	PVC and Copolymers Production: Suspension Process
6-46-300-10	Process Vents: Suspension Process
6-46-300-11	Process Vents: VCM Evaporator Monomer Recovery
6-46-300-12	Process Vents: Weight Tanks
6-46-300-15	Process Vents, Reactor: Opening Loss
6-46-300-16	Process Vents, Reactor: Safety Valve Vents
6-46-300-25	Process Vents, Stripper: Vinyl Chloride Stripped from Polymer to Atmos
6-46-300-26	Process Vents, Stripper: Transfer of Batch
6-46-300-30	Process Vents: Slurry Blend Tank
6-46-300-35	Process Vents: Centrifuge
6-46-300-40	Process Vents: Rotary Dryer
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VOLUME II: CHAPTER 15

# PREFERRED AND ALTERNATIVE METHODS FOR ESTIMATING AIR EMISSIONS FROM THE PRINTING, PACKAGING, AND GRAPHIC ARTS INDUSTRY

May 2002



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Prepared for:  
Point Sources Committee  
Emission Inventory Improvement Program

## **DISCLAIMER**

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.



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# 1

## INTRODUCTION

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The purposes of the preferred methods guidelines are to describe emission estimation techniques for point sources in a clear and unambiguous manner and to provide concise example calculations to aid in the preparation of emission inventories. While emissions factors are not provided, the information presented in this document can be used to select the emission estimation technique best suited to a particular application. This chapter describes the process and recommends the approaches for estimating volatile organic compound (VOC) and hazardous air pollutant (HAP) emissions from printing and graphic arts operations. This chapter is intended to be a useful guide for industry, federal, state, and local agencies.

Section 2 of this chapter contains a general description of the printing and graphic arts source category; the various printing processes used by the printing and graphic arts industry; and the common emission sources. Section 3 of this chapter provides an overview of available emission estimation methods.

Section 4 presents the preferred methods for estimating emissions from printing and graphic arts operations. Although preferred methods are identified, this document does not mandate any method. Preferred methods are desirable when data are readily available, when expected emissions are high, or when their use is cost-effective. Alternative methods may be used when preferred methods are not cost-effective. Section 5 presents the alternative emission estimation techniques. Quality Assurance and Quality Control are described in Section 6. Section 7 of this chapter contains coding procedures used for data input and storage. Some states use their own unique identification codes, so individual state agencies should be contacted to determine the appropriate coding scheme to use. Complete citations for all references are provided in Section 8.

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# 2

## SOURCE CATEGORY DESCRIPTIONS

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This section presents a brief overview of the printing and graphic arts industry and a description of the various printing processes involved in the graphic arts industry. For a more detailed discussion of printing processes, refer to *EPA Office of Compliance Sector Notebook Project: Profile of the Printing and Publishing Industry* (EPA, 1995a), and the *Sector Notebook Data Refresh* (EPA, 1998a).

The printing and graphic arts industry, defined most broadly, includes:

- Firms whose business is dominated by printing operations;
- Firms performing operations commonly associated with printing, such as platemaking or bookbinding; and
- Publishers, whether or not they actually print their own material (EPA, 1995a).

This document will focus on the first group, firms whose business is dominated by printing operations. Products printed include newspapers, books, greeting cards, checks, annual reports, magazines, flexible packaging, corrugated cartons, and vinyl and urethane products, such as resilient flooring, wallpaper, upholstery, and shower curtains. The United States Bureau of Census' Standard Industrial Classification (SIC) code 27 corresponds to this category. Some 58,000 firms and 62,000 facilities were identified within SIC code 27 by the Census (Census Bureau, 1997). This figure does not include the large number of "in-plant" printing operations located throughout the manufacturing sectors, which could bring the total number of operations well in excess of 100,000 (EPA, 1995a).

The markets for printing can be international, national, regional, or local in scope. Some facilities, such as those printing books, periodicals, and newspapers, serve national and international markets; while other printers may serve regional and local customers. As a result, the geographic distribution of printing facilities parallels U.S. population distribution. The printing and graphic arts industry is dominated by small firms. Almost one-half of all printing facilities have fewer than five employees; while approximately 84 percent employ fewer than 20 (EPA, 1995a).

From the printing industry's perspective, the industry is organized according to the type of printing process used. Types of printing processes include:

- Lithography;
- Flexography;
- Gravure;
- Screen printing;
- Letterpress; and
- Digital.

Historically, facilities tended to exclusively use one of these processes, with some larger facilities in operation that operated using some combination of these processes. Recently, it is becoming more common to have more than one process located at a facility. Based on 1997 estimated shipment values, the industry breaks down as 68.5 percent lithography, 6.4 percent flexography, 5.4 percent gravure, 0.6 percent digital, 4.5 percent letterpress, 9.0 percent screen printing, and 5.7 percent quick printing.<sup>1</sup> (Census Bureau, 1997).

The equipment, applications, and chemicals vary for each of these six printing processes. However, they all print an image on a substrate following the same basic sequence. The fundamental steps in printing are:

- **Pre-press operations** - The entire goal of the prepress operation is to produce an image carrier. The image carrier is used on a press to transfer an inked image from the image area to substrate. There are a variety of image carriers used and the specific one depends upon the particular printing process that will be utilized. The most common image carriers are planographic plates (lithography), relief plates (flexography and letterpress), screens (screen printing), and engraved cylinders (rotogravure).

In order to create the image carrier, often times a film negative or positive is created. The film negative or positive can be produced in a conventional manner, where the type is set with a computer and original photographs and

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<sup>1</sup>Quick printers are engaged in traditional printing activities, such as short-run offset printing or prepress services, in combination with providing document photocopying service. 91% of all quick printers utilize offset lithographic printing presses.

artwork are separated into the four primary colors and a film flat is assembled. Over the past decade, these conventional steps have been computerized and films can be imaged directly from the computer. The film negative or positive is used to transfer the image to the image carrier. More recently, image carriers are now imaged directly from the computer.

The other important step very common in the prepress operations is that of proofing. Prior to the final imaging setup, a proof of the job is made for customer approval. Not all printing jobs are proofed prior to image carrier preparation.

- **Printing operations** - Ink is applied to the image carrier, and the image is transferred to a substrate.
- **Post-press step** - The printed material may receive any one of numerous finishing operations, depending on the desired form of the finished product. The post-press step includes such processes as cutting, folding, collating, binding, perforating, drilling, coating, gluing, and laminating.

## 2.1 PROCESS DESCRIPTIONS

The printing and graphic arts industry as well as trade associations, technical foundations, and suppliers can be divided into six main categories by the printing process used:

- Lithography;
- Flexography;
- Gravure;
- Screen printing;
- Letterpress; and
- Digital or electronic printing.

Digital printing is any printing completed via digital files, not restricted to short runs and is able to provide variable printing such as incorporating data directly for a compact database and printing not using traditional methods of film or printing plates. Calculating emissions from digital printing is not discussed in this document. Such plateless printing processes include electronic (e.g., laser printers), electrostatic (e.g., xerographic copiers), magnetic, thermal (e.g.,

facsimile machines), and ink jet printing. Electrostatic toners and ink jet printers may contain HAPs; however, the quantities emitted at any location are small (EIIP, 1996a).

### 2.1.1 LITHOGRAPHY

Lithography is a planographic printing technique, that is, the printing and non-printing surfaces are essentially in the same plane. The image area of that plane is hydrophobic and oleophilic, while the non-image area is hydrophilic and chemically repellant to oil-based inks. The “offset” in offset lithography refers to the use of a rubber blanket to transfer the image from the plate to the substrate. Figure 15.2-1 presents a process flow diagram of the sheetfed offset lithographic printing process.

Fountain solution, a mixture of water and other volatile and non-volatile chemicals and additives that maintain the quality of the printing plate and reduces the surface tension of the water so that it spreads easily across the printing plate surface, is applied to the plate. The fountain solution wets the nonimage area so that the ink is maintained within the image areas. Non-volatile additives include mineral salts and hydrophilic gums. Alcohol and alcohol substitutes, including isopropyl alcohol, glycol ethers, and ethylene glycol, are the most common VOC additives used to reduce the surface tension of the fountain solution. There is also a type of lithography called waterless, in which no fountain solution is used. The non-image areas have a silicon coating which repels ink.

Lithography can be divided into two broad subdivisions based upon ink drying and substrate feed mechanisms:

- **Sheetfed press** - The substrate is fed into the press one sheet at a time. Sheetfed printing is typically used for printing books, posters, brochures, and artwork. Sheetfed inks dry by a combination of penetration and oxidation.
- **Web-press** - Prints on a continuous roll of substrate, known as a web. Web-fed lithography can be divided into heatset and non-heatset, the difference being that heatset web lithography dries the ink by evaporating the ink oils with indirect hot air dryers, and non-heatset web inks dry principally by absorption. Web-fed printing is commonly used for high speed production of magazines, catalogs, newspapers, and other periodicals.

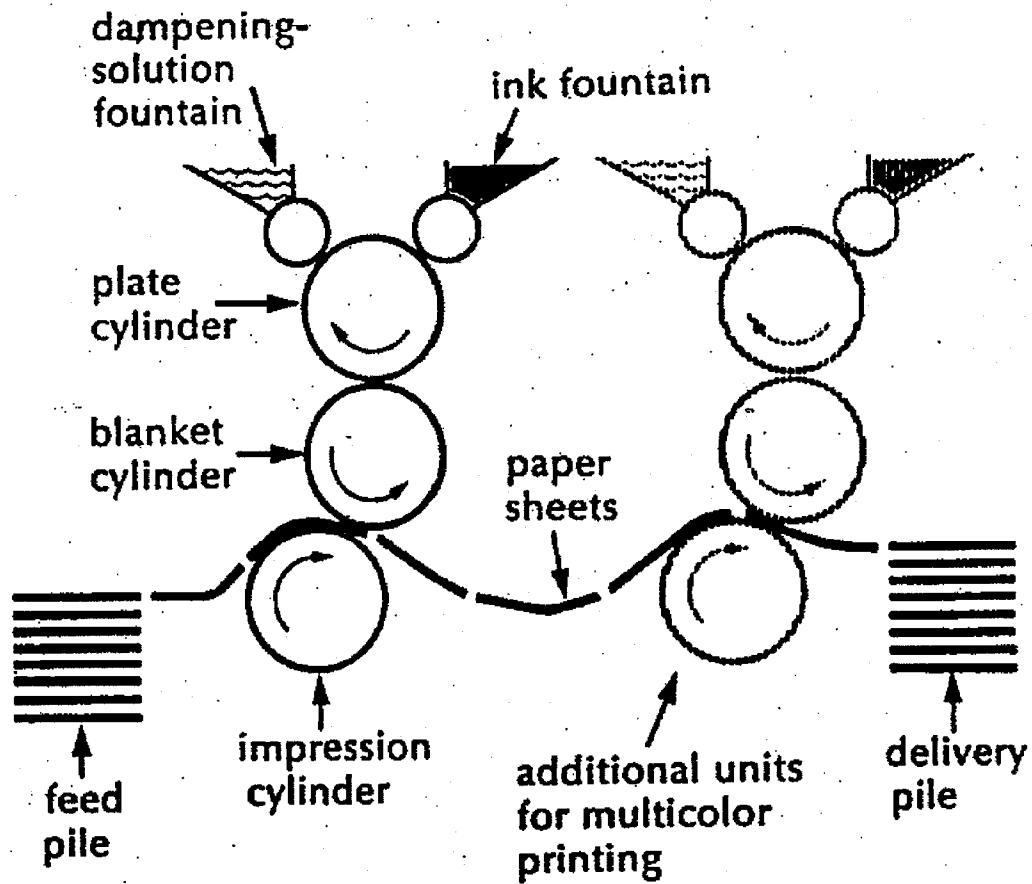


Figure 15.2-1. The Sheetfed Offset Lithographic Printing Process

Source: EPA, 1994b.

### 2.1.2 FLEXOGRAPHY

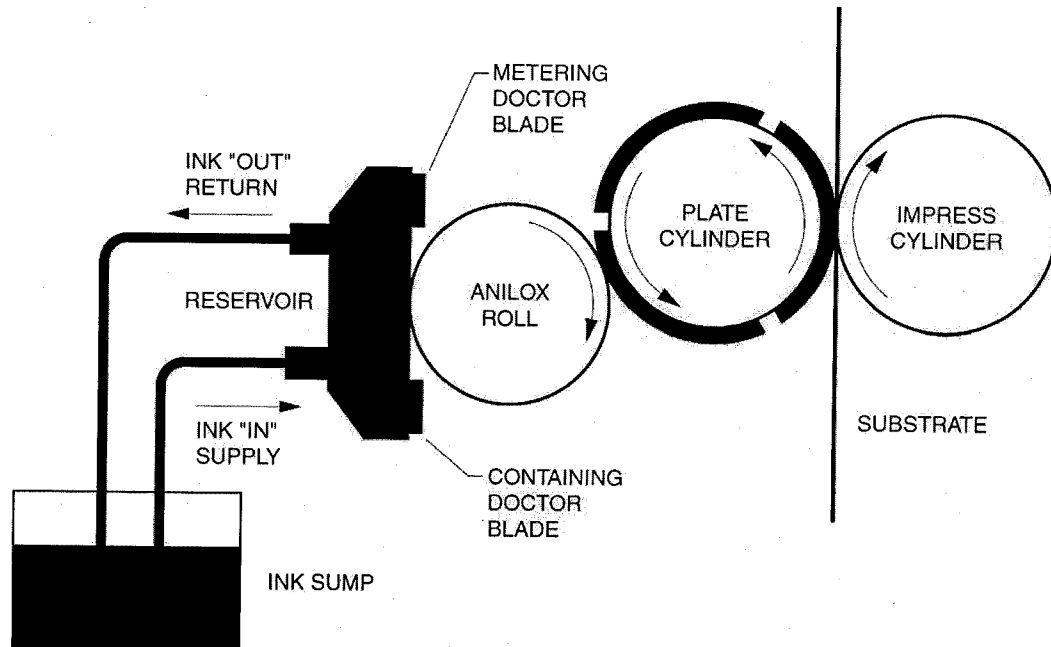
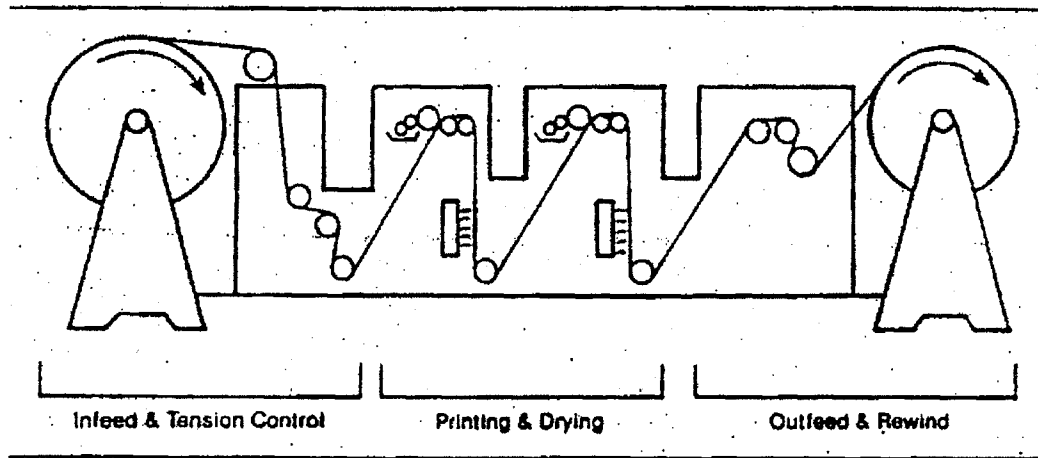
Flexographic printing uses flexible plates with raised images to transfer fluid inks to a substrate. The plates are typically rubber or photopolymer and are attached to a roller cylinder. Traditionally, four rollers are used to transfer an ink to a substrate. The first roller transfers an ink from an ink fountain to an engraved roller, known as an anilox roller. The anilox roller meters the ink to a uniform thickness for transfer to the third roller, the plate cylinder. The fourth roller is the impression cylinder. The impression cylinder applies pressure to the substrate as it passes between the plate cylinder and impression cylinder during printing. The substrate will pass through a dryer before another ink is printed. Flexography presses with a common impression cylinder are also frequently used. Doctor blade systems can be used in place of the first ink transfer roller. In a single doctor-blade system, the anilox roller is in direct contact with the ink fountain, and a single, reverse-angle doctor blade is employed to scrape off excess ink. In a double-blade system, the anilox roller rotates in an enclosed ink chamber with two doctor blades. Figure 15.2-2 shows a process flow diagram of the flexographic printing process.

Flexographic printing presses can be either sheetfed or webfed. Flexographic inks can be used on both absorbent (paper, corrugated cardboard) and non-absorbent substrates (film and foil). Flexographic inks need to be fast-drying, low-viscosity inks. These inks lie on the surface of substrates and solidify when solvents are removed, making flexography ideal for printing on impervious materials, such as plastics or metallized surfaces. The soft plates allow quality printing on compressible surfaces, such as cardboard packaging, as well.

### 2.1.3 GRAVURE

Almost all gravure is webfed (GATF, 1993). The image area of a gravure cylinder consists of small, recessed cells, which are typically electro-mechanically engraved. The engraved surface of a gravure cylinder consists of millions of minute cells engraved into a copper cylinder and is protected with a very thin electroplated layer of chromium. Chemical etching, formerly the most common method of gravure cylinder engraving, accounts for only a small fraction of the etching done today.

During gravure printing, a low viscosity ink floods the lower portion of the gravure cylinder. The ink is then wiped from the surface of the cylinder with a doctor blade, leaving ink only in the image area. The ink left in the recessed cells is then pressed onto the substrate as the substrate is pressed against the gravure cylinder with a rubber-covered impression roll. The substrate is then passed through a high volume, recirculated air dryer before the next ink or coating is applied. Low-boiling point organic solvents are commonly used to achieve the low viscosity, fast drying properties required of inks used in a rotogravure process. Inks in the press fountain can contain



Enclosed Doctor Blade System Diagram

Figure 15.2-2. The Flexographic Printing Process

as much as 75 percent solvent by weight (GATF, 1993). Figure 15.2-3 shows a process flow diagram of the gravure printing process.

#### 2.1.4 SCREEN PRINTING

Screen printing differs from the other printing processes in that ink is transferred to a substrate through a porous mesh rather than on an impervious surface. Mesh is stretched across a frame and a stencil applied to the mesh defines the print image. Mesh thread count and diameter control the volume of ink applied to the substrate. A rubber or synthetic blade known as a squeegee applies pressure to the ink, causing the ink to flow through the imaged mesh and onto the substrate. Once the substrate has been printed, it is placed either on drying racks or on a conveyor into a dryer. Due to the flexibility in the screen printing process, a wide variety of substrates are possible, including, but not limited to, textiles, plastics, metals, and paper. Figure 15.2-4 shows a process flow diagram of the screen printing process.

#### 2.1.5 LETTERPRESS

Similar to flexography, letterpress printing uses metal or plastic plates with a raised printing image to transfer ink to a substrate. There are three types of letterpresses:

- Platen;
- Flatbed; and
- Rotary.

In a platen press, the raised plate is locked on a flat surface, while the substrate is pressed between the raised plate and another flat surface. In both flatbed presses and rotary presses, the substrate passes between the plate cylinder and an impression cylinder during printing. With a flatbed press, only one side of the substrate is printed at a time, whereas rotary presses are designed to print both sides simultaneously. The web-fed rotary letterpress is the most common letterpress used today. Figure 15.2-5 shows a process flow diagram of the letterpress printing process.

Letterpress, once the predominant used printing process, is being replaced by lithography, flexography, and gravure. Lithography and flexography have been replacing letterpress in the printing of newspapers. Flexography has also been replacing letterpress in the printing of paperbacks, labels, business forms, and corrugated cartons. Gravure has largely replaced



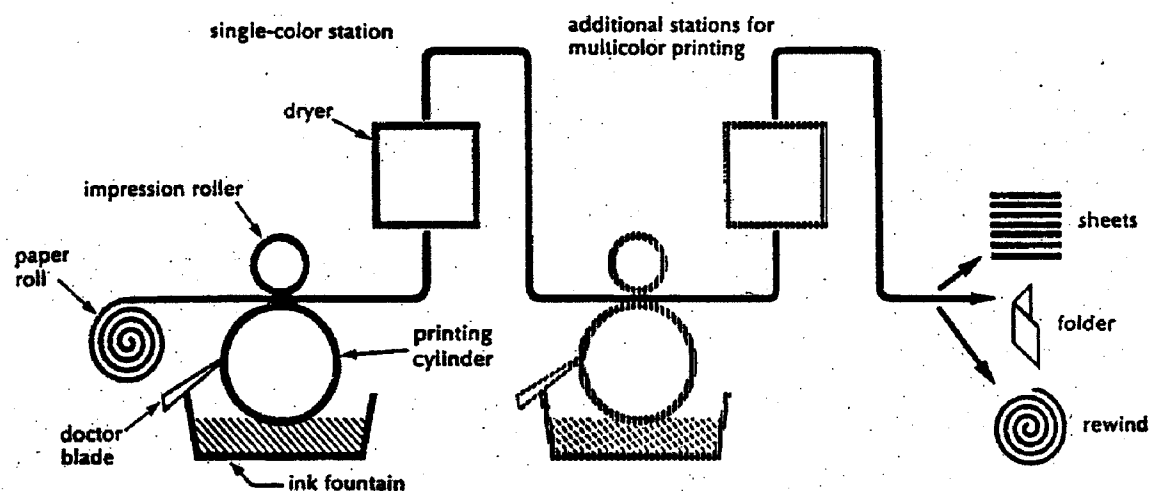


Figure 15.2-3. The Gravure Printing Process

Source: EPA, 1994b.

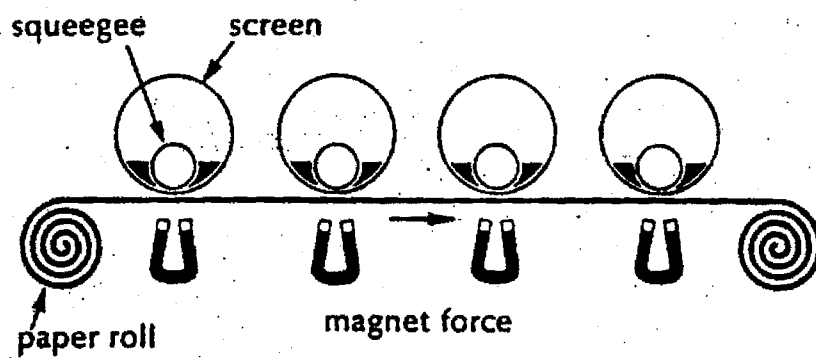
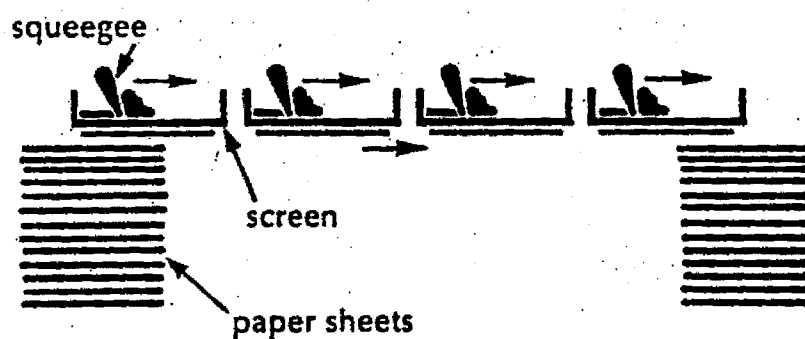


Figure 15.2-4. The Screen Printing Process

Source: EPA, 1994b.

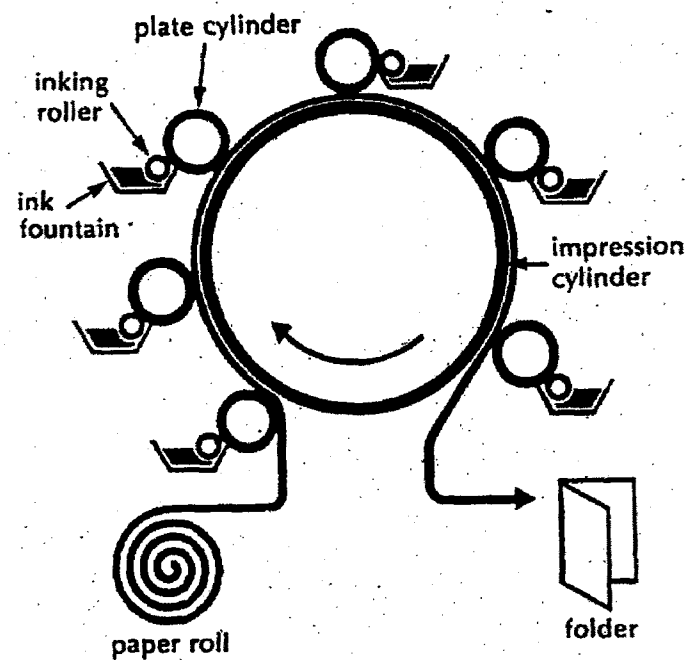
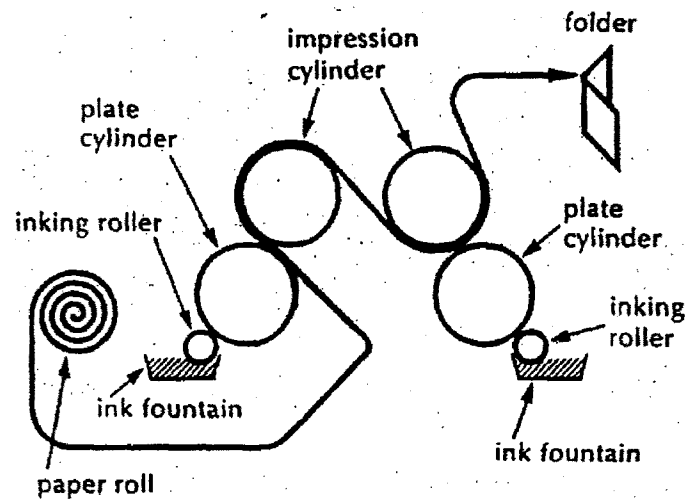


Figure 15.2-5. The Letterpress Printing Process

Source: EPA, 1994b.

letterpress for long-run magazine and catalog print jobs. Today, letterpress is used primarily for the printing of books, business cards, and advertising brochures.

## 2.2 EMISSION POINTS

Each of the printing processes follows the same basic sequence of imaging, pre-press, printing, and post-press.

### ***Pre-Press***

Pre-press operations include those operations used to create a positive or negative image which is then in turn used to create a plate, cylinder, or screen. The input materials used in the creation of the image are very similar to the input materials used in other fields of photography. Emissions may be the result of the use of developers, fixers, photographic processing solutions, or cleaning solutions. Emissions from the imaging step are minimal and are usually considered insignificant. The plate, cylinder, or screen produced will be used in the printing stage to transfer ink in the form of the image to the substrate. Emissions from the lithographic platemaking operation are minimal and typically considered insignificant. In flexographic platemaking, emissions may result from platemaking using perchloroethylene (PERC) or VOC-containing perchloroethylene alternative solvents (PAS) to wash photopolymer plates. PERC is being phased out as a solvent for flexographic platemaking. Most prepress operations now use PASs or water washable plates. Figure 15.2-6 presents examples of the various image carriers used in the printing and graphic arts industry.

### ***Printing***

The majority of releases in the printing and graphic arts industry occur during the printing step, during the process of transferring the ink and coating to a substrate. For the purpose of emission estimation, the printing step includes cleanup operations, which may occur during or between print runs. Emissions result from the evaporation of VOC contained in the inks and cleaning solutions. Lithography will also produce emissions from the evaporation of VOC contained in fountain solutions. In lithography, a portion of the VOC in inks can be retained on the substrate, thus reducing the amount available to volatilize into the atmosphere. The use of retention factor to account for this substrate retention is discussed in Section 4.1.1 of this document, along with a list of references on this subject.

Combustion of fuel, such as natural gas or oil, to provide heat for dyers also produces some emissions. In some cases, recovered solvent may be used as a supplemental fuel (EIIP, 1996a). A detailed discussion of the methodology used to calculate emissions associated with fuel

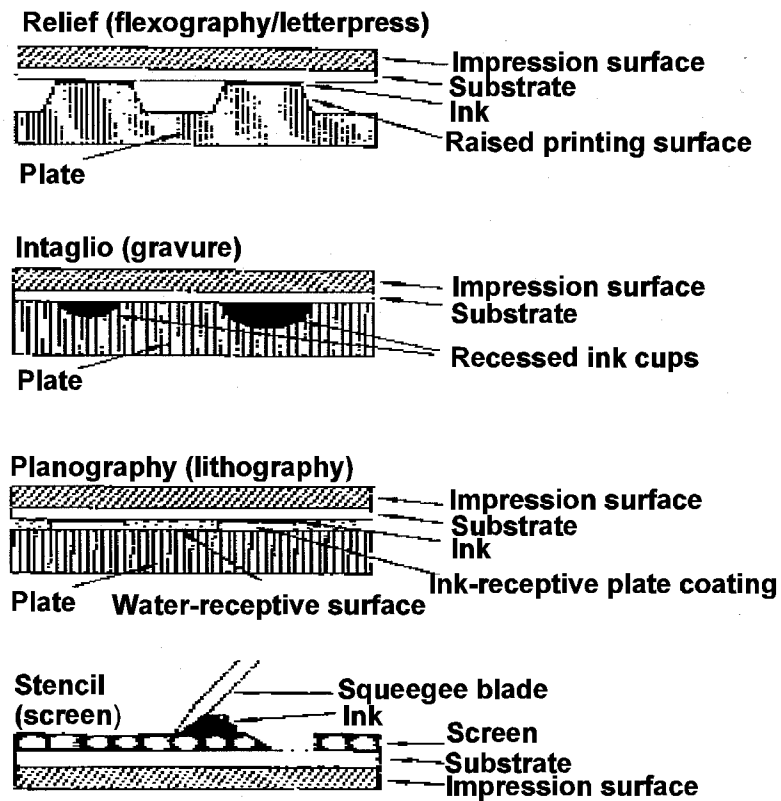


Figure 15.2-6. Typical Image Carriers Used in the Printing and Graphic Arts Industry

Source: EPA, 1994b.

combustion is presented in EIIP Volume 2, Chapter 2, *Preferred and Alternative Methods for Estimating Air Emissions from Boilers* (EIIP, 1996a).

### **Post-Press**

The post-press step includes such processes as cutting, folding, collating, binding, perforating, and drilling. From an emissions perspective, binding is the most significant of the various post-press operations. Emissions may result from the volatilization of VOC contained in the adhesives used in the binding operation and solvents found in some types of ink jets inks, coatings, and some laminates used in the finishing process.

## **2.3 CONTROL EQUIPMENT AND POLLUTION PREVENTION TECHNIQUES**

There are several methods by which VOC/HAP emissions at a facility can be reduced. These include material substitution, and control devices.

### **Material Substitution**

Switching to cleaning solutions with lower hazardous air pollutant (HAP) and VOC contents or low volatility cleaners (those with VOC composite vapor pressure of less than 10mm Hg at 20°C) have been shown to reduce emissions. In lithography, the use of isopropyl alcohol has been replaced in many operations with alcohol substitutes. Some printers have also had success in reducing their emissions by switching from solvent-based inks to water-based inks and ultra violet (UV) curable inks. Some lithographic operations use vegetable oil-based inks. HAPs associated with printing and publishing industries are listed in Table 15.2-1.

### **Control Devices**

Another strategy to control emissions is the installation of control devices. Control techniques commonly used in the printing and graphics arts industry and their typical control efficiency ranges are presented in Table 15.2-2. Control devices used by the printing and graphics arts industry can be described as either destructive or nondestructive. Destructive control devices are combustion devices, such as thermal oxidizers and catalytic oxidizers, designed to destroy volatile organic compounds in the vent stream prior to release into the atmosphere. Nondestructive control devices are recovery devices, such as carbon adsorbers or cooler/condenser filtration units. Recovery devices control emissions by recovering VOC for other uses, rather than destroying them.

TABLE 15.2-1

## HAPs ASSOCIATED WITH PRINTING AND GRAPHIC ARTS INDUSTRIES

1,4-Dioxane	Glycol Ethers
2-Nitropropane	Hydrochloric Acid (Hydrogen Chloride gas only)
4-4'-Methylenediphenyl Diisocyanate	Lead & Compounds
Acrylic Acid	Maleic Anhydride
Benzene	Methanol
Bis 2-ethylhexyl phthalate	Methyl Ethyl Ketone
Cadmium & Compounds	Methyl Isobutyl Ketone
Chromium & Compounds	Methylene Chloride
Cobalt Compounds	Nickel & Compounds
Cumene	Phthalic Anhydride
Cyanide Compounds	Tetrachloroethylene
Dibutylphthalate	Toluene
Ethylbenzene	Trichloroethylene
Ethylene Glycol	Vinyl Acetate
Formaldehyde	Xylenes (includes o, m, and p)

Source: EPA, 1998a.

TABLE 15.2-2

## TYPICAL GRAPHIC ARTS INDUSTRY EMISSION CONTROL TECHNIQUES

Pollutant	Control Device Type	Average Control Device Efficiency (%)
VOC	Recuperative Thermal Oxidizer <sup>a</sup>	95 - 99.8
	Regenerative Thermal Oxidizer <sup>b</sup>	90 - 99
	Catalytic oxidizer <sup>c</sup>	95 - 99
	Regenerative Catalytic Oxidizer <sup>b</sup>	90 - 99
	Carbon Adsorber <sup>d,e</sup>	95 - 98

<sup>a</sup> EIIP, 2000<sup>b</sup> EPA, 1999c<sup>c</sup> EPA, 1999d<sup>d</sup> EPA, 1999e<sup>e</sup> For concentrations between 500 and 2000 ppm

***Other Process Changes***

In lithography, refrigerated circulators are used to control emissions of isopropyl alcohol from fountain solutions by cooling the solution to between 55 and 60°F. Using refrigerated circulators reduces the evaporation of isopropyl alcohol, thereby reducing emissions of isopropyl alcohol and stabilizing the ink/water balance, as well as providing operators with better control of ink emulsification and hot weather scumming. There is no such equivalent reduction when alcohol substitutes are used. Refrigeration of fountain solutions with alcohol substitutes is not appropriate as a control technology.

In flexography, enclosed doctor blade systems have been used to reduce emissions from the printing process. While enclosed doctor blade systems are not control devices or material substitution, they can reduce VOC emissions due to reduced evaporation and more efficient cleaning.



# 3

## OVERVIEW OF AVAILABLE METHODS

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### 3.1 EMISSION ESTIMATION METHODS

Several methods are available for calculating emissions from printing and graphic arts operations. The “best” method to use depends upon available data, available resources, and the degree of accuracy required in the estimate. In general, site-specific data that are representative of normal operating conditions are preferred over industry-average data, such as the emission factors presented in *Compilation of Air Pollution Emission Factors* (AP-42) (EPA, 1995c).

This section discusses and compares the methods available for calculating emissions from printing and graphic arts operations and identifies the preferred method of calculation on a pollutant basis. Although preferred methods are identified, this document does not mandate any emission estimation method. Industry personnel using this manual should contact the appropriate state or local air pollution control agency regarding suggested methods prior to calculating emissions estimates.

#### 3.1.1 MATERIAL BALANCE

Material balance utilizes the raw material usage rates, fraction of the pollutant in the raw material, and portion (if any) of the pollutant in the raw material that is retained in the substrate to estimate the amount of pollutant emitted. Material balance is used most often where a relatively consistent amount of material is emitted during use. The material balance emission rate is calculated by multiplying the raw material usage by the amount of pollutant in the raw material, and subtracting the amount of the pollutant retained in the substrate. For VOC/HAP-containing materials, the amount of pollutant emitted is assumed to be 100 percent of the amount of pollutant contained in the material, unless a control device is used to remove or destroy VOC/HAP in the exhaust stream or a known portion of ink, for example, is retained in the substrate. To estimate VOC/HAP emissions where a control device is being used, it is necessary to establish the efficiency of the capture system and the control device. Regardless of whether a control device is being used, it is necessary to utilize all accepted retention factors and emission factors to accurately perform the mass balance equations. Guidance on retention factor utilization can also be found at the EPA’s Technology Transfer Network (TTN) web site (EPA, 1998b).

### 3.1.2 SOURCE TESTING

Source sampling provides a “snapshot” of emissions during the period of the test. EPA has promulgated several test methods for performing source testing at printing and graphic arts facilities. These methods are outlined in Section 5.1 of this document. Because there are many steps in the source sampling procedures where errors can occur, only experienced source testers should perform such tests. Source sampling methods are available to measure VOC and HAP emissions. For further guidance on when source testing may be appropriate/required, contact your federal, state, or local agencies.

### 3.1.3 EMISSION FACTORS

An emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant (e.g., pound of VOC emitted per gallon of ink applied). Emission factors are available for some printing operations and are based on the results of source tests or material balances performed for one or more facilities within an industry. Chapter 1, *Introduction to Point Source Emission Inventory Development*, contains a detailed discussion of the reliability and quality of available emission factors. The EPA provides compiled emission factors for criteria and hazardous air pollutants in AP-42 (EPA, 1995c) and the Factor Information Retrieval (FIRE) System (EPA, 1999a). Refer to Chapter 1, *Introduction to Point Source Emission Inventory Development*, of this series for a complete discussion of available information sources for locating, developing, and using emission factors as an estimation technique.

Due to their availability and acceptance, emission factors are commonly used to prepare emission inventories. However, the emissions estimate obtained from using emission factors is likely to be based upon emission testing performed at similar but not identical facilities and may not accurately reflect emissions at a single source. Thus, the user should recognize that, in most cases, emission factors are averages of available industry-wide data with varying degrees of quality and uncertainty, and may not be representative for an individual facility within that industry.

Source-specific emission factors can be developed from multiple source test data, predictive emissions monitoring data, or from single source tests. These factors, when used for the specific operations for which they are intended, are generally more representative than the average emission factors found in AP-42 (EPA, 1995c) or FIRE (EPA, 1999a).

### 3.2 COMPARISON OF AVAILABLE EMISSION ESTIMATION METHODOLOGIES

Table 15.3-1 identifies the preferred and alternative emission estimation approaches for selected pollutants for the printing and graphic arts industry. For many of the pollutants emitted from the printing and graphic arts industry, several of the previously defined emission estimation methodologies can be used.

TABLE 15.3-1

SUMMARY OF PREFERRED AND ALTERNATIVE EMISSION ESTIMATION METHODS FOR THE PRINTING AND GRAPHIC ARTS INDUSTRY

Parameter	Preferred Emission Estimation Approach	Alternative Emission Estimation Approach
VOC	Material Balance	Source Testing Emission Factor
HAP	Material Balance	Source Testing Emission Factor

The preferred method for estimating VOC and HAP emissions is material balance. Source testing may provide accurate emission estimates, but the quality of the data will depend on a variety of factors, including the number of data points generated, the representativeness of those data points, and the proper operation and maintenance of the equipment being used to record the measurements.

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# 4

## PREFERRED METHODS FOR ESTIMATING EMISSIONS

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### 4.1 MATERIAL BALANCE APPROACH

Emissions from the materials used in the four fundamental process operations (imaging, pre-press, printing, and post-press processes) can be calculated using the mass balance approach described below. The equations presented below apply to more than one process operation (i.e., emission point). For example, cleaning solutions may be used in both the pre-press step and the printing step.

#### 4.1.1 CALCULATION OF EMISSIONS FROM EACH EMISSIONS SOURCE

If control devices are in place, the emissions from each VOC/HAP-containing material (i.e., inks, fountain solutions, cleaning solvents, and coatings) can be calculated as follows:

$$E_{\text{material}} = V * (1 - R/100) * (1 - [K/100 * J/100]) \quad (15.4-1)$$

Where:  $V = U * (W/100)$  or  $G * C$

Where:

$E_{\text{material}}$	=	Emissions, of VOC/HAP material, lb
$U$	=	Material Usage, lb
$W$	=	VOC/HAP Content, % by weight
$R$	=	% VOC/HAP Retained on Substrate
$K$	=	Control Efficiency, %
$J$	=	Capture Efficiency, %
$V$	=	VOC/HAP Content, lb
$G$	=	Material Usage, gal
$C$	=	VOC/HAP Content, lb/gal

VOCs/HAPs that are captured and re-introduced to the process do not count as being controlled. If no control device is in place, the equation simplifies to:

$$E_{\text{material}} = V * (1 - R/100). \quad (15.4-2)$$

A detailed discussion of the factors assumed for the amount of each material retained on the substrate can be found in *Control Of Volatile Organic Compound Emissions From Offset Lithographic Printing, Guideline Series {Draft}* (EPA, 1995b) and *Alternative Control Techniques Document: Offset Lithographic Printing (ACT)* (EPA, 1994a). The documents addressing retention factors address lithography only. Similar materials are often used in letterpress operations, so it is reasonable to assume the same retention factors in letterpress emission estimates, depending on the specific material and process configuration. The specific retention factors in these documents are not applicable for flexography, gravure, or screen printing, though the concept of retention may apply.

A detailed discussion of capture efficiency determination can be found in the *Guidelines for Determining Capture Efficiency* (EPA, 1995d). The ACT (EPA, 1994a) also provides a detailed discussion on capture efficiencies, particularly in distinguishing between indirect and direct capture efficiencies. Indirect capture efficiency refers to VOC that is first dispersed in the press room air and is subsequently drawn into the dryer (and into a control device). Direct capture efficiency refers to the fraction of VOC (such as that contained in blanket wash) that is carried into the dryer on the substrate. Table 15.4-1 lists the web addresses where electronic versions of these useful documents are available. Federal, state, or local agencies should be able to provide guidance on the specific requirements for estimating and reporting capture efficiency.

VOC content can be determined using EPA Test Method 24. Method 24A is appropriate when determining VOC-content of publication gravure inks and coatings. HAP-content can be determined using EPA Method 311, or in situations where all the HAPs are also VOC, then Method 24 or 24A is appropriate. Copies of these documents are available at <http://www.epa.gov/ttn/emc/promgate.html>. Material safety data sheets (MSDS) may also be useful in determining VOC- and HAP-content.

EPA Test Methods 25 and 25A can be used to determine control device efficiency. They are also available at <http://www.epa.gov/ttn/emc/promgate.html>. The ACT (EPA, 1994a) provides guidance regarding when to use Method 25 and when to use Method 25A.

#### 4.1.2 COMBUSTION SOURCES

Refer to EIIP Volume II, Chapter 2 on calculating emissions from combustion sources.

#### 4.1.3 FACILITY TOTALS

The following approaches can be used to calculate total emissions from a facility, based on the printing process used.

TABLE 15.4-1

REFERENCES FOR RETENTION FACTORS AND CAPTURE  
EFFICIENCIES AVAILABLE ON THE INTERNET

Document	Internet Address
Alternative Control Techniques Document : Offset Lithographic Printing (EPA, 1994a)	<a href="http://www.epa.gov/ttnuatw1/print/printpg.html">http://www.epa.gov/ttnuatw1/print/printpg.html</a>
Guidelines for Determining Capture Efficiency (EPA, 1995d)	<a href="http://www.epa.gov/ttncaaa1/t1/meta/m28508.html">http://www.epa.gov/ttncaaa1/t1/meta/m28508.html</a>
Printer's Plain Language Workbook (EPA, 1999f)	<a href="http://www.epa.gov/ooaujeag/sectors/pdf/lngwkbk.pdf">http://www.epa.gov/ooaujeag/sectors/pdf/lngwkbk.pdf</a>
Background Information Document (BID) for Final NESHAP for Printing	<a href="http://www.epa.gov/ttn/uatw/print/prbid2.pdf">http://www.epa.gov/ttn/uatw/print/prbid2.pdf</a>
EPA Test Methods 204, 204 a-f	<a href="http://www.epa.gov/ttn/emc/promgate.html">http://www.epa.gov/ttn/emc/promgate.html</a>
Potential to Emit (PTE) Guidance for Specific Source Categories (EPA, 1998b)	<a href="http://www.epa.gov/ttn/oarpg/t3/meta/m29616.html">http://www.epa.gov/ttn/oarpg/t3/meta/m29616.html</a>

**Lithography**

Total emissions for a facility can then be calculated by summing the emissions from usage of the various materials as follows:

$$E_{\text{Total}} = E_{\text{ink}} + E_{\text{fountain solutions}} + E_{\text{hand cleaning solutions}} + E_{\text{automatic blanket wash}} + E_{\text{coatings/adhesives}} + E_{\text{other}} \quad (15.4-3)$$

Where:

$E_{\text{total}}$	= Emissions, total, lb
$E_{\text{ink}}$	= Emissions, ink, lb
$E_{\text{fountain solutions}}$	= Emissions, fountain solutions, lb
$E_{\text{cleaning solutions}}$	= Emission, cleaning solutions, lb
$E_{\text{automatic blanket wash}}$	= Emissions, automatic blanket wash, lb
$E_{\text{coating/adhesives}}$	= Emissions, coatings/adhesives, lb
$E_{\text{other}}$	= Emissions, other VOC - or HAP containing materials, lb

### ***Flexography, Gravure, and Screen Printing***

Total emissions for a facility can then be calculated by summing the emissions from usage of the various materials as follows:

$$E_{\text{Total}} = E_{\text{ink}} + E_{\text{dilution solvent}} + E_{\text{cleaning solutions}} + E_{\text{coatings/adhesives}} + E_{\text{other}} \quad (15.4-4)$$

Where:

$E_{\text{total}}$	=	Emissions, total, lb
$E_{\text{ink}}$	=	Emissions, ink, lb
$E_{\text{dilution solvent}}$	=	Emissions, dilution solvent, lb
$E_{\text{cleaning solutions}}$	=	Emission, hand cleaning solutions, lb
$E_{\text{coating/adhesives}}$	=	Emissions, coatings/adhesives, lb
$E_{\text{other}}$	=	Emissions, other VOC - or HAP containing materials, lb

### ***Letterpress***

Total emissions for a facility can then be calculated by summing the emissions from usage of the various materials as follows:

$$E_{\text{Total}} = E_{\text{ink}} + E_{\text{cleaning solutions}} + E_{\text{coatings/adhesives}} + E_{\text{other}} \quad (15.4-5)$$

Where:

$E_{\text{total}}$	=	Emissions, total, lb
$E_{\text{ink}}$	=	Emissions, ink, lb
$E_{\text{cleaning solutions}}$	=	Emission, cleaning solutions, lb
$E_{\text{coating}}$	=	Emissions, coatings/adhesives, lb
$E_{\text{other}}$	=	Emissions, other VOC - or HAP containing materials, lb

## **4.1.4 EMISSIONS CALCULATIONS WHEN USING EPA METHODS 204 AND 204A-F**

EPA has promulgated Methods 204 and 204a-f to determine site-specific capture efficiencies. A detailed description of each of these test methods is not presented in this document. Instead, readers are referred to the EPA website for a complete methodology for each of these test procedures. Table 15.5-1 lists each of these test methods and its internet address. A complete list



TABLE 15.4-2

## EPA TEST METHODS FOR DETERMINING CAPTURE EFFICIENCY

Promulgated Test Method	Internet Address
Method 204-204f Preamble	<a href="http://www.epa.gov/ttn/emc/promgate/pre204.pdf">http://www.epa.gov/ttn/emc/promgate/pre204.pdf</a>
Method 204 - Permanent or Temporary Total Enclosure (TTE) for Determining Capture Efficiency	<a href="http://www.epa.gov/ttn/emc/promgate/m-204.pdf">http://www.epa.gov/ttn/emc/promgate/m-204.pdf</a>
Method 204a - VOCs in Liquid Input Stream	<a href="http://www.epa.gov/ttn/emc/promgate/m-204a.pdf">http://www.epa.gov/ttn/emc/promgate/m-204a.pdf</a>
Method 204b - VOCs in Captured Stream	<a href="http://www.epa.gov/ttn/emc/promgate/m-204b.pdf">http://www.epa.gov/ttn/emc/promgate/m-204b.pdf</a>
Method 204c - VOCs in Captured Stream (Dilution Technique)	<a href="http://www.epa.gov/ttn/emc/promgate/m-204c.pdf">http://www.epa.gov/ttn/emc/promgate/m-204c.pdf</a>
Method 204d - Fugitive VOCs from Temporary Total Enclosure	<a href="http://www.epa.gov/ttn/emc/promgate/m-204d.pdf">http://www.epa.gov/ttn/emc/promgate/m-204d.pdf</a>
Method 204e - Fugitive VOCs from Building Enclosure	<a href="http://www.epa.gov/ttn/emc/promgate/m-204e.pdf">http://www.epa.gov/ttn/emc/promgate/m-204e.pdf</a>
Method 204f - VOCs in Liquid Input Stream (Distillation)	<a href="http://www.epa.gov/ttn/emc/promgate/m-204f.pdf">http://www.epa.gov/ttn/emc/promgate/m-204f.pdf</a>

of all EPA Emissions Measurement Center (EMC) promulgated test methods is available at [www.epa.gov/ttn/emc/promgate.html](http://www.epa.gov/ttn/emc/promgate.html).

#### 4.1.5 EXAMPLE CALCULATIONS

The following pages provide example calculations for each of the printing processes described in this document. Example 15.4-1 provides sample calculations for lithography, 15.4-2 for flexography, 15.4-3 for gravure, 15.4-4 for screen printing, and 15.4-5 for letterpress. These sample calculations can be used for estimating HAP emissions

Example 15.4-1

Part A:

A print shop using a sheetfed lithography process reports the following material usage:

Material	Annual Use	Unit	VOC Content (Percent by weight or lb/gal)	HAP Content (% by VOC weight or lb/gal)
Ink	19,000	lb	35%	0%
Fountain Solution: Concentrate	300	gal	1.85 lb/gal	Ethylene Glycol, 100%
Fountain Solution: Additive	100	gal	4.5 lb/gal	2-Butoxyethanol, 82% Ethylene Glycol, 18%
Automatic Blanket Wash	7,750	gal	0.8 lb/gal	Naphthalene, 0.296 lb/gal 2-Butoxyethanol, 0.144 lb/gal
Cleaning Solution	2,212.5	gal	0.8 lb/gal	Naphthalene, 0.16 lb/gal
Coating: UV	1,530	lb	2%	0%
Coating: Conventional	6,003	lb	35%	0%

No control devices are in place for this particular facility. According to the ACT (EPA, 1994a), it can be assumed that 95 percent of the ink and conventional coating (i.e., varnish) VOC is retained in the substrate. A 50% retention factor is assumed for cleaning solutions, since soiled towels are kept in a closed container and have a vapor pressure of less than 10 mmHg at 20°C. Therefore, the emissions can be calculated as described below.

**Ink Emissions**

With no control device in place, VOC emissions are calculated using equation 15.4-2.

$$\begin{aligned}
 E_{\text{VOC}}(\text{ink}) &= U * (W/100) * (1 - R/100) \\
 &= (19,000 \text{ lb/year}) * (35/100) * (1 - 95/100) \\
 &= 332.5 \text{ lb VOC/year from ink usage}
 \end{aligned}$$

Note: In this example, the ink is 0% HAP by weight, therefore, no HAPs are emitted from the ink.

Example 15.4-1 (Continued)**Fountain Solution Emissions**

With no control device in place, VOC and HAP emissions are calculated using equation 15.4-2.

$$\begin{aligned}
 E_{\text{VOC}} (\text{Concentrate}) &= U * (W/100) * (1 - R/100) \\
 &= (300 \text{ gal/year}) * (1.85 \text{ lb/gal}) * (1 - 0/100) \\
 &= 555 \text{ lb VOC/year from fountain solution concentrate usage}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{VOC}} (\text{Additive}) &= U * (W/100) * (1 - R/100) \\
 &= (100 \text{ gal/year}) * (4.5 \text{ lb/gal}) * (1 - 0/100) \\
 &= 450 \text{ lb VOC/year from fountain solution additive usage}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{VOC}} (\text{Total, Fountain Solution}) &= E_{\text{VOC}} (\text{Concentrate}) + E_{\text{VOC}} (\text{Additive}) \\
 &= 555 \text{ lb VOC/year} + 450 \text{ lb VOC/year} \\
 &= 1055 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{HAP}} (\text{Concentrate}) &= U * (W/100) * (1 - R/100) \\
 &= (300 \text{ gal/year}) * (1.85 \text{ lb/gal}) * (1 - 0/100) \\
 &= 555 \text{ lb HAP}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{HAP}} (\text{Additive}) &= U * (W/100) * (1 - R/100) \\
 &= (100 \text{ gal/year}) * 4.50 * ((82+18)/100) * (1 - 0/100) \\
 &= 450 \text{ lb HAP}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{HAP}} (\text{Total, Fountain Solution}) &= E_{\text{HAP}} (\text{Concentrate}) + E_{\text{HAP}} (\text{Additive}) \\
 &= 555 \text{ lb} + 450 \text{ lb HAP/year} \\
 &= 1050 \text{ lb HAP/year}
 \end{aligned}$$

**Cleaning Solution Emissions**

With no control device in place, VOC and HAP emissions are calculated using equation 15.4-2.

$$\begin{aligned}
 E_{\text{VOC}} (\text{Automatic Blanket Wash}) &= G * C * (1 - R/100) \\
 &= (7,750 \text{ lb/year}) * (0.8) * (1 - 0/100) \\
 &= 6,200 \text{ lb VOC/year}
 \end{aligned}$$

Example 15.4-1 (Continued)

$$\begin{aligned}
 E_{\text{VOC}} (\text{Cleaning Solutions}) &= G * C * (1 - R/100) \\
 &= (2,212.5) * (0.8) * (1-50/100) \\
 &= 885 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{VOC}} (\text{Total, Cleaning Solutions}) &= E_{\text{VOC}} (\text{Automatic Blanket Wash}) + E_{\text{VOC}} (\text{Hand Cleaning Solutions}) \\
 &= 6,200 \text{ lb VOC/year} + 885 \text{ lb VOC/year} \\
 &= 7,085 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{HAP}} (\text{Automatic Blanket Wash}) &= G * C * (1 - R/100) \\
 &= (7,750) * (0.296 + 0.144) * (1 - 0/100) \\
 &= 3,410 \text{ lb HAP/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{HAP}} (\text{Cleaning Solutions}) &= G * C * (1 - R/100) \\
 &= (2,212.5) * (0.16) * (1-50/100) \\
 &= 177 \text{ lb HAP/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{HAP}} (\text{Total, Cleaning Solution}) &= E_{\text{HAP}} (\text{Automatic Blanket Wash}) + E_{\text{HAP}} (\text{Hand Cleaning Solutions}) \\
 &= 3,410 (\text{lb HAP/year}) + 177 (\text{lb HAP/year}) \\
 &= 3,587 \text{ lb HAP/year}
 \end{aligned}$$

**Coating Emissions**

With no control device in place, VOC emissions are calculated using equation 15.4-2.

$$\begin{aligned}
 E_{\text{VOC}} (\text{UV Coating}) &= U * (W/100) * (1 - R/100) \\
 &= (1,530 \text{ lb/year}) * (2/100) * (1-0/100) \\
 &= 31 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{VOC}} (\text{Conventional Coating}) &= U * (W/100) * (1 - R/100) \\
 &= (6,003 \text{ lb/year}) * (35/100) * (1-95/100) \\
 &= 105 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{VOC}} (\text{Total, Coating}) &= E_{\text{VOC}} (\text{UV Coating}) + E_{\text{VOC}} (\text{Conventional Coating}) \\
 &= 31 \text{ lb VOC/year} + 105 \text{ lb VOC/year} \\
 &= 136 \text{ lb VOC/year}
 \end{aligned}$$

Example 15.4-1 (Continued)

Note: In this example, the coatings are 0 percent HAP by weight, therefore, no HAPs are emitted.

**Facility Totals**

Total HAP and VOC emissions for this facility are then calculated using equation 15.4-3.

$$E_{\text{total}} = E_{\text{ink}} + E_{\text{fountain solutions}} + E_{\text{cleaning solutions}} + E_{\text{coating}}$$

$$\begin{aligned} E_{\text{VOC}} &= 332.5 \text{ lb VOC/year} + 1050 \text{ lb VOC/year} + 7,085 \text{ lb VOC/year} + \\ &\quad 136 \text{ lb VOC/year} \\ &= 8,603.5 \text{ lb VOC/year} \end{aligned}$$

$$\begin{aligned} E_{\text{HAP}} &= 0 \text{ lb HAP/year} + 1050 \text{ lb HAP/year} + 3,587 \text{ lb HAP/year} + \\ &\quad 0 \text{ lb HAP/year} \\ &= 4,637 \text{ lb HAP/year} \end{aligned}$$

Example 15.4-1 (Continued)

## Part B:

A print shop using a heatset web offset lithographic process reports the following material usage:

Material	Annual Use	Unit	VOC Content (Percent by weight or lb/gal)	HAP Content (% by VOC weight or lb/gal)
Ink	100,000	lbs	45%	0%
Fountain Solution: Concentrate	300	gal	1.85 lb/gal	Ethylene Glycol, 1.85 lb/gal
Fountain Solution: Additive	100	gal	4.5 lb/gal	2-Butoxyethanol, 4.5 lb/gal
Automatic Blanket Wash	500	gal	6.48 lb/gal	Xylene, 0.10 lb/gal Cumene, 0.08 lb/gal
Hand Cleaning Solution	1,000	gal	6.73 lb/gal	Naphthalene, 0.16 lb/gal 2-Butoxyethanol, 0.14 lb/gal
Coating: UV	1,500	lb	1%	0%
Coating: Conventional	10,000	lb	40%	0%

An oxidizer with a destruction efficiency of 95% is in place for this particular facility. According to the ACT for Offset Lithography (EPA, 1994a), it can be assumed that 20 percent of the ink and conventional coating (i.e., varnish) VOC is retained in the substrate and the remaining 80% is completely captured in the dryer. A 70% capture efficiency can be used for fountain solutions utilizing alcohol substitutes. In this example, a 40% capture efficiency can be used for automatic blanket washes with composite VOC vapor pressures of less than 10 mmHg at 20°C. A 50% retention factor can be assumed for hand cleaning solutions, since soiled towels are kept in a closed container and have a composite VOC vapor pressure of less than 10 mmHg at 20°C. Therefore, the emissions can be calculated as described below.

**Ink Emissions**

With a 95% efficient oxidizer in place, VOC emissions are calculated using equation 15.4-1.

$$\begin{aligned}
 E_{\text{VOC}} (\text{Ink}) &= V * (1 - R/100) * (1 - [K/100 * J/100]) \\
 V &= (100,000 \text{ lb/year} * (45/100)) = 45,000 \text{ lb/year} \\
 E_{\text{VOC}} (\text{Ink}) &= 45,000 * (1 - 80/100) * (1 - [95/100 * 100/100]) \\
 &= 1,800 \text{ lb VOC/year from ink usage}
 \end{aligned}$$

Note: In this example, the ink is 0% HAP by weight, therefore, no HAPs are emitted from the ink.

Example 15.4-1 (Continued)**Fountain Solution Emissions**

With a 95% efficient oxidizer in place, VOC emissions are calculated using equation 15.4-1.

$$\begin{aligned}
 E_{\text{VOC}} (\text{Concentrate}) &= V * (1 - R/100) * (1 - [K/100 * J/100]) \\
 &V = (300 * 1.85) = 555 \text{ lb} \\
 E_{\text{VOC}} (\text{Concentrate}) &= 555 * (1 - 0/100) * (1 - [95/100 * 70/100]) \\
 &= 186 \text{ lb VOC/year from fountain solution concentrate usage} \\
 E_{\text{VOC}} (\text{Additive}) &= V * (1 - R/100) * (1 - [K/100 * J/100]) \\
 &V = (100 * 4.5) = 450 \text{ lb} \\
 E_{\text{VOC}} (\text{Additive}) &= 450 * (1 - 0/100) * (1 - [95/100 * 70/100]) \\
 &= 151 \text{ lb VOC/year from fountain solution concentrate usage} \\
 E_{\text{VOC}} (\text{Total, Fountain Solution}) &= E_{\text{VOC}} (\text{Concentrate}) + E_{\text{VOC}} (\text{Additive}) \\
 &= 186 \text{ lb/year VOC} + 151 \text{ lb/year VOC} \\
 &= 337 \text{ lb HAP/year} \\
 E_{\text{HAP}} (\text{Concentrate}) &= V * (1 - R/100) * (1 - [K/100 * J/100]) \\
 &V = (300 * 1.85) = 555 \text{ lb} \\
 E_{\text{HAP}} (\text{Concentrate}) &= 555 * (1 - 0/100) * (1 - [95/100 * 70/100]) \\
 &= 186 \text{ lb HAP/year from fountain solution concentrate usage} \\
 E_{\text{HAP}} (\text{Additive}) &= V * (1 - R/100) * (1 - [K/100 * J/100]) \\
 &V = (100 * 4.5) = 450 \text{ lb} \\
 E_{\text{HAP}} (\text{Additive}) &= 450 * (1 - 0/100) * (1 - [95/100 * 70/100]) \\
 &= 151 \text{ lb HAP/year from fountain solution concentrate usage} \\
 E_{\text{HAP}} (\text{Total Fountain Solution}) &= E_{\text{HAP}} (\text{Concentrate}) + E_{\text{HAP}} (\text{Additive}) \\
 &= 186 \text{ lb/year HAP} + 151 \text{ lb/year HAP} \\
 &= 337 \text{ lb HAP/year}
 \end{aligned}$$

Example 15.4-1 (Continued)**Cleaning Solution Emissions**

With a 95% efficient oxidizer in place, VOC emissions from the automatic blanket wash are calculated using equation 15.4-1.

$$\begin{aligned}
 E_{\text{VOC}} (\text{Automatic Blanket Wash}) &= V * (1 - R/100) * (1 - [K/100 * J/100]) \\
 &= V = (500 * 6.48) = 3,240 \text{ lb} \\
 E_{\text{VOC}} (\text{Automatic Blanket Wash}) &= 3,240 * (1 - 0/100) * (1 - 95/100 * 40/100) \\
 &= 2,009 \text{ lb VOC/year from auto blanket wash usage}
 \end{aligned}$$

Since hand washing does not occur while the dryer is running, VOC emissions from the hand wash cleaning solution are calculated using equation 15.4-2.

$$\begin{aligned}
 E_{\text{VOC}} (\text{Hand Wash}) &= V * (1 - R/100) \\
 &= V = (1,000 * 6.73) = 6,730 \text{ lb} \\
 E_{\text{VOC}} (\text{Hand Wash}) &= 6,730 * (1 - 50/100) \\
 &= 3,365 \text{ lb VOC/year from hand wash usage} \\
 E_{\text{VOC}} (\text{Total, Cleaning Solution}) &= E_{\text{VOC}} (\text{Auto Blanket Wash}) + E_{\text{VOC}} (\text{Hand Wash}) \\
 &= 2,009 \text{ lb/year VOC} + 3,365 \text{ lb/year VOC} \\
 &= 5,374 \text{ lb VOC/year} \\
 E_{\text{HAP}} (\text{Automatic Blanket Wash}) &= V * (1 - R/100) * (1 - [K/100 * J/100]) \\
 &= (500 * 0.18) = 90 \text{ lb} \\
 E_{\text{HAP}} (\text{Automatic Blanket Wash}) &= 90 * (1 - 0/100) * (1 - [95/100 * 40/100]) \\
 &= 56 \text{ lb HAP/year from automatic blanket wash usage} \\
 E_{\text{HAP}} (\text{Hand Wash}) &= V * (1 - R/100) \\
 &= V = (1,000 * 0.3) = 300 \\
 E_{\text{HAP}} (\text{Handwash}) &= 300 * (1 - 50/100) \\
 &= 150 \text{ lb HAP/year from hand wash usage} \\
 E_{\text{HAP}} (\text{Total, Cleaning Solution}) &= E_{\text{HAP}} (\text{Auto Blanket Wash}) + E_{\text{HAP}} (\text{Hand}) \\
 &= 56 \text{ lb/year HAP} + 150 \text{ lb/year HAP} \\
 &= 206 \text{ lb HAP/year}
 \end{aligned}$$



Example 15.4-1 (Continued)**Coating Emissions**

Since the conventional coating in this example is applied before the dryer ducted to a 95% efficient oxidizer, VOC emissions from the coating are calculated using equation 15.4-1.

$$\begin{aligned}
 E_{\text{VOC}} (\text{Conventional Coating}) &= V * (1 - R/100) * (1 - [K/100 * J/100]) \\
 &V = (10,000 * 45/100) = 4,500 \text{ lb} \\
 E_{\text{VOC}} (\text{Conventional Coating}) &= 4,500 * (1 - 80/100) * (1 - [95/100 * 100/100]) \\
 &= 180 \text{ lb VOC/year from conventional coating usage}
 \end{aligned}$$

Since the UV coating in this example is applied after the dryer, VOC emissions from the coating are calculated using equation 15.4-2.

$$\begin{aligned}
 E_{\text{VOC}} (\text{UV Coating}) &= V * (1 - R/100) \\
 &V = (1,500 * 1/100) = 15 \text{ lb} \\
 E_{\text{VOC}} (\text{UV Coating}) &= 15 * (1 - 0/100) \\
 &= 15 \text{ lb VOC/year from hand wash usage} \\
 E_{\text{VOC}} (\text{Total, Coating}) &= E_{\text{VOC}} (\text{Conventional Coating}) + E_{\text{VOC}} (\text{UV Coating}) \\
 &= 180 \text{ lb/year VOC} + 15 \text{ lb/year VOC} \\
 &= 195 \text{ lb VOC/year}
 \end{aligned}$$

Note: In this example, the coating is 0% HAP by weight, therefore, no HAPs are emitted from the coating.

**Facility Totals**

Total HAP and VOC emissions for this facility are then calculated using equation 15.4-3.

$$\begin{aligned}
 E_{\text{total}} &= E_{\text{ink}} + E_{\text{fountain solutions}} + E_{\text{cleaning solutions}} + E_{\text{coating}} \\
 E_{\text{VOC}} &= 1,800 \text{ lb VOC/year} + 337 \text{ lb VOC /year} + 5,374 \text{ lb VOC/year} + 195 \text{ lb VOC/year} \\
 &= 7,706 \text{ lb VOC/year} \\
 E_{\text{HAP}} &= 0 \text{ lb HAP/year} + 337 \text{ lb HAP/year} + 206 \text{ lb HAP year} + 0 \text{ lb HAP/year} \\
 &= 543 \text{ lb HAP/year}
 \end{aligned}$$

Example 15.4-2

A flexography printing operation reported using a thermal incinerator with a 95% control device efficiency. The press is in an enclosure that has 70% capture efficiency, based on EPA Method 204 test results. The facility reported following annual material usage, and associated VOC content, based on EPA Method 24 test results:

Material	Annual Use (lb)	VOC Content (by weight)
Ink	30,000	18%
Dilution Solvent	15,000	25%
Cleaning Solution	9,000	40%

The plant engineer calculated this facility's emissions as follows, using equations 15.4-1 through 15.4-3:

$$\begin{aligned}
 E_{\text{VOC}} (\text{Ink}) &= U * (M/100) * (1-R/100) * [1 - (K/100 * J/100)] \\
 &= (30,000 \text{ lb/year}) * (18/100) * (1-0/100) * [1 - (95/100 * 70/100)] \\
 &= 1,809 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{VOC}} (\text{Dilution Solvent}) &= G * C * (1-R/100) * [1 - (K/100 * J/100)] \\
 &= (15,000 \text{ lb/year}) * (25/100) * (1-0/100) * [1 - (95/100 * 70/100)] \\
 &= 1,256 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{VOC}} (\text{Cleaning Solution}) &= G * C * (1-R/100) * [1 - (K/100 * J/100)] \\
 &= (9,000 \text{ lb/year}) * (40/100) * (1-50/100) * [1 - (95/100 * 70/100)] \\
 &= 603 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{VOC}} &= E_{\text{ink}} + E_{\text{dilution solvents}} + E_{\text{cleaning solutions}} \\
 &= 1,809 \text{ lb/year} + 1,256 \text{ lb/year} + 603 \text{ lb/year} \\
 &= 3,668 \text{ lb/year}
 \end{aligned}$$

Note: Calculation of emissions involving numerous inks, coatings, solvents, and other materials will require separate calculations such as presented here for each of the numerous inks being used with the different formulas at a given facility.

Example 15.4-3

A gravure printing operation reported using a carbon adsorber on its ink press with a 75% overall control efficiency, based on test results from a liquid-liquid mass balance (i.e.,  $K/100 * J/100 * 0.75$ ). The facility reported following annual material usage, and associated VOC content, based on EPA Method 24a test results:

Material	Annual Use	Unit	VOC Content (% by weight or lb/gal)
Ink	75,000	lb	12%
Dilution Solvent	37,500	gal	0.256 lb/gal
Cleaning Solution	22,500	gal	0.44 lb/gal
Coating	45,000	lb	10%

The plant engineer calculated this facility's emissions as follows, using equations 15.4-1 through 15.4-3:

$$\begin{aligned}
 E_{\text{VOC}} (\text{Ink}) &= U * (M/100) * (1-R/100) * [1 - (K/100 * J/100)] \\
 &= (75,000 \text{ lb/year}) * (12/100) * (1 - 0/100) * [1 - (0.75)] \\
 &= 2,250 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{VOC}} (\text{Dilution Solvent}) &= G * C * (1-R/100) * [1 - (K/100 * J/100)] \\
 &= (37,500) * (0.256) * (1-0/100) * [1 - (0.75)] \\
 &= 2,400 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{VOC}} (\text{Cleaning Solution}) &= G * C * (1 - R/100) \\
 &= (22,500) * (0.44) * (1 - 0/100) \\
 &= 9,900 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{VOC}} (\text{Coating}) &= U * (M/100) * (1 - R/100) \\
 &= (45,000 \text{ lb/year}) * (10/100) * (1-0/100) \\
 &= 4,500 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{VOC}} &= E_{\text{ink}} + E_{\text{dilution solvents}} + E_{\text{cleaning solutions}} + E_{\text{coating}} \\
 &= 2,250 \text{ lb/year} + 2,400 \text{ lb/year} + 9,900 \text{ lb/year} \\
 &\quad 4,500 \text{ lb/year} \\
 &= 19,050 \text{ lb/year}
 \end{aligned}$$

Note: Calculation of emissions involving numerous inks, coatings, solvents, and other materials will require separate calculations such as presented here for each of the numerous inks being used with the different formulas at a given facility.

Example 15.4-4

A screen printing shop reported the following annual material usage:

<b>Material</b>	<b>Annual Use (gal)</b>	<b>VOC Content (lb/gal)</b>	<b>HAP Content (lb/gal)</b>
Ink	2,000	1.5	0
Cleaning Solution	9,375	0.32	Toluene, 0.16
Haze Remover	667	0.48	0
Adhesive	312.5	3	1,1,1-Trichloroethylene, 0.2

The plant engineer calculated this facility's emissions as follows, using equations 15.4-2 and 15.4-3:

$$\begin{aligned}
 E_{\text{VOC}} (\text{Ink}) &= G * (1 - R/100) \\
 &= (2,000) * (1.5) * (1 - 0/100) \\
 &= 3,000 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{VOC}} (\text{Cleaning Solution}) &= G * C * (1 - R/100) \\
 &= (9,375) * (0.32) * (1 - 0/100) \\
 &= 3,000 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{HAP}} (\text{Cleaning Solution}) &= G * C * (1 - R/100) \\
 &= (9,375) * (0.16) * (1 - 0/100) \\
 &= 1,500 \text{ lb HAP/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{VOC}} (\text{Haze Remover}) &= G * C * (1 - R/100) \\
 &= (667) * (0.48) * (1 - 0/100) \\
 &= 320 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{VOC}} (\text{Adhesive}) &= G * C * (1 - R/100) \\
 &= (312.5) * (3) * (1 - 0/100) \\
 &= 937.5 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{HAP}} (\text{Adhesive}) &= G * C * (1 - R/100) \\
 &= (312.5) * (0.2) * (1 - 0/100) \\
 &= 62.5 \text{ lb HAP/year}
 \end{aligned}$$

Example 15.4-4 (Continued)

$$E_{\text{total}} = E_{\text{ink}} + E_{\text{cleaning solutions}} + E_{\text{coating/adhesive}} + E_{\text{other}}$$

$$\begin{aligned} E_{\text{VOC}} &= 3,000 \text{ lb VOC/year} + 3,000 \text{ lb VOC/year} + 320 \text{ lb VOC/year} \\ &\quad + 937.5 \text{ lb VOC/year} \\ &= 7257.5 \text{ lb VOC/year} \end{aligned}$$

$$\begin{aligned} E_{\text{HAP}} &= 1,500 \text{ lb HAP/year} + 62.5 \text{ lb HAP/year} \\ &= 1,562.5 \text{ lb HAP/year} \end{aligned}$$

Note: Calculation of emissions involving numerous inks, coatings, solvents, and other materials will require separate calculations such as presented here for each of the numerous inks being used with the different formulas at a given facility.

Example 15.4-5

A print shop using a letterpress process reports the following material usage:

<b>Material</b>	<b>Annual Use (lb)</b>	<b>VOC Content (by weight)</b>	<b>HAP Content (by weight)</b>
Ink	92,500	15%	0%
Cleaning Solution: Concentrate	32,500	100%	Toluene 60%
Coating: Conventional	8,500	30%	0%

This facility uses no add-on control devices. It's cleaning solution has a vapor pressure of less than 10 mm Hg at 20°C and rags are kept in a closed container. Therefore, a 50% retention factor can be assumed for cleaning solutions. Letterpress inks and conventional coatings are virtually identical to lithographic inks. Therefore, a 95% retention factor is assumed for this non-heat set press. Emissions are calculated as follows:

**Ink Emissions**

VOC emissions are calculated using equations 15.4-1.

$$\begin{aligned}
 E_{\text{voc}} (\text{Ink}) &= U * (M/100) * (1 - R/100) \\
 &= (92,500 \text{ lb/year}) * (15/100) * (1-95/100) \\
 &= 694 \text{ lb/year VOC}
 \end{aligned}$$

**Cleaning Solution Emissions**

VOC/HAP emissions are calculated using equations 15.4-2.

$$\begin{aligned}
 E_{\text{VOC}} (\text{Cleaning Solution}) &= U * (M/100) * (1 - R/100) \\
 &= (32,000 \text{ lb/year}) * (100/100) * (1-50/100) \\
 &= 16,000 \text{ lb VOC/year}
 \end{aligned}$$

$$\begin{aligned}
 E_{\text{HAP}} (\text{Cleaning Solution}) &= U * (M/100) * (1 - R/100) \\
 &= (32,000 \text{ lb/year}) * (60/100) * (1-50/100) \\
 &= 9,600 \text{ lb HAP/year}
 \end{aligned}$$

Example 15.4-5 (Continued)**Coating Emissions**

VOC emissions are calculated using equations 15.4-2.

$$\begin{aligned} E_{\text{VOC}} (\text{Coating}) &= U * (M/100) * (1 - R/100) \\ &= (8,500 \text{ lb/year}) * (30/100) * (1 - 95/100) \\ &= 128 \text{ lb VOC/year} \end{aligned}$$

**Facility Totals**

Total HAP and VOC emissions for this facility are then calculated using equation 15.4-5.

$$\begin{aligned} E_{\text{total}} &= E_{\text{ink}} + E_{\text{cleaning solutions}} + E_{\text{coating adhesives}} \\ E_{\text{VOC}} &= 694 \text{ lb VOC/year} + 16,000 \text{ lb VOC/year} + 128 \text{ lb VOC/year} \\ &= 16,822 \text{ lb VOC/year} \\ E_{\text{HAP}} &= 0 \text{ lb HAP/year} + 9,600 \text{ lb HAP/year} + 0 \text{ lb HAP/year} \\ &= 9,600 \text{ lb HAP/year} \end{aligned}$$

Note: Calculation of emissions involving numerous inks, coatings, solvents, and other materials will require separate calculations such as presented here for each of the numerous inks being used with the different formulas at a given facility.

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# 5

## ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

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Where there is a choice of methods, material balance is generally preferred over an emission factor unless the assumptions needed to perform a material balance have a high degree of uncertainty and/or the emission factor is site-specific.

For the printing and graphic arts industry, source testing and emission factors are the alternative methods for estimating VOC and HAP emissions.

### 5.1 EMISSIONS CALCULATIONS USING EMISSION FACTORS

Emission factors can be used when site-specific monitoring data are unavailable. The EPA maintains AP-42 (EPA, 1995c), a compilation of approved emission factors for criteria pollutants and HAP. Another comprehensive source of available air pollutant emission factors from numerous sources is the FIRE system (EPA, 1999a). Refer to Chapter 1, *Introduction to Point Source Emission Inventory Development*, of this series for a complete discussion of available information sources for locating, developing, and using emission factors as an estimation technique.

The basic equation used to calculate emissions using an emission factor is shown in Equation 15.5-1.

$$E_x = EF_x * AF \quad (15.5-1)$$

Where:

$E_x$  = Emissions of pollutant x

$EF_x$  = Emission factor of pollutant x

$AF$  = Activity factor

Example 15.5-1 shows how VOC emissions may be calculated for a printing operation.

#### Example 15.5-1

A publication gravure printing press uses 45,000 gallons of ink annually. A carbon adsorber with an overall control efficiency of 85 percent is currently in place at the facility.

Table 4.9.2-1 from *AP-42* gives us an emission factor of 1.86 lb total VOC/gallon of ink used, including the 85% control efficiency (12.40 lb VOC/gallon was the uncontrolled emission factor presented in this table). The VOC emissions were calculated as follows:

$$\begin{aligned} E_{\text{VOC}} &= EF_{\text{VOC}} * AF \\ &= 1.86 \text{ lb/gal} * 45,000 \text{ gallons of ink used/year} \\ &= 83,700 \text{ lb VOC/year} \end{aligned}$$

# 6

## QUALITY ASSURANCE/QUALITY CONTROL

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The consistent use of standardized methods and procedures is essential in the compilation of reliable emission inventories. Quality assurance (QA) and quality control (QC) of an inventory is accomplished through a set of procedures that ensure the quality and reliability of data collection and analysis. These procedures include the use of appropriate emission estimation techniques, applicable and reasonable assumptions, accuracy/logic checks of computer models, checks of calculations, and data reliability checks. Volume VI of this series, *Quality Assurance Procedures*, describes additional QA/QC methods and tools for performing these procedures.

Volume II, Chapter 1, *Introduction to Point Source Emission Inventory Development*, presents recommended standard procedures to follow to ensure that the reported inventory data are complete and accurate. Chapter 1 discusses preparation of a QA plan, development and use of QC checklists, and QA/QC procedures for specific emission estimation methods (e.g., emission factors). If further guidance is needed, federal, state, and local agencies should be able to provide guidance regarding specific reporting requirements.

Another useful document, “Guidelines for Determining Capture Efficiency,” can be found at <http://www.epa.gov/ttn/emc/guidlnd.html> (EPA, 1995d). This document presents details of the EPA approved test methods for determining capture efficiency, which is critical to determining the effectiveness of VOC emission control systems. The document also provides the data quality objective (DQO) and lower confidence limit (LCL) approaches for validating alternative test methods. The DQO and LCL methods are sets of approval criteria which, when met by the data obtained with any given protocol of process parameter measurement procedures, may be used to determine capture efficiency (CE). EPA Method 204 and 204a-f (EPA, 1997) also document procedures using Permanent Total Enclosures and Temporary Total Enclosures to determine capture efficiency.

### 6.1 QA/QC FOR USING MATERIAL BALANCE

The material balance method for estimating emissions may use various approaches; the QA/QC considerations will also vary and may be specific to an approach. Generally, the fates of all materials of interest are identified, and then the quantity of material allocated to each fate determined. Identifying these fates, such as material contained in a product or material leaving the process in the wastewater, is usually straightforward. However,

estimating the amount of material allocated to each fate may be complicated and is the prime QA/QC consideration in using the material balance approach. Amounts obtained by direct measurement are more accurate and produce emission estimates of higher quality than those obtained by engineering or theoretical calculations. QA/QC of an emissions estimate developed from a material balance approach should include a thorough check of all assumptions and calculations. Also, a reality check of the estimate in the context of the overall process is recommended.

## 6.2 QA/QC FOR USING EMISSION FACTORS

The use of emission factors is straightforward when the relationship between process data and emissions is direct and relatively uncomplicated. When using emission factors, the user should be aware of the quality indicator associated with the value. Emission factors published within EPA documents and electronic tools have a quality rating applied to them. The lower the quality rating, the more likely that a given emission factor may not be representative of the source type. The reliability and uncertainty of using emission factors as an emission estimation technique are discussed in detail in the QA/QC section of Chapter 1 of this volume.

## 6.3 QA/QC FOR USING SOURCE TEST DATA

Data collected via source testing must meet quality objectives. Source test data must be reviewed to ensure that the test was conducted under normal operating conditions, or under maximum operating conditions in some states, and that the results were generated according to an acceptable method for each pollutant of interest. Calculation and interpretation of accuracy for source testing methods are described in detail in the *Quality Assurance Handbook for Air Pollution Measurements Systems: Volume III. Stationary Source Specific Methods (Interim Edition)*.

The acceptance criteria, limits, and values for each control parameter associated with manual sampling methods, such as dry gas meter calibration, are summarized in Chapter 1 of this volume. The magnitudes of concentration and emission rate errors caused by a +10 percent error in various types of measurements (e.g., temperature) are also presented in Chapter 1 of this volume.

# 7

## DATA CODING PROCEDURES

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This section describes the methods and codes available for characterizing emission sources at graphic arts facilities. Consistent categorization and coding will result in greater uniformity among inventories. In addition, the procedures described here will assist the reader who is preparing data for input to the Aerometric Information Retrieval System (AIRS) or a similar database management system. The use of Source Classification Codes (SCCs) provided in Table 15.7-1 is recommended for describing various printing operations. Refer to the Clearinghouse for Inventories and Emission Factors (CHIEF) website for a complete listing of SCCs for printing and graphic arts facilities.

### 7.1 SOURCE CLASSIFICATION CODES

SCCs for various components of a printing and graphic art operation are presented in Table 15.7-1. These include the following:

- Lithography;
- Flexography;
- Gravure;
- Letterpress; and
- Screen Printing.

### 7.2 AIRS CONTROL DEVICE CODES

Control device codes applicable to printing and graphic art operations are presented in Table 15.7-2. These should be used to enter the type of applicable emission control device into the AIRS Facility Subsystem (AFS). The "099" control code may be used for miscellaneous control devices that do not have a unique identification code.

Note: At the time of publication, these control device codes were under review by the EPA. The reader should consult the EPA for the most current list of codes.

TABLE 15.7-1

## SOURCE CLASSIFICATION CODES FOR PRINTING PROCESSES

Printing Process	Process Description	SCC	Units
Lithographic: SIC 2752	Lithographic: 2752	4-05-004-01	Tons Ink
	Lithographic: 2752	4-05-004-11	Tons Solvent in Ink
	Lithographic: 2752	4-05-004-12	Gallons Ink
	Lithographic: Isopropyl Alcohol Cleanup	4-05-004-13	Tons Solvent Used
	Flexographic: Propyl Alcohol Cleanup	4-05-004-14	Tons Solvent Consumed
	Offset Lithography: Dampening Solution with Alcohol Substitute	4-05-004-15	Tons of Substitute
	Offset Lithography: Dampening Solution with High Solvent Content	4-05-004-16	Tons of Pure Solvent
	Offset Lithography: Cleaning Solution: Water-based	4-05-004-17	Tons Used
	Offset Lithography: Dampening Solution with Isopropyl Alcohol	4-05-004-18	Tons Alcohol Used
	Offset Lithography: Heatset Ink Mixing	4-05-004-21	Tons Solvent in Ink
	Offset Lithography: Heatset Solvent Storage	4-05-004-22	Tons Solvent Stored
	Offset Lithography: Nonheated Lithographic Inks	4-05-004-31	Tons Ink
	Offset Lithography: Nonheated Lithographic Inks	4-05-004-32	Tons Solvent in Ink
	Offset Lithography: Nonheated Lithographic Inks	4-05-004-33	Gallons Ink
Flexographic: SIC 2759	Printing: Flexographic	4-05-003-01	Tons Ink
	Ink Thinning Solvent (Carbitol)	4-05-003-02	Tons Solvent Added
	Ink Thinning Solvent (Cellosolve)	4-05-003-03	Tons Solvent Added

TABLE 15.7-1

(CONTINUED)

Printing Process	Process Description	SCC	Units
Flexographic: SIC 2759 (Cont'd)	Ink Thinning Solvent (Ethyl Alcohol)	4-05-003-04	Tons Solvent Added
	Ink Thinning Solvent (Isopropyl Alcohol)	4-05-003-05	Tons Solvent Added
	Ink Thinning Solvent (n-Propyl Alcohol)	4-05-003-06	Tons Solvent Added
	Ink Thinning Solvent (Naphtha)	4-05-003-07	Tons Solvent Added
	Printing: Flexographic	4-05-003-11	Tons Solvent in Ink
	Printing: Flexographic	4-05-003-12	Gallons Ink
	Printing: Flexographic: Propyl Alcohol Cleanup	4-05-003-14	Tons Solvent Consumed
	Flexographic: Steam: Water-based	4-05-003-15	Tons Ink
	Flexographic: Steam: Water-based	4-05-003-16	Tons Solvent in Ink
	Flexographic: Steam: Water-based	4-05-003-17	Tons Solvent Stored
	Flexographic: Steam: Water-based in Ink	4-05-003-18	Tons Solvent in Ink
	Flexographic: Steam: Water-based Ink Storage	4-05-003-19	Tons Solvent Stored
Gravure: SIC 2754	Gravure: 2754	4-05-005-01	Tons Ink
	Ink Thinning Solvent: Dimethylformamide	4-05-005-02	Tons Solvent Added
	Ink Thinning Solvent: Ethyl Acetate	4-05-005-03	Tons Solvent Added
	Ink Thinning Solvent: Methyl Ethyl Ketone	4-05-005-06	Tons Solvent Added
	Ink Thinning Solvent: Methyl Isobutyl Ketone	4-05-005-07	Tons Solvent Added
	Ink Thinning Solvent: Toluene	4-05-005-10	Tons Solvent Added
	Gravure: 2754	4-05-005-11	Tons Solvent in Ink
	Gravure: 2754	4-05-005-12	Gallons Ink
	Gravure: 2754	4-05-005-13	Gallons Ink
	Gravure: Cleanup Solvent	4-05-005-14	Tons Solvent Consumed

TABLE 15.7-1

(CONTINUED)

Printing Process	Process Description	SCC	Units
Gravure: SIC 2754 (Cont'd)	Other Not Classified	4-05-005-97	Pounds Liquid Ink Consumed
	Ink Thinning Solvent: Other Not Specified	4-05-005-98	1000 Gallons Solvent
	Ink Thinning Solvent: Other Not Specified	4-05-005-99	Tons Solvent Added
Screen Printing: SIC 2759	Screen Printing	4-05-008-01	Tons Ink
	Cleaning Rags	4-05-008-02	Tons Solvent Used
	Screen Printing	4-05-008-11	Tons Solvent in Ink
	Screen Printing	4-05-008-12	Gallons Ink
Letterpress: SIC 2751	Letter Press	4-05-002-01	Tons Ink
	Ink Thinning Solvent (Kerosene)	4-05-002-02	Tons Solvent Added
	Ink Thinning Solvents (Mineral Solvents)	4-05-002-03	Tons Solvent Added
	Letter Press	4-05-002-11	Tons Solvent in Ink
	Printing: Letter Press	4-05-002-12	Gallons Ink
	Letterpress: Cleaning Solution	4-05-002-15	Tons Solvent Consumed
General Processes	Dryer	4-05-001-01	Tons Solvent in Ink
	Dryer	4-05-001-99	Gallons Ink
	Ink Mixing	4-05-006-01	Tons Solvent in Ink
	Solvent Storage	4-05-007-01	Tons Solvent Stored
	Specify in Comments Field	4-05-888-01	Process Unit-Year
	Specify in Comments Field	4-05-888-02	Process Unit-Year
	Specify in Comments Field	4-05-888-03	Process Unit-Year
	Specify in Comments Field	4-05-888-04	Process Unit-Year
	Specify in Comments Field	4-05-888-05	Process Unit-Year



TABLE 15.7-2

AIRS CONTROL DEVICE CODES FOR GRAPHIC ARTS  
PROCESSES<sup>a</sup>

Control Device	Code
Catalytic Afterburner	019
Catalytic Afterburner with Heat Exchanger	020
Direct Flame Afterburner	021
Direct Flame Afterburner with Heat Exchanger	022
Vapor Recovery Systems (Including Condensers,Hooding,Other Enclosures)	047
Activated Carbon Adsorption	048
Process Enclosed	054
Miscellaneous Control Device	099

<sup>a</sup>At the time of publication, these control device codes were under review by the EPA. The reader should consult the EPA for the most current list of codes.

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**VOLUME II: CHAPTER 16**

# **METHODS FOR ESTIMATING AIR EMISSIONS FROM CHEMICAL MANUFACTURING FACILITIES**

**February 2004**

**Draft**



Prepared by:  
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## 1 INTRODUCTION

The purpose of this guideline document is to describe emission estimation techniques for point sources in an organized manner and to provide concise example calculations to aid in the preparation of emission inventories. While emissions estimates are not provided, the information presented in this document may be used to select an emission estimation technique best suited to a particular application. This chapter describes the procedures and recommended approaches for estimating emissions from batch chemical manufacturing operations and is intended to assist industry as well as regulatory agency personnel.

As EPA has indicated in this and other EIIP documents, the choice of methods to be used to estimate emissions depends on how the estimate will be used and the degree of accuracy required, and methods using site-specific data are preferred over other methods. Because this document provides non-binding guidance and is not a rule, EPA, the States, and others retain the discretion to employ or require other approaches that meet the specific requirements of the applicable regulations in individual circumstances.

Section 2 of this chapter provides an overview of available emission estimation methods. It should be noted that the use of site-specific emissions data is always preferred over the use of default values developed through use of industry emission averages.

Section 3 provides an overview of considerations that should be used when assessing process vent emissions for basic process unit operations.

Section 4 describes many of the underlying physical property relationships that are used in support of the basic models that are presented in earlier sections of this document.

## 2 SOURCE CATEGORY DESCRIPTION

### 2.1 PROCESS DESCRIPTION

This section provides a brief overview of batch chemical manufacturing operations. Chemical processes vary widely from one industry to another with respect to the types of chemicals that are used, batch and production sizes, and unit operations that are involved. However, most chemical processes include at least one or more combinations of four basic operations: preassembly, reaction, isolation, and purification. Solvent recovery operations are also important because they enable the chemical operator to reuse basic raw materials and reduce the manufacturing cost and environmental impact. Additionally, cleanout operations are important since they enable production equipment to be reused for other manufacturing operations.

- **Preassembly.** A preassembly (or premixing) is normally the initial step of the process and typically involves charging, mixing, or dissolving various liquids, solids, and/or gases. Essential equipment for this step might include agitated vessels or tanks with charge chutes, liquid inlet lines, and utility connections for temperature and pressure control. For certain continuous chemical processes, feed preparation might involve inline mixers with heat exchangers.
- **Reaction.** The purpose of the reaction step is to facilitate the actual chemical synthesis. A reaction may be carried out by applying heat or by adding specific reactants to the batch. The batch composition changes as the reaction takes place although many of the compounds such as process solvents and other materials remain unchanged. Equipment that is used to carry out reactions includes a batch, semi-continuous stirred tank or tubular reactor. The actual reactor used must meet the specific chemical, physical, and productivity needs of the process design.
- **Isolation.** Once chemical products have been formed from reaction, they must be recovered or isolated from basic process impurities that also formed or from unreacted materials and/or process solvents. In many cases the product is the solid portion of a batch slurry. Isolation can be achieved through the use of spray driers coupled with various dust collectors. Extraction, crystallization, filtration, or distillation might be applied in cases when the batch product is a homogeneous solution. Distillation is often used for collecting liquid products when the vapor pressure/temperature relationships can be exploited.
- **Purification.** Once isolated, chemical products must be further processed through purification equipment to obtain the desired high purity level. Products from this purification step are to be used either as the final product or as a key ingredient in the next step of a multi-step synthesis. For example, in a pharmaceutical process a low quality product might be purified by carbon treatment, additional extractions, ion exchange, chromatography, or crystallization. The overall purification process involves other preassembly, purification, and final isolation steps.

### 2.2 EMISSION SOURCES

The majority of emissions that occur from batch chemical manufacturing operations are from volatile organic solvents that evaporate during manufacturing. Particulate matter emissions may also occur from the handling of solid powders that are used in manufacturing.

Several air emission sources have been identified for chemical manufacturing operations; they are as follows:

- Process operations
- Storage tanks
- Equipment leaks

- Wastewater collection and treatment
- Cleaning
- Solvent recovery
- Spills

### 2.2.1 Process Operations

#### **Material charging emissions**

Volatile Organic Compounds (VOC) emissions may occur during material loading of equipment due to the displacement of organic vapors.

Particulate matter (PM) and PM equal to or less than 10 micrometers in diameter (PM10) emissions may also occur during the material loading process from handling of solids in powder form. VOC and PM emissions during material loading operations may occur as point source or fugitive, depending on whether a PM emissions collection system is in place.

#### **Emissions from process heating**

Many processes involve batch heating in conjunction with a reaction or in preparing for distillation. As the batch temperature is increased to a new level, the molar capacity of the vessel headspace is reduced due to the ideal gas law ( $PV=nRT$ ). Additionally, the vapor pressures of volatile materials in the batch also increase. Vapors from vessel headspace are emitted through the process vent until the final temperature is reached.

#### **Emissions from process depressurization**

Reducing the system pressure is one way that solvents can be recovered from the batch at a lower temperature than would normally be possible. In some cases it is desired to replace the primary process solvent with a different one at reduced temperature. In other cases it may be desired to concentrate the batch through solvent stripping at reduced temperature to avoid thermal decomposition of compounds in the batch. When the pressure of the batch is reduced then solvent vapors are drawn from the vessel (and connected equipment) by the vacuum system.

#### **Emissions from gas evolution processes**

Some reactions produce off gases such as hydrogen chloride, sulfur dioxide, and others that evolve from the batch and exit the process through the vessel vent. These off gases will also carry solvent vapors from the batch with them.

#### **Emissions from gas sweep and purge operations**

Nitrogen is frequently applied to the process vessel as a means of establishing inert conditions for safety purposes or to prevent moisture from entering the system and avoiding undesirable chemical reactions to take place. As nitrogen enters the vessel it must exit the vessel through the process vent along with solvent vapors from the vessel.

#### **Surface Evaporation**

Surface evaporation may occur during mixing and blending operations if the vessel contents are exposed to the atmosphere.

### 2.2.2 Miscellaneous Operations

#### **Solvent Reclamation**

Solvent reclamation refers to the purification of contaminated or spent solvent through distillation. VOC emissions occur from the solvent charging and the normal distillation equipment operation.

#### **Cleaning**

Cleaning is an important ancillary part of the chemical manufacturing process. Process equipment may be cleaned with solvent as often as after each batch. VOC emissions will result from any of the normal process operations such as charging, heating, gas sweep, and others. Additionally, emissions will result from the wiping of equipment with solvent wet cloths. In addition to this type of cleaning, small items used in the chemical manufacturing process may be cleaned by washing with solvents in a cold cleaner or open-top vapor degreaser.

### 2.2.3 Wastewater Treatment

A chemical manufacturing facility may use a wastewater treatment system to treat contaminated water generated during the chemical manufacturing process (e.g., water that has been used to clean equipment, extractions, crystallizations, and other operations). Wastewater treatment systems generally consist of a series of surface impoundments that are used for equalization, neutralization, aeration, and clarification of the waste stream. Fugitive VOC emissions may occur from each type of basin. Procedures used to estimate emissions from wastewater treatment facilities are described in detail in Volume II, Chapter 5, *Preferred and Alternative Methods for Estimating Air Emissions from Wastewater Collection and Treatment*.

### 2.2.4 Storage Tanks

Various types and sizes of storage tanks are used to store solvents and resins used in the chemical manufacturing process. Most of these tanks have a fixed-roof design. The two significant types of emissions from fixed-roof tanks are breathing and working losses. Breathing loss is the expulsion of vapor from a tank through vapor expansion and contraction that result from changes in ambient temperature and barometric pressure. This loss occurs without any liquid level change in the tank. The combined loss from filling and emptying tanks is called working loss. Evaporation during filling operations results from an increase in the liquid level in the tank. As the liquid level increases, the pressure inside the tank exceeds the relief pressure and vapors are expelled from the tank. Evaporative emissions during emptying occur when air drawn into the tank during liquid removal becomes saturated with organic vapor and expands, expelling vapor through the vapor relief valve (EPA, 1995a). Emissions from tanks are characterized as a point source because VOCs are released through a vent.

### 2.2.5 Equipment Leaks

In order to transport stored materials (e.g., organic solvents and resins) from storage tanks to the chemical manufacturing operation, a network of pipes, pumps, valves, and flanges is employed. As liquid material is pumped from the storage tanks to the particular process area, the pipes and supporting hardware (process line components) may develop leaks over time. When leaks occur, volatile components in the transported material are released to the atmosphere. This generally occurs from the following process line components:

- Pump seals
- Valves
- Compressor seals
- Safety relief valves

- Flanges
- Open-ended lines
- Sampling connections.

Emissions from equipment leaks can be characterized as fugitive and are described in detail in Volume II, Chapter 4, *Preferred and Alternative Methods for Estimating Fugitive Emissions from Equipment Leaks*.

### 2.2.6 Spills

Solvents, resins, or product may be accidentally spilled during manufacturing or cleaning activities. Materials that are spilled onto the ground may spread over an area, vaporize, and thus result in an air emission (EPA, 1987). Such an emission would be characterized as fugitive.

## 2.3 PROCESS DESIGN AND OPERATING FACTORS INFLUENCING EMISSIONS

VOC and PM emissions from chemical manufacturing may be reduced through the use of add-on control systems or through equipment and process modifications.

### 2.3.1 VOC Control Systems

A VOC control system typically consists of a capture device and a removal device. The capture device (such as a hood or enclosure) captures the VOC-laden air from the emission area and ducts the exhaust air stream to removal equipment such as a recovery device or a destructive control device. In either case, the purpose of the control system is to remove VOCs from the exhaust air stream. The overall efficiency of a control system is a function of the specific removal efficiency for each device in the system.

Example recovery devices:

- Condensers are one of the most frequently used control devices in industry. They work by reducing the temperature of the emission exhaust gas so that VOC vapors are recovered through condensation.
- Adsorption Devices that incorporate activated carbon are capable of removing VOC vapors from exhaust emission streams to very low levels in the final gas stream. Large scale adsorption based recovery systems normally have two or more activated carbon adsorption chambers. One carbon chamber is being used to remove VOCs from emission stream while the spent carbon chamber is being regenerated. VOCs are recovered from the system during the regeneration phase. Steam is routed into the saturated carbon bed to cause the VOCs to desorb from the carbon and condense at the condenser. Once VOCs liquids have been collected then they may be recycled or further purified prior to reuse in the manufacturing operation.
- Dust collectors are used to collect particulate matter from the emission stream. Dust collectors are constructed in many different designs. A bag house consists of a large rectangular housing with many internal banks of vertically mounted filter bags. The emission stream enters the bag house through the side inlet, passes through the bag filter media, and exits the unit through the discharge port at the top. Particulate matter builds up on the filter media until it is shaken off by pulses of compressed air from within each bag. The dust that falls from the bags during the pulsing process is collected at the lower section of the bag house and finally discharged through the solids outlet to a drum or other container. When designing a bag house for an installation it is important to select the appropriate filter media and surface area for the particulate matter to be collected. The pore size of the filter cloth will determine the removal efficiency of the overall unit.

- A floating roof on a storage tank helps to reduce solvent emissions by eliminating the headspace that is present in conventional storage tanks. For the conventional storage tank air that is saturated with solvent vapors exits the vessel as the surrounding temperature increases during the day. Outside air then reenters the vessel during the evening hours as the surrounding temperature decreases and the daily cycle prepares to be repeated. Additionally, when a conventional storage tank is filled periodically then emissions occur by way of displacement. A floating roof moves up and down the vessel vertical walls as the level of the storage tank changes. Since the vessel contains no headspace all breathing and filling losses are avoided.

Example destructive control devices:

- Catalytic Incinerators are used to eliminate VOCs from process exhaust gases from a broad variety of process operations. Catalytic incineration is a technology used in selective applications to greatly reduce emissions due to VOCs, hydrocarbons, odors, and opacity in process exhaust. The catalyst section operates at between 315°C to 400°C to convert VOC to CO<sub>2</sub> and H<sub>2</sub>O. A properly designed and installed system can achieve a VOC destruction efficiency of greater than 95%.
- Thermal Incinerators control VOC levels in a gas stream by passing the stream through a combustion chamber where the VOCs are burned in air at temperatures between 700°C to 1,300°C. Fuel is burned in the unit to supply the necessary heat for decomposition of the VOC's. Heat exchangers may also be installed as part of the unit to conserve energy by warming the inlet air stream with the hot exhaust gases.
- Venturi Scrubbers are used to remove particulate material from vent exhaust streams. These units normally incorporate a spray nozzle section where liquid is discharged at a high velocity, a mixing section where liquid droplets contact the incoming emission gas stream, and a settling/separation section where scrubber fluid is recycled to the inlet spray nozzle and the exit gas is discharged to the atmosphere or to a secondary control device.
- Enclosed Oxidizing Flares convert VOCs into CO<sub>2</sub> and H<sub>2</sub>O by way of direct combustion. Normally an enclosed oxidizing flare is used when the waste gas is rich enough in organic content to be its own fuel source. If the process gas stream does not contain an adequate level of combustible VOCs then additional fuel must be supplied for effective operation.

The removal efficiency for each control device is a function of the specific design of the unit and how well its capability matches the intended application. Before selecting pollution equipment one should consult different manufacturers and/or engineering firms to determine the most appropriate control device solution for a given application.

### 2.3.2 PM/PM<sub>10</sub> Control Systems

PM/PM<sub>10</sub> control systems for the chemical industry consist of a capture device paired with a control device that is typically a fabric filter (bag house). These systems are typically employed to reduce PM emissions from charging pigments and other solids into mixing and grinding devices. The captured dust may be recycled or sent for off-site disposal or treatment.

Bag Houses remove particulate material from an emission gas stream by passing the emission stream through engineered fabric filter tubes, envelopes, or cartridges. Particulate material is retained on the filter media as the clean air is discharged to the atmosphere. Vibrators or timed air blast are used for removing and discharging the dust that has been collected in the unit. When identifying a bag house for



an application it is important to consider the particle size in the emission stream, the particle size control requirements, the air flow rate of the emission stream, and the bag filter surface area requirements. Additionally, it is important to identify the appropriate chemical resistance requirements for the materials of construction in the unit.

Fabric filters are least efficient with particles 0.1 to 0.3  $\mu\text{m}$  in diameter and with emission streams of high moisture content. When operated under optimum conditions, they can generally achieve control efficiencies of up to 99+ percent (EIIP, 2000). However, typical control efficiencies range from 95 to 99 percent.

### 3 Basic Air Emission Models

Processes for chemical manufacturing consist of different unit operations including filling, mixing, heating, depressurization, gas sweep, gas evolution, dispersing, milling, and others. A mathematical approach to estimating air emissions from these types of processes is to model them as a collection of separate unit operations. This section contains several models that can be applied to many of the operations within these processes. For example, the filling model can be used to estimate the emissions from charging the primary raw materials or transferring the batch from one vessel to a second vessel. The heating and filling models can be used to model distillation operations.

#### 3.1 Vessel Filling

When a solvent or volatile process mixture is charged into a process vessel then material losses will occur through the process vent in the form of solvent vapors. The amount of solvent that is emitted during this displacement operation is a function of the (1) volume of liquid entering the tank, (2) the equilibrium vapor pressure of each component that is contained in the inlet stream and/or present in the vessel before the filling operation begins, and (3) degree of saturation of the associated vapors. The resulting emission rate is simply a function of how quickly the filling operation takes place.

The equilibrium vapor pressure for each volatile component in the system is calculated by applying Raoult's Law to the pure vapor pressure and the mole fraction of each compound in the inlet stream and/or initial vessel contents. If non-idealities exist between molecules in the system then activity coefficient may be used to adjust the vapor pressures accordingly. The calculated equilibrium vapor pressure represents the gas space composition assuming that the degree of vapor saturation is 100%. It is highly possible that the actual saturation level of the solvent vapors may be less than the assumed 100% level. For example, if representative samples have been taken of the gas space and analyzed then this data may be substituted for the calculated vapor pressure values. However, the conservative approach is normally applied and a 100% saturation level is assumed in most cases.

Displacement emissions that are caused by charging operations may be calculated using the ideal gas law on the volume of gas that is emitted. This equation assumes that the partial pressure of component  $i$  in the vent gas is at saturated levels.

Ideal Gas Law:

$$E_{n-i} = \frac{p_i V}{RT} \quad (9.1)$$

Where

- $E_{n-i}$  are the moles of component  $i$  that are emitted due to vapor displacement
- $p_i$  is the saturated vapor pressure of component  $i$ .
- $V$  is the displacement volume that was caused by the filling operation.
- $R$  is the ideal gas constant in consistent units,
- $T$  is the temperature of the liquid being charged

**3.1.1 Charging to an empty vessel**

When a solvent mixture is being charged to an empty vessel then the vapor composition for the displacement calculation may be made based entirely upon the inlet stream composition.

$$p_i = x_i \gamma_i P_i \quad (9.2)$$

where:  $p_i$  = effective vapor pressure for component  $i$   
 $x_i$  = mole fraction of component  $i$   
 $\gamma_i$  = component activity coefficient (Becomes 1.0 when Raoult's Law applies)  
 $P_i$  = pure component pressure  $i$

**Illustration 1: Charging a pure solvent to an empty vessel.**

A 5000 gallon reactor is filled at ambient conditions (25°C and 1 atm) with 3,600 gallons of hexane in one hour. The empty vessel was previously made inert with nitrogen, and the vessel is vented to atmosphere. Calculate the vapor emissions from this process.

**Step 1. The displaced gas is defined by the following conditions:**

T	=	25°C	=	298°K	(System temperature)
P <sub>System</sub>	=	1.0 atm	=	760 mm Hg	(Total system pressure)
V <sub>displacement</sub>	=	3600 gal	=	481.28 ft <sup>3</sup>	(Displacement volume)
Time	=	1 hr			(Time for event)

Constants and Relationships:

Universal Gas Constant:  $R = 998.9 \frac{\text{mmHg} \cdot \text{ft}^3}{\text{lb} - \text{mole} \cdot ^\circ\text{K}}$

Antoine Equation:  $P_i = \exp\left(a - \frac{b}{T + c}\right)$

Gas Law:  $n = \frac{PV}{RT}$  also  $n_i = \frac{P_i V}{RT}$  for component  $i$  in the gas space.

Sum of the partial pressures in the gas space:  $P_T = \sum_{i=1}^N p_i$

Sum of component moles in the gas space:  $N_T = \sum_{i=1}^N n_i$

**Step 2. Calculate the amount of each component in the displaced gas.**

Hexane is the only component in the liquid, so the vapor pressure for hexane is only a function of the system temperature, 25°C. The partial pressure of nitrogen is determined by the difference between the total system pressure, 760 mm Hg, and the partial pressure of hexane. The vapor pressure of hexane may be calculated from the Antoine equation as follows:

$$p_{\text{hexane}} = \exp\left(15.8366 - \frac{2697.55}{298.15 - 48.78}\right) = \exp(5.019) = 151.28 \text{ mmHg}$$

therefore  $p_{N_2} = P_T - p_{\text{hexane}} = 760 \text{ mmHg} - 151.28 \text{ mmHg} = 608.719 \text{ mmHg}$

Ideal Gas Law: 
$$E_{n-\text{hexane}} = \frac{p_{\text{hexane}} V}{RT} = \frac{151.281 \text{ mmHg} \cdot 481.28 \text{ ft}^3}{(998.9)(25^\circ\text{C} + 273.15)} = 0.244 \text{ lb} - \text{moles}$$

$$E_{n-N_2} = \frac{p_{N_2} V}{RT} = \frac{608.719 \text{ mmHg} \cdot 481.28 \text{ ft}^3}{(998.9)(298.15)} = 0.984 \text{ lb} - \text{moles}$$

Emission level: 
$$E_{Wt-\text{hexane}} = (0.244 \text{ lb} - \text{moles}) \left( 86.17 \frac{\text{lb}}{\text{lb} - \text{mole}} \right) = 21.03 \text{ lb}$$

$$E_{Wt-N_2} = (0.984 \text{ lb} - \text{moles}) \left( 28.01 \frac{\text{lb}}{\text{lb} - \text{mole}} \right) = 27.562 \text{ lb}$$

**Step 3. Calculate the emission rate based on the 1 hour addition.**

Emission Rates: 
$$E_{R-\text{hexane}} = \frac{21.03 \text{ lb}}{1.0 \text{ hr}} = 21.03 \frac{\text{lb}}{\text{hr}}$$

$$E_{R-N_2} = \frac{27.56 \text{ lb}}{1.0 \text{ hr}} = 27.56 \frac{\text{lb}}{\text{hr}}$$

**Illustration 2: Charging a solvent mixture to an empty vessel.**

A 50-50 volume percent solvent mixture of heptane and toluene is charged to a surge tank at a rate of 50 gal/min. A total of 1,500 gal of mixed solvent is charged at 20°C.

**Step 1. Define conditions of the displaced gas:**

T	=	20°C	=	298.15°K	(System temperature)
P <sub>T</sub>	=	1.0 atm	=	760 mm Hg	(Total system pressure)
V <sub>disp</sub>	=	1,500 gal	=	200.53 ft <sup>3</sup>	(Displacement volume)
Time	=	5 min			(Time for event)

Constants and Relationships:

Universal Gas Constant: 
$$R = 998.9 \frac{\text{mmHg} \cdot \text{ft}^3}{\text{lb} - \text{mole} \cdot ^\circ\text{K}}$$

Antoine Vapor Pressure Equation: 
$$P_i = \exp\left(a - \frac{b}{T + c}\right)$$

Gas Law: 
$$n = \frac{PV}{RT}, \text{ also } n_i = \frac{p_i V}{RT} \text{ for a single component } i \text{ in the gas space.}$$

Sum of the partial pressures in the gas space: 
$$P_T = \sum_{i=1}^N p_i$$

Sum of component moles in the gas space: 
$$N_T = \sum_{i=1}^N n_i$$

**Step 2. Calculate the vapor-phase mole fractions.**

VOC	Mol. Wt. lb/lbmole	Density lb/gal	Volume Charged	Weight Charged	lb- moles	X <sub>i</sub>
Heptane	100.205	5.6977	750	4,273.3	42.65	0.42
Toluene	92.13	7.2138	750	5,410.3	58.72	0.58
<i>Total</i>					<i>101.37</i>	<i>1.00</i>

In this problem, heptane and toluene coexist in a miscible liquid. The vapor space partial pressure for each compound may be estimated from the pure component pressure and liquid composition using Raoult's Law. It is assumed that the vessel contains nitrogen as the remaining gas component. Pure component vapor pressures for the liquid components may be estimated using the Antoine equation.

$$P_{\text{heptane}} = \exp\left(15.8737 - \frac{2911.32}{293.15 - 56.51}\right) = \exp(3.571) = 35.55 \text{ mmHg}$$

$$P_{\text{toluene}} = \exp\left(16.0137 - \frac{3096.52}{293.15 - 53.67}\right) = \exp(3.0835) = 21.84 \text{ mmHg}$$

VOC	X <sub>i</sub>	P <sub>i</sub> (mm Hg)	p <sub>i</sub> (mm Hg)
Heptane	0.42	35.55	14.93
Toluene	0.58	21.84	12.67
Nitrogen	0.0		732.40

Ideal Gas Law: 
$$E_{n\text{-heptane}} = \frac{p_{\text{heptane}} V}{RT_{\text{sys}}} = \frac{14.93 \text{ mmHg} \cdot 200.53 \text{ ft}^3}{(998.9)(293.15)} = 0.0102 \text{ lb - moles}$$

$$n_{n\text{-toluene}} = \frac{p_{\text{toluene}} V}{RT_{\text{sys}}} = \frac{12.67 \text{ mmHg} \cdot 200.53 \text{ ft}^3}{(998.9)(293.15)} = 0.0087 \text{ lb - moles}$$

$$n_{\text{nitrogen}} = \frac{p_{\text{air}} V}{RT_{\text{sys}}} = \frac{732.40 \text{ mmHg} \cdot 200.53 \text{ ft}^3}{(998.9)(293.15)} = 0.5015 \text{ lb - moles}$$

Emission level: 
$$E_{W1\text{-heptane}} = (0.0102 \text{ lb - moles}) \left( 100.205 \frac{\text{lbs}}{\text{lb - mole}} \right) = 1.02 \text{ lbs}$$

$$E_{W1\text{-toluene}} = (0.0087 \text{ lb - moles}) \left( 92.13 \frac{\text{lbs}}{\text{lb - mole}} \right) = 0.80 \text{ lbs}$$

$$E_{W1\text{-nitrogen}} = (0.5015 \text{ lb - moles}) \left( 28.0134 \frac{\text{lbs}}{\text{lb - mole}} \right) = 14.05 \text{ lbs}$$

**Step 3. Calculate the emission rate in lb/hr units.**

Since 1,500 of solvent mixture is charged at 50 gpm the complete charge is completed in 30 minutes.

$$E_{R-\text{heptane}} = 1.02 \text{ lbs} \left( \frac{60 \text{ min/hr}}{30 \text{ min}} \right) = 2.04 \text{ lbs/hr}$$

$$E_{R-\text{toluene}} = 0.80 \text{ lbs} \left( \frac{60 \text{ min/hr}}{30 \text{ min}} \right) = 1.6 \text{ lbs/hr}$$

$$E_{R-\text{nitrogen}} = 14.05 \text{ lbs} \left( \frac{60 \text{ min/hr}}{30 \text{ min}} \right) = 28.1 \text{ lbs/hr}$$

**3.1.2 Charging to a partially filled vessel with miscible contents**

When a liquid mixture is charged to a vessel that already contains process material from a prior process operation then the vessel contents composition will dynamically change as the charging operation takes place. The equilibrium vapor composition above the batch will also change in accordance to the batch composition.

At any point in the filling operation one may calculate the batch composition from the initial vessel contents and the amount of material that has been added. Let  $n_A$  represent the moles of inlet mixture that are to be added to the vessel and let  $N_B$  represent the total number of moles of mixture that are initially contained in the vessel regardless of composition. For example, if the inlet stream contained ethanol, water, and methanol then  $n_A$  would represent the total moles of ethanol, water, and methanol that have been charged at any point in the operation.

$$\varphi_A = \frac{n_A}{n_A + N_B} \quad (9.3)$$

where  $\varphi_A$  is the degree of dilution of the inlet stream mixture at any point during the addition,  $n_A$  are the moles of inlet steam mixture charged to the vessel, and  $N_B$  are the moles of mixture that were initially contained in the vessel prior to the addition.

The average dilution  $\bar{\varphi}_A$  of the inlet stream A from being mixed with the contents of the vessel may be calculated by integrating a differential expression for  $d\varphi_A$  with respect to moles of inlet mixture A and then dividing the results by the total number of moles of mixture A that were charged. [Hatfield, 2003d].

$$\bar{\varphi}_A = \frac{1}{N_A} \int_0^{N_A} \frac{n_A}{(n_A + N_B)} dn_A \quad (9.4)$$

$$\bar{\varphi}_A = 1 + \frac{N_B}{N_A} \ln \left( \frac{N_B}{N_A + N_B} \right) \quad (9.5)$$

A similar calculation may be made for the average dilution factor of mixture B (the initial vessel contents) that exists during the filling process.

$$\bar{\varphi}_B = \frac{N_B}{N_A} \int_0^{N_A} \frac{1}{(n_A + N_B)} dn_A \quad (9.6)$$

$$\bar{\varphi}_B = -\frac{N_B}{N_A} \ln \left( \frac{N_B}{N_A + N_B} \right) \quad (9.7)$$

Once  $\bar{\varphi}_A$  and  $\bar{\varphi}_B$  are determined then the average batch composition that exists during the filling operation may be calculated by multiplying the composition of each mixture by its corresponding integrated average dilution factor.

When the filling operation involves subsurface addition then the inlet stream is exposed to the vessel headspace only as it mixes with the vessel contents. In this case only the average batch composition that exists during the filling operation is used to calculate the average vessel headspace vapor composition.

$\bar{\varphi}_A$  and  $\bar{\varphi}_B$  are calculated

However, if the operation involves above surface addition then the inlet stream is exposed directly to the headspace in the vessel. The equilibrium vapor pressure of the inlet stream must then be considered as an independent source of vapors in addition to the average batch composition.

### **Subsurface Addition**

#### **Illustration 3: Charging a mixture to a partially filled vessel (subsurface addition).**

Three hundred gallons of acetone at 20°C are to be added to the vessel featured in Illustration 2 by way of subsurface addition. For this problem, the initial contents of the vessel are 1,500 gallons of a mixture of heptane (42% mole fraction) and toluene (58% mole fraction) at 20°C. The system pressure is 760 mm Hg and the addition process is complete in 0.5 hour.

#### **Step 1. Define conditions of the displaced gas:**

T	=	20°C	=	298.15°K	(System temperature)
PT	=	1.0 atm	=	760 mm Hg	(Total system pressure)
Vdisp	=	300 gal	=	40.1 ft <sup>3</sup>	(Displacement volume)
Time	=	30 min			(Time for event)
Acetone	=	6.5632 lb/gal @ 20°C			

Constants and Relationships:

Universal Gas Constant: 
$$R = 998.9 \frac{\text{mmHg} \cdot \text{ft}^3}{\text{lb} - \text{mole} \cdot ^\circ\text{K}}$$

Antoine Vapor Pressure Equation: 
$$P_i = \exp \left( a - \frac{b}{T + c} \right)$$

Gas Law: 
$$n = \frac{PV}{RT}, \text{ also } n_i = \frac{p_i V}{RT} \text{ for a single component } i \text{ in the gas space.}$$

Sum of the partial pressures in the gas space: 
$$P_T = \sum_{i=1}^N p_i$$

Sum of component moles in the gas space:  $N_T = \sum_{i=1}^N n_i$

**Step 2. Calculate the dilution factors for the inlet stream and the initial vessel contents.**

Inlet Stream Analysis:

VOC	Mol. Wt. lb/lbmole	Density lb/gal	Volume Charged	Weight Charged	lb- moles	Xi
Acetone	58.08	6.5632	300	1968.96	33.90	1.00
<i>Total</i>					<i>33.90</i>	<i>1.00</i>

Initial Vessel Contents Analysis:

VOC	Mol. Wt. lb/lbmole	Density lb/gal	Volume Charged	Weight Charged	lb- moles	Xi
Heptane	100.205	5.6977	750	4,273.3	42.65	0.42
Toluene	92.13	7.2138	750	5,410.3	58.72	0.58
<i>Total</i>					<i>101.37</i>	<i>1.00</i>

Calculate the inlet stream dilution factor:

From Eq 8.5:

$$\bar{\varphi}_A = 1 + \frac{N_B}{N_A} \ln \left( \frac{N_B}{N_A + N_B} \right)$$

$$\bar{\varphi}_A = 1 + \frac{101.37}{33.90} \ln \left( \frac{101.37}{33.90 + 101.37} \right)$$

$$\bar{\varphi}_A = 1 + 2.99 \ln(0.7494) = 0.14$$

Calculate the dilution factor for the initial vessel contents:

From Eq 8.6

$$\bar{\varphi}_B = -\frac{N_B}{N_A} \ln \left( \frac{N_B}{N_A + N_B} \right)$$

$$\bar{\varphi}_B = -\frac{101.37}{33.90} \ln \left( \frac{101.37}{33.90 + 101.37} \right)$$

$$\bar{\varphi}_B = -2.99 \ln(0.7494) = 0.86$$



**Step 3. Calculate the average batch and vapor-phase compositions.**

VOC	X <sub>i</sub>	φ <sub>A</sub> , φ <sub>B</sub>	$\bar{X}_i$	P <sub>i</sub> (mm Hg)	p <sub>i</sub> (mm Hg)
Acetone	1.00	0.14	0.14	184.80	25.87
Heptane	0.42	0.86	0.36	35.55	12.80
Toluene	0.58	0.86	0.50	21.84	10.92
Nitrogen					710.41
<i>Total</i>	<i>1.00</i>		1.00		760.00

Ideal Gas Law:

$$E_{n\text{-acetone}} = \frac{p_{\text{acetone}} V}{RT_{\text{sys}}} = \frac{25.87 \text{ mmHg} \cdot 40.1 \text{ ft}^3}{(998.9)(293.15)} = 0.00354 \text{ lb-moles}$$

$$E_{n\text{-heptane}} = \frac{p_{\text{heptane}} V}{RT_{\text{sys}}} = \frac{12.83 \text{ mmHg} \cdot 40.1 \text{ ft}^3}{(998.9)(293.15)} = 0.00176 \text{ lb-moles}$$

$$E_{n\text{-toluene}} = \frac{p_{\text{toluene}} V}{RT_{\text{sys}}} = \frac{10.92 \text{ mmHg} \cdot 40.1 \text{ ft}^3}{(998.9)(293.15)} = 0.0015 \text{ lb-moles}$$

$$E_{n\text{-nitrogen}} = \frac{p_{\text{nitrogen}} V}{RT_{\text{sys}}} = \frac{710.41 \text{ mmHg} \cdot 40.1 \text{ ft}^3}{(998.9)(293.15)} = 0.0973 \text{ lb-moles}$$

Emission level:

$$E_{\text{wt-acetone}} = (0.00354 \text{ lb-moles}) \left( 58.08 \frac{\text{lbs}}{\text{lb-mole}} \right) = 0.21 \text{ lbs}$$

$$E_{\text{wt-heptane}} = (0.00176 \text{ lb-moles}) \left( 100.205 \frac{\text{lbs}}{\text{lb-mole}} \right) = 0.18 \text{ lbs}$$

$$E_{\text{wt-toluene}} = (0.0015 \text{ lb-moles}) \left( 92.13 \frac{\text{lbs}}{\text{lb-mole}} \right) = 0.14 \text{ lbs}$$

$$E_{\text{wt-nitrogen}} = (0.0973 \text{ lb-moles}) \left( 28.0134 \frac{\text{lbs}}{\text{lb-mole}} \right) = 2.73 \text{ lbs}$$

**Step 3. Calculate the emission rate in lb/hr units.**

$$E_{R\text{-acetone}} = \frac{0.21 \text{ lbs}}{0.5 \text{ hr}} = 0.42 \text{ lbs/hr}$$

$$E_{R\text{-heptane}} = \frac{0.18 \text{ lbs}}{0.5 \text{ hr}} = 0.36 \text{ lbs/hr}$$

$$E_{R\text{-toluene}} = \frac{0.28 \text{ lbs}}{0.5 \text{ hr}} = 0.56 \text{ lbs/hr}$$

$$E_{R\text{-nitrogen}} = \frac{2.73 \text{ lbs}}{0.5 \text{ hr}} = 5.46 \text{ lbs/hr}$$

**Above Surface Addition****Illustration 4: Charging a mixture to a partially filled vessel (above surface addition).**

Three hundred gallons of acetone at 20°C are to be added to the vessel featured in Illustration 2 by way of above surface addition. For this problem, the initial contents of the vessel are 1,500 gallons of a mixture of heptane (42% mole fraction) and toluene (58% mole fraction) at 20°C. The system pressure is 760 mm Hg and the addition process is complete in 0.5 hours.

For this problem, the inlet stream is in direct contact with the vessel headspace as it enters the vessel. Therefore, the equilibrium vapor composition for the inlet stream will be based on the exact composition of the inlet stream. A dilution factor  $\bar{\phi}_A$  for the inlet stream will be assumed to be 1.0.

**Step 1. Define the conditions of the displaced vent gas:**

T	=	20°C	=	298.15°K	(System temperature)
PT	=	1.0 atm	=	760 mm Hg	(Total system pressure)
V <sub>disp</sub>	=	300 gallons	=	40.1 ft <sup>3</sup>	(Displacement volume)
Time	=	30 min			(Time for event)
Acetone	=	6.5632 lb/gal @ 20°C			

Constants and Relationships:

Universal Gas Constant: 
$$R = 998.9 \frac{\text{mmHg} \cdot \text{ft}^3}{\text{lb-mole} \cdot ^\circ\text{K}}$$

Antoine Vapor Pressure Equation: 
$$P_i = \exp\left(a - \frac{b}{T + c}\right)$$

Gas Law: 
$$n = \frac{PV}{RT} \text{ also } n_i = \frac{p_i V}{RT} \text{ for a single component } i \text{ in the gas space.}$$

Sum of the partial pressures in the gas space: 
$$P_T = \sum_{i=1}^N p_i$$

Sum of component moles in the gas space: 
$$N_T = \sum_{i=1}^N n_i$$

**Step 2. Calculate the dilution factor for the initial vessel contents.**

Inlet Stream Analysis:

VOC	Mol. Wt. lb/lbmole	Density lb/gal	Volume Charged	Weight Charged	lb-moles	X <sub>i</sub>
Acetone	58.08	6.5632	300	1968.96	33.90	1.00
<i>Total</i>					<i>33.90</i>	<i>1.00</i>

Initial Vessel Contents Analysis:

VOC	Mol. Wt. lb/lbmole	Density lb/gal	Volume Charged	Weight Charged	lb-moles	Xi
Heptane	100.205	5.6977	750	4,273.3	42.65	0.42
Toluene	92.13	7.2138	750	5,410.3	58.72	0.58
<i>Total</i>					<i>101.37</i>	<i>1.00</i>

Calculate the dilution factor for the initial vessel contents:

From Eq 9.7

$$\bar{\phi}_B = -\frac{N_B}{N_A} \ln \left( \frac{N_B}{N_A + N_B} \right)$$

$$\bar{\phi}_B = -\frac{101.37}{33.90} \ln \left( \frac{101.37}{33.90 + 101.37} \right)$$

$$\bar{\phi}_B = -2.99 \ln (0.7494) = 0.86$$

**Step 2. Calculate the average batch and vapor-phase compositions.**

VOC	Xi	$\Phi_A, \Phi_B$	$\bar{X}_i$	$P_i$ (mm Hg)	$P_i$ (mm Hg)
Acetone	1.00	1.00	1.00	184.80	184.80
Heptane	0.42	0.86	0.36	35.55	12.80
Toluene	0.58	0.86	0.50	21.84	10.92
Nitrogen					551.48
<i>Total</i>	<i>1.00</i>		1.00		760.00

Ideal Gas Law:

$$E_{n\text{-acetone}} = \frac{p_{\text{acetone}} V}{RT_{\text{sys}}} = \frac{184.80 \text{ mmHg} \cdot 40.1 \text{ ft}^3}{(998.9)(293.15)} = 0.0253 \text{ lb-moles}$$

$$E_{n\text{-heptane}} = \frac{p_{\text{heptane}} V}{RT_{\text{sys}}} = \frac{12.83 \text{ mmHg} \cdot 40.1 \text{ ft}^3}{(998.9)(293.15)} = 0.00176 \text{ lb-moles}$$

$$E_{n\text{-toluene}} = \frac{p_{\text{toluene}} V}{RT_{\text{sys}}} = \frac{10.92 \text{ mmHg} \cdot 40.1 \text{ ft}^3}{(998.9)(293.15)} = 0.0015 \text{ lb-moles}$$

$$E_{n\text{-nitrogen}} = \frac{p_{\text{nitrogen}} V}{RT_{\text{sys}}} = \frac{551.48 \text{ mmHg} \cdot 40.1 \text{ ft}^3}{(998.9)(293.15)} = 0.0755 \text{ lb-moles}$$

Emission level:

$$E_{wt-acetone} = (0.0253 \text{ lb} - \text{moles}) \left( 58.08 \frac{\text{lbs}}{\text{lb} - \text{mole}} \right) = 1.47 \text{ lbs}$$

$$E_{wt-heptane} = (0.00176 \text{ lb} - \text{moles}) \left( 100.205 \frac{\text{lbs}}{\text{lb} - \text{mole}} \right) = 0.18 \text{ lbs}$$

$$E_{wt-toluene} = (0.0015 \text{ lb} - \text{moles}) \left( 92.13 \frac{\text{lbs}}{\text{lb} - \text{mole}} \right) = 0.14 \text{ lbs}$$

$$E_{wt-nitrogen} = (0.0755 \text{ lb} - \text{moles}) \left( 28.0134 \frac{\text{lbs}}{\text{lb} - \text{mole}} \right) = 2.12 \text{ lbs}$$

**Step 3. Calculate the emission rate in lb/hr units.**

$$E_{R-acetone} = \frac{1.47 \text{ lbs}}{0.5 \text{ hr}} = 2.94 \text{ lbs / hr}$$

$$E_{R-heptane} = \frac{0.18 \text{ lbs}}{0.5 \text{ hr}} = 0.36 \text{ lbs / hr}$$

$$E_{R-toluene} = \frac{0.28 \text{ lbs}}{0.5 \text{ hr}} = 0.56 \text{ lbs / hr}$$

$$E_{R-nitrogen} = \frac{2.12 \text{ lbs}}{0.5 \text{ hr}} = 4.24 \text{ lbs / hr}$$

### **Addition of immiscible liquids**

#### **Illustration 5: Charging a mixture to a partially filled vessel (immiscible liquids).**

Seven hundred fifty gallons of toluene at 20°C are to be added to the vessel that contains 500 gallons of water at 20°C. The system pressure is 760 mm Hg and the addition process is complete within 0.5 hours.

For this problem, the two mixtures are insoluble and form two distinct liquid phases as the addition process takes place. Therefore, dilution of one stream by the other does not occur and the equilibrium vapor composition is determined based on the initial composition of each mixture.

#### **Step 1. Define conditions of the displaced gas:**

T	=	20°C	=	298.15°K	(System temperature)
P <sub>T</sub>	=	1.0 atm	=	760 mm Hg	(Total system pressure)
V <sub>disp</sub>	=	750 gal	=	100.2 ft <sup>3</sup>	(Displacement volume)
Time	=	30 min			(Time for event)

Constants and Relationships:

Universal Gas Constant:

$$R = 998.9 \frac{\text{mmHg} \cdot \text{ft}^3}{\text{lb} - \text{mole} \cdot ^\circ\text{K}}$$

Antoine Vapor Pressure Equation:

$$P_i = \exp\left(a - \frac{b}{T + c}\right)$$

Gas Law:  $n = \frac{PV}{RT}$ , also  $n_i = \frac{p_i V}{RT}$  for a single component  $i$  in the gas space.

Sum of the partial pressures in the gas space:  $P_T = \sum_{i=1}^N p_i$

Sum of component moles in the gas space:  $N_T = \sum_{i=1}^N n_i$

**Step 2. Calculate the dilution factor for the initial vessel contents.**

Inlet Stream Analysis:

VOC	Mol. Wt. lb/lb-mole	Density lb/gal	Volume Charged	Weight Charged	lb-moles	Xi
Toluene	92.13	7.2138	750	5,410.4	58.72	1.00
<i>Total</i>					<i>58.72</i>	<i>1.00</i>

Initial Vessel Contents Analysis:

VOC	Mol. Wt. lb/lb-mole	Density lb/gal	Volume	Weight	lb-moles	Xi
Water	18.02	8.33	500	4,165	231.13	1.00
<i>Total</i>					<i>231.13</i>	<i>1.00</i>

**Step 3. Calculate the average batch and vapor-phase compositions.**

VOC	Xi	P <sub>i</sub> (mm Hg)
Toluene	1.00	21.84
Water	1.00	17.35
Nitrogen		720.81
<i>Total</i>	<i>1.00</i>	<i>760.00</i>

Ideal Gas Law:

$$E_{n-toluene} = \frac{p_{toluene} V}{RT_{sys}} = \frac{21.84 \text{ mmHg} \cdot 100.2 \text{ ft}^3}{(998.9)(293.15)} = 0.00747 \text{ lb-moles}$$

$$E_{n-water} = \frac{p_{water} V}{RT_{sys}} = \frac{17.35 \text{ mmHg} \cdot 100.2 \text{ ft}^3}{(998.9)(293.15)} = 0.00594 \text{ lb-moles}$$

$$E_{n-nitrogen} = \frac{p_{nitrogen} V}{RT_{sys}} = \frac{720.81 \text{ mmHg} \cdot 100.2 \text{ ft}^3}{(998.9)(293.15)} = 0.24665 \text{ lb-moles}$$

Emission level:

$$E_{wt-toluene} = (0.00747 \text{ lb-moles}) \left( 92.13 \frac{\text{lbs}}{\text{lb-mole}} \right) = 0.69 \text{ lbs}$$

$$E_{wt-water} = (0.00594 \text{ lb-moles}) \left( 18.02 \frac{\text{lbs}}{\text{lb-mole}} \right) = 0.11 \text{ lbs}$$

$$E_{wt-nitrogen} = (0.24665 \text{ lb-moles}) \left( 28.0134 \frac{\text{lbs}}{\text{lb-mole}} \right) = 6.91 \text{ lbs}$$

**Step 4. Calculate the emission rate in lb/hr units.**

$$E_{R-toluene} = \frac{0.69 \text{ lbs}}{0.5 \text{ hr}} = 1.38 \text{ lbs/hr}$$

$$E_{R-water} = \frac{0.11 \text{ lbs}}{0.5 \text{ hr}} = 0.22 \text{ lbs/hr}$$

$$E_{R-nitrogen} = \frac{6.91 \text{ lbs}}{0.5 \text{ hr}} = 13.82 \text{ lbs/hr}$$

## 3.2 PURGE/GAS SWEEP MODELS

### 3.2.1 Purge or Gas Sweep - Empty Vessel Purge

When a gas purge is applied to an empty vessel that still contains residual vapors from a previous process operation then compound emissions may be determined by the following expression.

$$E_{n-i} = \frac{p_{i,l} V}{RT} \left( 1 - e^{-Ft/V} \right)$$

Where  $E_{n-i}$  are the moles of component  $i$  that are emitted due to vapor displacement,  
 $p_{i,l}$  is the saturated vapor pressure of component  $i$  at initial conditions,  
 $V$  is the gas space volume of vessel when empty,  
 $R$  is the ideal gas constant in consistent units,  
 $T$  is the temperature of the liquid being charged,  
 $F$  is the purge gas flowrate,  
 $t$  is the elapsed time for the purge operation.

**Illustration 6: Purging an empty vessel or reactor containing solvent vapors.**

A 2,000 gallon reactor vessel was cooled to 20°C and the contents, an acetone solvent, were pumped out leaving only vapors. If this vessel is then purged with 1,000 standard cubic feet of nitrogen at 20°C, how much acetone is in the vented nitrogen?

**Step 1: Determine the initial partial pressure of acetone in the vessel gas space.**

$$p_{\text{acetone}, 20^{\circ}\text{C}} = \exp\left(16.6513 - \frac{2940.46}{293.15 - 3593}\right) = \exp(5.2196) = 184.86 \text{ mmHg}$$

$$F \cdot t = (1000 \text{ scf}) \left( \frac{273.15 + 20}{273.15} \right) = 1073 \text{ acf}$$

$$V = \frac{2000 \text{ gal}}{7.48 \text{ gal / ft}^3} = 267 \text{ ft}^3$$

$$n = \frac{F \cdot t}{V} = \frac{1073 \text{ acf}}{267 \text{ ft}^3} = 4.02$$

**Step 2: Calculate the acetone loss from the vessel by conducting a material balance around the vessel.**

Where  $N_{\text{acetone}}$  is the amount of acetone displaced from the vessel:

$$N_T = \sum_{i=1}^N n_i$$

$$E_{n-i} = \frac{(184.86)(267)}{(998.9)(293.15)} (1 - e^{-4.02})$$

$$E_{n-\text{acetone}} = (0.1686)(1 - e^{-4.02}) = (0.1686)(0.9821) = 0.166 \text{ lb - moles}$$

$$E_{\text{wt-acetone}} = (0.166 \text{ lb - moles})(58.08 \text{ lb / lb - mole}) = 9.58 \text{ lb}$$

**Step 3: Calculate the amount of nitrogen emitted from the vessel.**

Before the empty vessel purge began, the gas space was saturated with acetone vapors at a partial pressure of 184 mm Hg. At the completion of the purge operation, the acetone partial pressure has been reduced to 3.32 mm Hg. The amount of nitrogen that leaves the vessel through the vent is equal to the inlet amount minus the accumulation amount.

$$E_{n-\text{nitrogen}} (\text{out}) = N_{\text{nitrogen}} (\text{in}) - N_{\text{nitrogen}} (\text{accum.})$$

$$E_{n-\text{nitrogen}} (\text{out}) = \frac{PV_{\text{purge}}}{RT} - \frac{(p_{i,1} - p_{i,2})V_{\text{vessel}}}{RT}$$

$$E_{n-\text{nitrogen}} (\text{out}) = \frac{(760)(1073)}{(998.9)(293.15)} - \frac{(184.86 - 3.32)(267)}{(998.9)(293.15)} = 2.62 \text{ lb - moles}$$

$$E_{\text{wt-nitrogen}} = (2.62 \text{ lb - moles})(28 \text{ lb / lb - mole}) = 73.4 \text{ lb}$$

### 3.2.2 Purge or Gas Sweep - partially filled vessel

Air or another non-condensable gas is directed into the vessel at a controlled rate. The discharge vapors from the vessel during this operation are normally assumed to be at equilibrium or saturated with the vessel's liquid contents within certain flow rate criteria. Further, it is assumed that the inlet purge rate is known. Eq-9.8 is used to calculate amounts of condensable components. The mixing factor  $S_i$  represents the degree of VOC saturation for the vent gas, and it is normally between 0 and 1.0. A value of 0.25 for  $S_i$  implies that the exit vent gas is at 25% saturation level with respect to the solvent vapors in the tank, while a  $S_i$  value of 1.0 implies that the exit vent gas is at equilibrium with the volatile contents of the vessel. [Hatfield, 2003a]

$$E_{R-i} = E_{R-nc} \frac{S_i p_i^{sat}}{p_{nc}^{sat}} \quad (9.8)$$

where:  $E_{R-i}$  = moles of volatile component  $i$  emitted per unit time,  
 $S_i$  = saturation level of the exit vent gas stream,  
 $E_{nc}$  = moles of non-condensable gas emitted per unit time (= inlet purge rate),  
 $p_i^{sat}$  = partial pressure of component  $i$  at saturated conditions,  
 $p_{nc}^{sat}$  = partial pressure of the non-condensable gas (i.e. air, nitrogen) at saturated solvent pressure conditions.

The saturation factor for a solvent vapor is a function of the evaporation mass transfer coefficient  $K_i$ , the liquid surface area in the vessel, and the solvent partial pressure in the vessel headspace. When the exit emission rate for a vessel is set equal to the evaporation rate in the vessel then the following expression results for the saturation level  $S_i$ .

$$\text{Saturation level } S_i: \quad S_i = \frac{p_i}{p_i^{sat}} = \frac{K_i A}{K_i A + F} = \frac{K_i A}{K_i A + F_{nc} + S_i F_i^{sat}} \quad (9.9)$$

$$\text{, where} \quad K_i = K_o \left( \frac{M_o}{M_i} \right)^{1/3}, \quad (9.10)$$

$$\text{and} \quad F_i^{sat} = F_{nc} \frac{p_i^{sat}}{p_{nc}^{sat}} = F_{nc} \frac{p_i^{sat}}{(P_{sys} - p_i^{sat})} \quad (9.11)$$

$S_i$  = saturated vapor pressure for compound  $i$ ,  
 $K_i$  = mass transfer coefficient  $i$ ,  
 $K_o$  = mass transfer coefficient of a reference compound,  
 $M_i$  = molecular weight of compound  $i$ ,  
 $M_o$  = molecular weight of the reference compound  $o$ ,  
 $A$  = surface area of the liquid,  
 $F_{nc}$  = volumetric flow rate of the non-condensable gas (i.e. air, nitrogen),  
 $F_i^{sat}$  = volumetric flow rate of component  $i$  (i.e. VOC) at saturated vapor pressure,  
 $p_i^{sat}$  = saturated vapor pressure of component  $i$ ,



$p_{nc}^{sat}$  = partial pressure of the noncondensable gas (i.e. air, nitrogen) at saturated solvent pressure conditions,

$P_{sys}$  = system pressure.

The saturated partial volumetric flow rate for each component is estimated from the component saturated vapor pressure, the inlet gas purge rate, and the partial pressure of the non-condensable at saturated conditions.

$S_i$  may be solved using the standard quadratic solution. Although the standard quadratic equation contains two roots, only the one solution shown in Eq-9.12 produces a realistic value since  $S_i$  must be a positive number between 0 and 1.0.

Quadratic solution: 
$$S_i = \frac{-(K_i A + F_{nc}) + \sqrt{(K_i A + F_{nc})^2 + 4F_i^{sat} K_i A}}{2F_i^{sat}} \quad (9.12)$$

Finally, the emission rate for the volatile component  $i$  may be calculated using Eq-9.13 which allows for the use of  $S_i$ , where  $p_i = S_i p_i^{sat}$ .

$$E_i = \frac{M_i S_i F_i^{sat} P_{sys}}{RT} \quad (9.13)$$

For multi-component liquid mixtures, Eq-9.14 may be expanded to provide partial volumetric flow levels for each volatile component in the liquid.

$$S_{i+1} = \frac{K_i A}{K_i A + F_{nc} + S_i F_i^{sat} + S_j F_j^{sat} + \dots + S_n F_n^{sat}} \quad (9.14)$$

where  $i$  is the compound for which the saturation level is being calculated, and terms  $j$  through  $n$  represent the other components in the liquid. Eq-9.14 is solved in an iterative trial and error manner with the initial value of  $S$  for each component assigned to 1.0. The value of  $S$  that is calculated for each component is then used as the starting point for the next iteration. Finally, when the saturation level  $S$  of each compound remains the same for subsequent iterations then the calculation process is stopped.

Emission rates for each solvent compound are then calculated based on the partial volumetric flow rate as calculated from the saturation level and the saturated volumetric flow rate  $F_i = S_i F_i^{sat}$ .

Solvent emission rate 
$$E_i = \frac{M_i S_i F_i^{sat} P_{sys}}{RT} \text{ (wt per unit of time)}$$

**Illustration 7: Gas sweep with a vessel containing with a single volatile solvent.**

A vertical process vessel with a 6-ft cross sectional diameter is at 1 atm pressure and contains a volume of heptane at 25°C. The vessel is being purged with 10 scfm (standard cubic feet per minute) of nitrogen gas. Calculate the emission rate of heptane during the purge operation.

The molecular weight of heptane is 100.2. The mass transfer coefficient is estimated using Eq-9.10 with the known mass transfer coefficient for water of 0.83 cm/s. Other variables are also calculated from established relationships.

$$K_i = K_o \left( \frac{M_o}{M_i} \right)^{1/3} = 0.83 \frac{cm}{s} \left( \frac{18.02}{100.2} \right)^{1/3} = 0.4685 \frac{cm}{s} \times \frac{60 \cdot s \cdot ft}{30.48 \cdot min \cdot cm} = 0.92 \frac{ft}{min}$$

$$P_{heptane}^{sat} = 45.86 \text{ mmHg}. \quad P_{nitrogen}^{sat} = 760 - 45.86 = 714.14 \text{ mmHg}.$$

$$F_{nitrogen} = 10 \text{ scfm} \frac{298.15^\circ K}{273.15^\circ K} = 10.92 \text{ ft}^3 / \text{min}$$

$$F_{heptane}^{sat} = 10.92 \frac{45.86 \text{ mmHg}}{714.14 \text{ mmHg}} = 0.70 \text{ ft}^3 / \text{min}$$

$$A = \frac{\pi d^2}{4} = \frac{3.14 \cdot 36 \text{ ft}^2}{4} = 28.26 \text{ ft}^2$$

$$S_{heptane} = \frac{-(0.92 \cdot 28.26 + 10.92) + \sqrt{(0.92 \cdot 28.26 + 10.92)^2 + 4 \cdot 0.70 \cdot 0.92 \cdot 28.26}}{2 \cdot 0.70}$$

$$S_{heptane} = \frac{-36.92 + \sqrt{1363.0 + 72.79}}{1.40} = \frac{0.97}{1.40} = 0.69$$

$$E_m = \frac{M_i S_i F_i^{sat} P_{sys}}{RT_L} = \frac{(100.2 \text{ lb} / \text{lb} - \text{mole})(0.69)(0.70 \text{ ft}^3 / \text{min})(760 \text{ mmHg})}{(554.98 \text{ ft}^3 \text{ atm} / \text{lb} - \text{mol}^\circ R)(537^\circ R)}$$

$$E_{R-m} = 0.12 \text{ lb} / \text{min} = 7.2 \text{ lb} / \text{hr}$$

As an illustration on how the saturation factor for heptane could have been calculated using the iteration technique Eq 9.14 can be applied directly.

$$S_i = \frac{K_i A}{K_i A + F_{nc} + S_i F_i^{sat}} = \frac{0.92 \cdot 28.26}{0.92 \cdot 28.26 + 10.92 + S_i \cdot 0.70} = \frac{25.99}{36.92 + 0.7 \cdot S_i}$$

Starting with an initial guess for  $S_i$  to equal 1.0, the convergence occurs rapidly with the final result 0.69 being equal to earlier results using the quadratic equation.

Iteration 0	$S_i = 1.00$
Iteration 1	$S_i = f(1.00) = 0.69$
Iteration 2	$S_i = f(0.69) = 0.69$

**Illustration 8: Gas sweep with a vessel containing with a volatile solvent mixture**

Suppose the vessel featured in Illustration 4 contained a solvent mixture consisting of 20% heptane, 70% toluene, and 10% methanol. Assuming that the composition is specified in mole percents, calculate the saturation factor for each component using Eq-9.14. Before applying Eq-9.14 to this solution several values must be calculated for each component as shown in the following table:

Table: Calculated Values for Use in Eq-9.14

Compound	MWt	VP@25C	Mole fraction	Vp	Fi(sat)	Ki	KiA
Heptane	100.21	45.86	0.2	9.17	0.14	0.47	13.24
Toluene	92.13	28.44	0.7	19.91	0.30	0.48	13.62

Methanol	32.04	126.88	0.1	12.69	0.19	0.69	19.36
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The calculated values in Table I are then substituted into Eq-9.14 for an iterative trial and error procedure.

$$S_{i+1} = \frac{K_i A}{K_i A + F_{nc} + S_i F_i^{sat} + S_j F_j^{sat} + \dots + S_n F_n^{sat}} \quad (9.8)$$

Table: Iterative Trial and Error Results for Si using Eq-9.14

Compound	KiA	FiSat	Si (iteration 0)	Si (iteration 1)	Si (iteration 2)	Si (iteration 3)
Heptane	13.24	0.14	1.00	0.53	0.54	0.54
Toluene	13.62	0.30	1.00	0.54	0.55	0.55
Methanol	19.36	0.19	1.00	0.63	0.63	0.63

Finally, the solvent emission rate for each component may be calculated from the relationship.

$$Q_i = \frac{M_i S_i F_i^{sat} P_{sys}}{RT} \quad (\text{weight per unit of time})$$

to produce the following emission rate results.

Table: Calculated Emission Rates

Compound	MWt	Si	FiSat	Qi (lb/min)	Qi (lb/hr)
Heptane	100.21	0.54	0.14	0.0192	1.15
Toluene	92.13	0.55	0.30	0.0389	2.33
Methanol	32.04	0.63	0.19	0.0100	0.60

### 3.3 Vacuum Operations

The application of vacuum is used in many distillation or drying operations as a means of reducing the boiling point temperature of a given process mixture. In the case of vacuum distillation, solvent is vaporized in the still vessel, condensed at a low temperature, and collected in a receiving vessel. In the case of a solids drying operation, wet product cake is placed in a rotary or tray dryer and vacuum is applied to the entire drying system. Heat is then applied to the dryer and solvent vapors are condensed at a low temperature and collected in the receiving vessel.

Vent emissions that occur from vacuum operations are the result of air being removed from the system by the vacuum pump or ejector. For solids drying, a nitrogen sweep may be applied at the dryer as a means of accelerating the drying process. The vacuum pump or ejector must remove this additional nitrogen along with any air that has leaked into the system due to the lower pressure.

When the initial distillation phase is underway then the vent emissions are calculated for the system as being from the distillate receiver based on the condensate volume, composition, and temperature. Additionally, the non-condensable gas flow rate (air leak rate and/or nitrogen) and operating vacuum level must be taken into account. It is assumed that the exiting vent gas from the vacuum receiver is saturated with vapors from the liquid condensate.

The moles of each volatile component in the exit vent gas are calculated using the following relationship.

$$E_{n-i} = E_{n-nc} \frac{P_i}{P_{nc}} \quad (9.15)$$

where:  $E_{n-i}$  = moles of volatile component  $i$  emitted from the process,  
 $E_{n-nc}$  = total moles of noncondensable gas emitted from the process,  
 $P_i$  = partial pressure of volatile component  $i$ ,  
 $P_{nc}$  = partial pressure of the noncondensable gas (i.e. air, nitrogen) at saturated solvent pressure conditions.

$E_{n-nc}$  represents the total moles of non-condensable gas component that are removed from the system by the vacuum pump.

$$E_{n-nc} = E_{n-nc-leakage} + E_{n-nc-displacement} + E_{n-nc-gas\ sweep} \quad (9.16)$$

where:  $E_{n-nc-leakage}$  are the moles of air due to leakage into the system,  
 $E_{n-nc-displacement}$  are the moles of air that are displaced by the condensate,  
 $E_{n-nc-gas\ sweep}$  are the moles of air or nitrogen admitted as a gas sweep.

If the distillation phase has been completed and the receiver continues to hold condensate while remaining under vacuum, then the non-condensable gas flow rate is based on the air leak rate and/or any nitrogen sweep flow that might exist.

In many cases the air leak rate might be expressed in acfm (ft<sup>3</sup>/min at actual temperature and pressure conditions) because it relates to either a known vacuum pump capacity at the 25 mm Hg condition or may have been measured through prior vacuum leak test on the equipment. The nitrogen gas sweep is normally specified in scfm (ft<sup>3</sup>/min at standard temperature and pressure conditions) because it relates to nitrogen gas flow meter that might be used for control purposes.

**Illustration 9: Vacuum operation with vessel filling.**

400 gallons of toluene are distilled from a process mixture under vacuum conditions in 2.5 hours. The equipment consists of a 1000 gallon still, condenser, and 1000 gallon receiver. A liquid ring vacuum is used to reduce the operating pressure of the equipment system to 100 mm Hg. The air leak rate is known to be 10 acfm at these conditions. The condenser is cooled with 5°C chilled glycol and the toluene condensate is measured to be 10°C. Calculate the vent emissions leaving the equipment system.

For this problem, toluene is being collected at 10°C in the receiver and an air leak rate has been specified.

Air leak rate:	10 acfm.
Receiver displacement volume:	400 gallons
Operating pressure:	100 mm Hg.
Vapor pressure of toluene at 10°C:	12.43 mm Hg. Antoine equation
Process time:	2.5 hours

Calculations:

Partial pressure of non-condensable:  $P_{nc} = 100 \text{ mm Hg} - 12.43 \text{ mm Hg} = 87.57 \text{ mm Hg}$ .

Displacement volume in ft<sup>3</sup>:

$$V = \frac{400 \text{ gal}}{7.485 \text{ gal / ft}^3} = 53.44 \text{ ft}^3$$

$$E_{n-nc-displacement} = \frac{p_{nc} V}{RT_{sys}} = \frac{87.57 \text{ mmHg} \cdot 53.44 \text{ ft}^3}{(998.9)(293.15^\circ K)} = 0.25 \text{ lb-moles}$$

Leakage volume in  $\text{ft}^3$ :

$$V_{leakage} = (10 \text{ acfm})(2.5 \text{ hr})(60 \text{ min/hr}) = 1560 \text{ ft}^3$$

$$E_{n-nc-leakage} = \frac{p_{nc} V T_m}{RT_{\circ K}} = \frac{100 \text{ mmHg} \cdot 1560 \text{ ft}^3}{(998.9)(293.15^\circ K)} = 0.53 \text{ lb-moles}$$

Therefore

$$E_{n-nc} = E_{n-nc-leakage} + E_{n-nc-displacement} + E_{n-nc-gas \text{ sweep}}$$

$$E_{n-nc} = 0.53_{n-nc-leakage} + 0.25_{n-nc-displacement} + 0_{n-nc-gas \text{ sweep}} = 0.78 \text{ lb-moles}$$

Finally

$$E_{n-toluene} = E_{n-nc} \frac{p_i}{p_{nc}} = 0.78 \frac{12.47}{87.57} = 0.11 \text{ lb-moles}$$

$$E_{wt-toluene} = E_{n-toluene} M_{wt-toluene} = (0.11 \text{ lb-moles})(92.13 \text{ lb/lb-mole}) = 10.23 \text{ lb}$$

**Illustration 10: Vacuum operation without vessel filling.**

100 gallons of toluene have been collected from a product solids drying operation. The equipment consists of a 200  $\text{ft}^3$  tray drier, condenser, and 250 gallon receiver. A liquid ring vacuum is used to maintain an operating pressure of 25 mm Hg. The air leak rate is known to be 1 acfm under these conditions. For this final phase of the drying operation a 1 scfm nitrogen gas sweep is applied to the tray drier to help accelerate the finally drying phase. Although the distillation phase of the operation has ended, the recovered toluene remains in the receiver and is maintained at  $7^\circ\text{C}$ . Calculate the toluene emissions from the equipment system to the vacuum pump over a 1.0 hour period.

Since the distillation phase has ended the only the air leak rate and nitrogen gas sweep rate needs to be considered.

Air leak rate:	1 acfm.	
Nitrogen gas sweep rate:	1 scfm	
Operating pressure:	25 mm Hg.	
Vapor pressure of toluene at $7^\circ\text{C}$ :	10.40 mm Hg.	Antoine equation

Calculations:

Leakage (air):

$$V_{leakage} = (1 \text{ acfm})(60 \text{ min}) = 60 \text{ ft}^3$$

$$E_{n-nc-leakage} = \frac{p_{nc} V T_m}{RT_{\circ K}} = \frac{25 \text{ mmHg} \cdot 60 \text{ ft}^3}{(998.9)(280.15^\circ K)} = 0.0054 \text{ lb-moles}$$

Gas sweep (nitrogen):

$$V_{\text{gas sweep}} = (1 \text{ scfm})(60 \text{ min}) = 60 \text{ ft}^3 (\text{stp})$$

$$E_{n\text{-nc-gas sweep}} = \frac{P_{\text{stp}} V}{RT_{\text{stp}}} = \frac{760 \text{ mmHg} \cdot 60 \text{ ft}^3}{(998.9)(273.15^\circ \text{K})} = 0.17 \text{ lb-moles}$$

Therefore

$$E_{n\text{-nc}} = E_{n\text{-nc-leakage}} + E_{n\text{-nc-displacement}} + E_{n\text{-nc-gas sweep}}$$

$$E_{n\text{-nc}} = 0.0054_{n\text{-nc-leakage}} + 0_{n\text{-nc-displacement}} + 0.17_{n\text{-nc-gas sweep}} = 0.18 \text{ lb-moles}$$

Finally

$$p_{nc} = P_{\text{sys}} - p_{\text{toluene}} = 25.0 - 10.4 = 14.6 \text{ mmHg}$$

$$E_{n\text{-toluene}} = E_{n\text{-nc}} \frac{p_i}{p_{nc}} = 0.18 \frac{10.40}{14.60} = 0.13 \text{ lb-moles}$$

$$E_{\text{wt-toluene}} = E_{n\text{-toluene}} M_{w_{\text{toluene}}} = (0.13 \text{ lb-moles})(92.13 \text{ lb/lb-mole}) = 11.98 \text{ lb}$$

### 3.4 Gas Evolution

Certain processes generate off gases as a function of the reaction chemistry. Vent emissions from these types of operations may be estimated by assuming that the exit vent off gas containing the reaction off gas is fully saturated with vapors from the volatile components in the batch. The partial pressure of each component is calculated based on the pure component vapor pressure, mixture composition, and any non-idealities that might exist (activity coefficients).

The moles of each volatile component in the exit vent gas are calculated using the following relationship.

$$E_{n-i} = E_{n\text{-rxn}} \frac{p_i}{p_{\text{rxn}}} \quad (9.17)$$

where:  $E_{n-i}$  = moles of volatile component  $i$  emitted from the process,  
 $E_{n\text{-rxn}}$  = total moles of reaction off gas emitted from the process,  
 $p_i$  = partial pressure of volatile component  $i$ ,  
 $p_{\text{rxn}}$  = partial pressure of the noncondensable gas (i.e. air, nitrogen) at saturated solvent pressure conditions.

The stoichiometric amount of off gas is usually determined by the process chemistry. However, other considerations may need to be taken into account when estimating the actual amount of off gas that leaves the system. For example, if the off gas is partially soluble in the process solvent then the portion that does not dissolve in the batch will exit the vessel through the vent. If the solubility of the off gas is not known then one could conservatively assume that 100% of the reaction off gas exits the process through the vessel vent.

#### **Illustration 11: Reaction involving a gas evolution of one component**

A reaction takes place in a vessel at 50°C with toluene as the primary solvent. Eight pounds of hydrogen chloride is generated based on the chemistry and vented out of the vessel over a one-hour period.

Calculate the compound emissions that occur from the reaction, if the system pressure is 760 mm Hg. Also, assume that the batch consists of 95% toluene (mole/mole) and 5% compounds that are nonvolatile.

**Step 1: Determine the hydrogen chloride that is discharged from the vessel.**

$$E_{n-HCl} = \frac{Wt_{HCl}}{MWt_{HCl}} = \frac{8 \text{ lbs}}{36.461 \text{ lb/lb-mole}} = 0.219 \text{ lb-mole}$$

**Step 2: Calculate the vapor pressure of toluene at 50°C using the Antoine equation.**

$$P_{\text{toluene}, 50^{\circ}\text{C}} = \exp\left(16.0137 - \frac{3096.52}{323.15 - 53.67}\right) = \exp(4.52298) = 92.11 \text{ mmHg}$$

$$p_{\text{toluene}, 50^{\circ}\text{C}} = 0.95 \times 92.11 \text{ mmHg} = 87.50 \text{ mmHg}$$

**Step 3: Calculate the toluene emission rate by the ratio of vapor pressures.**

$$E_{n\text{-toluene}} = E_{HCl} \left( \frac{P_{\text{toluene}}}{P_{HCl}} \right)$$

$$E_{n\text{-toluene}} = 0.219 \text{ lb-moles} \left( \frac{87.50 \text{ mmHg}}{760 \text{ mmHg} - 87.50 \text{ mmHg}} \right) = 0.0285 \text{ lb-moles}$$

$$E_{wt\text{-toluene}} = 0.0285 \text{ lb-moles} \times 92.13 \text{ lb/lb-mole}$$

$$E_{wt\text{-toluene}} = 2.63 \text{ lbs}$$

**Illustration 12: Reaction involving gas evolution of two components**

A reaction takes place in a vessel at 50°C with toluene as the primary solvent. Eight pounds of hydrogen chloride along with an equal molar quantity of sulfur dioxide is generated and vented out of the vessel over a one-hour period. Calculate the compound emissions that occur from the reaction, if the system pressure is 760 mm Hg. Also, assume that the batch consists of 95% toluene (mole/mole) and 5% compounds that are nonvolatile.

**Step 1: Determine the hydrogen chloride and sulfur dioxide that is discharged from the vessel**

The molar amount of HCl is calculated from the molecular weight and the quantity of HCL emitted. The molar amount of SO<sub>2</sub> is set equal to the calculated molar amount of HCl.

$$E_{n-HCl} = \frac{Wt_{HCl}}{MWt_{HCl}} = \frac{8 \text{ lbs}}{36.461 \text{ lb/lb-mole}} = 0.219 \text{ lb-mole}$$

$$E_{n-SO_2} = n_{HCl} = 0.219 \text{ lb-moles}$$

$$E_{wt-SO_2} = 0.219 \text{ lb-moles} \times 64.063 \text{ lb/lb-mole} = 14.03 \text{ lbs}$$

**Step 2: Calculate the vapor pressure of toluene at 50°C using the Antoine equation.**

$$P_{\text{toluene}, 50^{\circ}\text{C}} = \exp\left(16.0137 - \frac{3096.52}{323.15 - 53.67}\right) = \exp(4.52298) = 92.11 \text{ mmHg}$$

$$p_{\text{toluene}, 50^{\circ}\text{C}} = 0.95 \times 92.11 \text{ mmHg} = 87.50 \text{ mmHg}$$

**Step 3: Calculate the toluene emission rate by the ratio of vapor pressures.**

$$E_{n\text{-toluene}} = \left( \frac{P_{\text{toluene}}}{P_{\text{HCl}} + P_{\text{SO}_2}} \right) (n_{\text{HCl}} + n_{\text{SO}_2}) = \left( \frac{P_{\text{toluene}}}{P_{\text{sys}} - P_{\text{toluene}}} \right) (n_{\text{HCl}} + n_{\text{SO}_2})$$

$$E_{n\text{-toluene}} = \left( \frac{87.50 \text{ mmHg}}{760 \text{ mmHg} - 87.50 \text{ mmHg}} \right) 0.438 \text{ lb - mole} = 0.057 \text{ lb - moles}$$

$$E_{\text{wt-toluene}} = 0.057 \text{ lb - moles} \times 92.13 \text{ lb / lb - mole}$$

$$E_{\text{wt-toluene}} = 5.26 \text{ lbs}$$

$$E_{\text{wt-HCl}} = 8.0 \text{ lbs}$$

$$E_{\text{wt-SO}_2} = 14.03 \text{ lbs}$$

**Illustration 13: Reaction involving multicomponent gas evolution and nitrogen purge**

A reaction takes place over a 1.0 hour period in a vessel at 50°C with toluene as the primary solvent. Eight pounds of hydrogen chloride along with an equal molar quantity of sulfur dioxide is generated and vented out of the vessel over a one-hour period. Calculate the compound emissions that occur from the reaction, if the system pressure is 760 mm Hg and a nitrogen purge is being applied at 30 SCFH. Also, assume that the batch consists of 95% toluene (mole/mole) and 5% compounds that are nonvolatile.

**Step 1: Determine the hydrogen chloride, sulfur dioxide, and nitrogen that are discharged from the vessel over the one hour period. The molar amount of HCl is calculated from the molecular weight and the quantity of HCL emitted. The molar amount of SO<sub>2</sub> is set equal to the calculated molar amount of HCl.**

$$E_{n\text{-HCl}} = \frac{Wt_{\text{HCl}}}{MW_{\text{HCl}}} = \frac{8 \text{ lbs}}{36.461 \text{ lb / lb - mole}} = 0.219 \text{ lb - mole}$$

$$E_{n\text{-SO}_2} = n_{\text{HCl}} = 0.219 \text{ lb - moles}$$

$$E_{\text{wt-SO}_2} = 0.219 \text{ lb - moles} \times 64.063 \text{ lb / lb - moles} = 14.03 \text{ lbs}$$

The molar amount of N<sub>2</sub> is calculated based on the 30 SCFH (standard cubic feet per hour) flow rate or nitrogen for the 1.0 hour reaction period.

$$E_{n\text{-N}_2} = \frac{30.0 \text{ SCFH} \times 1.0 \text{ HR}}{359.046 \text{ SCF / lb - mole}} = 0.084 \text{ lb - mole}$$

$$E_{\text{wt-N}_2} = 0.084 \text{ lb - moles} \times 28.013 \text{ lb / lb - moles} = 2.35 \text{ lbs}$$

The total moles of non-condensable compounds are calculated by summing the molar amounts of HCl, SO<sub>2</sub>, and N<sub>2</sub>.

$$E_{n\text{-nc}} = E_{n\text{-HCl}} + E_{n\text{-SO}_2} + E_{n\text{-N}_2} = 0.219 + 0.219 + 0.084$$

$$E_{n\text{-nc}} = 0.522 \text{ lb - moles}$$



**Step 2: Calculate the vapor pressure of toluene at 50°C using the Antoine equation.**

$$P_{\text{toluene}, 50^{\circ}\text{C}} = \exp\left(16.0137 - \frac{3096.52}{323.15 - 53.67}\right) = \exp(4.52298) = 92.11 \text{ mmHg}$$

$$P_{\text{toluene}, 50^{\circ}\text{C}} = 0.95 \times 92.11 \text{ mmHg} = 87.50 \text{ mmHg}$$

**Step 3: Calculate the toluene emission rate by the ratio of vapor pressures.**

$$E_{n\text{-toluene}} = \left(\frac{P_{\text{toluene}}}{\sum P_{nc}}\right) E_{n\text{-nc}} = \left(\frac{P_{\text{toluene}}}{P_{\text{sys}} - P_{\text{toluene}}}\right) E_{n\text{-nc}}$$

$$E_{n\text{-toluene}} = \left(\frac{87.50 \text{ mmHg}}{760 \text{ mmHg} - 87.50 \text{ mmHg}}\right) 0.522 \text{ lb - mole} = 0.13 \text{ lb - moles}$$

$$E_{\text{wt-toluene}} = 0.13 \text{ lb - moles} \times 92.13 \text{ lb / lb - mole}$$

$$E_{\text{wt-toluene}} = 11.98 \text{ lbs}$$

$$E_{\text{wt-HCl}} = 8.0 \text{ lbs}$$

$$E_{\text{wt-SO}_2} = 14.03 \text{ lbs}$$

$$E_{\text{wt-N}_2} = 2.35 \text{ lbs}$$

### 3.5 Depressurization

Estimating solvent emissions from the depressurization of a batch pressure filter for solids discharge or for the evacuation of a vessel that contains a volatile liquid mixture and a noncondensable gas-phase component, such as air or nitrogen, requires certain assumptions and approximations be made:

- The system pressure is decreased linearly over time.
- Air leakage into the vessel during the operation is negligible.
- The liquid and gas space temperature remains constant during the operation.
- The vapor space of the vessel remains in equilibrium with the volatile liquid contents during the depressurization process.

Since the system temperature is assumed to remain constant during the depressurization operation then the equilibrium vapor pressure of the vessel liquid contents remains constant as well. The moles of solvent vapor that exist within the vessel headspace during the depressurization remain constant for this reason. However, the volatile solvent vapor occupies a greater fraction of the vessel headspace and exit vent gas as the depressurization takes place since the system pressure is being reduced toward the solvent vapor pressure level. As the depressurization unfolds then more and more solvent must evaporate in order to maintain the equilibrium vapor pressure. Therefore, the solvent emissions that occur during depressurization are equal to the net solvent evaporation within the vessel, based on the assumptions for this model.

Eq-9.17 is based on a material balance for the non-condensable in the vessel headspace and the assumption that the total system pressure is equal to the partial pressure of the volatile plus the partial

pressure of the non-condensable. Eq-9.17 may be integrated as shown in Eq-9.18 to result in Eq-9.19. .  
[Hatfield, 1998b]

$$dn_i(out) = -\left(\frac{V}{RT}\right) \frac{p_i}{p_{nc}} dp_{nc} \quad (9.18)$$

$$\int_A^{p_2} dn_i(out) = -\left(\frac{Vp_i}{RT}\right) \int_{T,V}^{p_2} \frac{dp_{nc}}{p_{nc}} \quad (9.19)$$

$$n_{i,out} = \frac{Vp_i}{RT} \ln\left(\frac{p_{nc,1}}{p_{nc,2}}\right) \quad (9.20)$$

where:  $n_{i,out}$  = moles of volatile component  $i$  leaving the vessel

$V$  = vessel headspace volume

$p_i$  = partial pressure of the volatile component

$R$  = Universal gas constant

$T$  = system temperature

$p_{nc,1}$  = partial pressure of the non-condensable component at initial conditions

$p_{nc,2}$  = partial pressure of the non-condensable component at final conditions

#### Illustration 14: Vessel depressurization involving one volatile component

A 1,000 gallon nutsche filter is used to compress a slurry containing acetone and nonvolatile solids at 80°F (26.7°C). A pressure of 35 psig is imparted onto the slurry until the desired filtration is achieved (approximately 40 minutes). The nutsche filter is then depressurized prior to the discharging of its contents. Residual solids in the filter are estimated to occupy 500 gallons of the filter volume. Calculate the acetone emissions from the depressurization operation.

Given:

T	=	26.7°C	=	299.85°K	
P1	=	35 psig	=	2570 mm Hg	(Initial pressure)
P2	=	0.0 psig	=	760 mm Hg	(Final pressure)
V	=	500 gal	=	66.843 ft <sup>3</sup>	(Gas space volume)

**Step 1. Determine the saturated vapor pressure for acetone at 26.7°C and the non-condensable partial pressure at initial ( $P_{nc,1}$ ) and final conditions ( $P_{nc,2}$ ).**

$$p_{acetone, 26.7^\circ C} = \exp\left(16.6513 - \frac{2940.46}{299.85 - 35.93}\right) = \exp(5.5098) = 247.11 \text{ mmHg}$$

Therefore:

$$P_{nc,1} = (2570 - 247.11) = 2,322.89 \text{ mm Hg}$$

$$P_{nc,2} = (760 - 247.11) = 512.89 \text{ mm Hg}$$

**Step 2. Calculate the amount of acetone vapor that is emitted from the depressurization operation.**

$$E_{n-\text{acetone}} = \frac{Vp_i}{RT} \ln \left( \frac{p_{nc,1}}{p_{nc,2}} \right) = \frac{(66.843)(247.11)}{(998.9)(300)} \ln \left( \frac{2322.89}{512.89} \right) = 0.0827 \text{ lb-moles}$$

$$E_{wt-\text{acetone}} = (0.0827 \text{ lb-moles}) (58.08 \text{ lb/lb-mole}) = 4.8 \text{ lbs}$$

**Illustration 15: Vessel depressurization involving a solvent mixture**

A 1,200 gallon process vessel contains 700 gallons of solvent mixture that is being prepared for vacuum distillation. The solvent mixture is at 20°C and has a molar composition of 20% acetone, 50% toluene, and 30% methanol. Calculate the emissions from the depressurization operation if the pressure is reduced from 760 mm Hg to 100 mm Hg.

Given:

T	=	20.0°C	=	293.15°K	
P1	=	760 mm Hg			(Initial pressure)
V	=	500 gal	=	66.843 ft <sup>3</sup>	(Gas space volume)

Universal Gas Constant:  $R = 998.9 \frac{\text{mmHg} \cdot \text{ft}^3}{\text{lb-mole} \cdot ^\circ\text{K}}$

Gas Law:  $n = \frac{PV}{RT}$ , also  $n_i = \frac{p_i V}{RT}$  for a single component,  $i$ , in the gas space.

**Step 1. Determine the saturated vapor pressure composition for the process material at 25°C.**

For this illustration the equilibrium vapor pressure composition for the process mixture may be calculated based on the pure vapor pressure and mole fraction of each component in the mixture. The total saturated vapor pressure for the mixture is calculated to be 77.08 mm Hg. as shown in the following table.

Compound	Pure Vapor Pressure (mm Hg)	Mole Fraction $X_i$	$P_i = X_i \cdot P_i$ (mm Hg)
Acetone	184.86	0.2	36.97
Methanol	97.30	0.3	29.19
Toluene	21.84	0.5	10.92
Total			77.08

$$E_{n-\text{acetone}} = \frac{Vp_i}{RT} \ln \left( \frac{p_{nc,1}}{p_{nc,2}} \right) = \frac{(66.843)(36.97)}{(998.9)(293.15)} \ln \left( \frac{682.92}{22.92} \right) = 0.0286 \text{ lb-moles}$$

$$E_{n-\text{methanol}} = \frac{Vp_i}{RT} \ln \left( \frac{p_{nc,1}}{p_{nc,2}} \right) = \frac{(66.843)(29.19)}{(998.9)(293.15)} \ln \left( \frac{682.92}{22.92} \right) = 0.0226 \text{ lb-moles}$$

$$E_{n-\text{toluene}} = \frac{Vp_i}{RT} \ln \left( \frac{p_{nc,1}}{p_{nc,2}} \right) = \frac{(66.843)(10.92)}{(998.9)(293.15)} \ln \left( \frac{682.92}{22.92} \right) = 0.0085 \text{ lb-moles}$$

### 3.6 Heating

Heat-up losses that occur during the operation of reactors, distillation equipment, and similar types of processing equipment may be estimated by application of the Ideal Gas Law and vapor-liquid equilibrium principles. Emissions are calculated using the following assumptions:

The vessel is closed during the operation but vapors are vented through a process vent. Additional material is not added to the vessel during heat-up. The displaced gas is assumed to be saturated with VOC vapor in equilibrium with the process material.

When a vessel containing a volatile liquid and a noncondensable gas (e.g. air) is heated at constant pressure, the vapor space gas undergoes expansion and a portion of the gas phase leaves the vessel through the vent. Additionally, the saturated vapor pressures for the volatile liquid components increase. The calculation is based on the premise that the amount of the non-condensable component (air, nitrogen, etc.) that is displaced from the vessel is determined by the initial and final gas space composition. If a nitrogen purge or sweep is placed on the vessel during the heating step, then the amount of non-condensable component that is displaced from the vessel is increased by the total amount of purge gas that passes through the vessel during the heating.

In the heating model, rising vapors from the vessel liquid contents displace the non-condensable gas components from the headspace through the process vent. As the liquid mixture reaches the boiling point, all of the non-condensable component is purged from the vapor space. This model assumes that the average molar headspace volume remains constant relative to changes in the molar composition of the vessel headspace. Eq-9.20 is derived from performing material balances around the vessel headspace for the non-condensable component and for component  $i$  during the heating. [Hatfield, 1998c]

$$E_{n-i,out} = N_{avg} \ln \left( \frac{p_{nc,1}}{p_{nc,2}} \right) - (n_{i,2} - n_{i,1})_{vessel} \quad (9.21)$$

where:

$$N_{avg} = \frac{1}{2}(n_1 + n_2) \quad (9.22)$$

$n_{i,out}$  = moles of volatile component  $i$  leaving the vessel process vent

$N_{avg}$  = average gas space molar volume during the heating process

$p_{nc1}$  = partial pressure of non-condensable in the vessel headspace at temperature  $T_1$

$p_{nc2}$  = partial pressure of non-condensable in the vessel headspace at temperature  $T_2$

$n_{i,1}$  = moles of volatile component  $i$  in the vessel headspace at temperature  $T_1$

$n_{i,2}$  = moles of volatile component  $i$  in the vessel headspace at temperature  $T_2$

$n_1$  = total moles of gas in the vessel headspace at temperature  $T_1$

$n_2$  = total moles of gas in the vessel headspace at temperature  $T_2$

**Illustration 16: Heatup losses from a vessel containing a single volatile component.**

A 1250 gallon reactor containing 750 gallons of a toluene solution is heated from 20°C to 70°C. The reactor is vented to the atmosphere during the heat up. How much toluene will be emitted?

**Step 1. Calculate the average molar volume of the vessel headspace.**

$T_i$	=	20°C	=	293.15°K	(Initial temperature)
$T_f$	=	70°C	=	343.15°K	(Final temperature)
$P_T$	=	1.0 atm	=	760 mm Hg	(Total system pressure)
$V_{\text{gas}}$	=	500 gallons	=	66.843 ft <sup>3</sup>	(Gas space volume)
$R$	=	998.9 (mmHg-ft <sup>3</sup> )/(lb-mole-°K)			(Universal gas constant)

Gas Law:  $n = \frac{PV}{RT}$ , also  $n_i = \frac{p_i V}{RT}$  for a single component,  $i$ , in the gas space.

$$N_{\text{avg}} = \frac{1}{2}(n_1 + n_2)$$

$$N_{\text{avg}} = \frac{1}{2} \left[ \left( \frac{PV}{RT} \right)_1 + \left( \frac{PV}{RT} \right)_2 \right] = \frac{760 \times 66.843}{2 \times 998.9} \left( \frac{1}{293.15} + \frac{1}{343.15} \right) = 0.1608 \text{ lb-moles}$$

**Step 2. Calculate the initial and final partial pressures of nitrogen.**

Use the Antoine equation to calculate the partial pressure of toluene:

$$P_{\text{toluene}, 20^\circ\text{C}} = \exp \left( 16.0137 - \frac{3096.52}{293.15 - 53.67} \right) = \exp(3.0835) = 21.84 \text{ mmHg}$$

$$P_{\text{toluene}, 70^\circ\text{C}} = \exp \left( 16.0137 - \frac{3096.52}{343.15 - 53.67} \right) = \exp(5.317) = 203.74 \text{ mmHg}$$

The partial pressure of nitrogen is the difference between the total system pressure and the partial pressure of toluene:

$$p_{nc,1} = 760 - p_{\text{toluene},1} = 760 - 21.84 = 738.16 \text{ mmHg}$$

$$p_{nc,2} = 760 - p_{\text{toluene},2} = 760 - 203.74 = 556.26 \text{ mmHg}$$

**Step 3: Calculate the initial and final number of moles of toluene in the vessel headspace.**

Use the Gas Law to calculate the moles of toluene:

$$n_{\text{toluene},1} = \left( \frac{p_{\text{toluene},1} V}{RT_1} \right) = \frac{21.84 \times 66.843}{998.9 \times 293.15} = 0.00499 \text{ moles}$$

$$n_{\text{toluene},2} = \left( \frac{p_{\text{toluene},2} V}{RT_2} \right) = \frac{203.74 \times 66.843}{998.9 \times 343.15} = 0.0397 \text{ moles}$$

**Step 4: Calculate the toluene emission using Eq-9.20.**

The moles of toluene that are displaced from the vessel are calculated by substituting values that have been calculated prior to this point into Eq-9.20.

$$E_{n-i} = N_{avg} \ln \left( \frac{p_{nc,1}}{p_{nc,2}} \right) - (n_{i,2} - n_{i,1})_{vessel}$$

$$E_{n-toluene} = (0.1608) \ln \left( \frac{738.16}{556.26} \right) - (0.0397 - 0.00499) = 0.0108 \text{ lb - moles}$$

$$E_{wt-toluene} = (0.0108 \text{ lb - moles})(92.13 \text{ lb / lb - mole}) = 0.995 \text{ lbs}$$

**Illustration 17: Heatup losses from a vessel containing a volatile mixture.**

A 2000 gallon reactor contains 1,500 gallons of a solvent mixture. The solvent mixture has a molar composition of 60% toluene, 30% methyl ethyl ketone, and 10% methylene chloride.

The solvent mixture is heated from 20°C to 70°C and the reactor is vented to atmosphere (760 mm Hg) during the heat up operation. How much of each component will be emitted from the process?

**Step 1: Calculate the gas space partial pressure for each compound in the liquid using Raoult's Law and residual partial pressure of nitrogen.**

**Table Containing Partial Pressure Calculates for 20°C and 70°C.**

Compound	X <sub>i</sub>	P <sub>i</sub> @ 20C (mm Hg)	X <sub>i</sub> P <sub>i</sub> (20C) (mm Hg)	P <sub>i</sub> @ 70C (mm Hg)	X <sub>i</sub> P <sub>i</sub> (70C) (mm Hg)
Toluene	0.60	21.835	13.101	203.74	122.25
Methyl Ethyl Ketone	0.30	74.908	22.472	555.52	166.66
Methylene Chloride	0.10	355.540	35.554	2005.2	200.52
Totals	1.00		71.127		489.43
			(mm Hg)		(mm Hg)
Nitrogen (Residual)			688.873		270.57

**Step 2: Calculate the average gas space molar volume.**

$$N_{avg} = \frac{1}{2}(n_1 + n_2)$$

$$N_{avg} = \frac{1}{2} \left[ \left( \frac{PV}{RT} \right)_1 + \left( \frac{PV}{RT} \right)_2 \right] = \left( \frac{760 \times 66.843}{2 \times 998.9} \right) \left( \frac{1}{293.15} + \frac{1}{343.15} \right) = 0.1608 \text{ lb - moles}$$

**Step 3: Calculate the initial and final number of moles of toluene in the vessel headspace.**

Use the Gas Law to calculate the moles of toluene:

$$n_{i,1} = \left( \frac{p_{i,1}V}{RT_1} \right) = \frac{71.12 \times 66.843}{998.9 \times 293.15} = 0.01623 \text{ moles}$$

$$n_{i,2} = \left( \frac{p_{i,2}V}{RT_2} \right) = \frac{489.43 \times 66.843}{998.9 \times 343.15} = 0.09544 \text{ moles}$$

$$E_{n-i} = N_{avg} \ln \left( \frac{p_{nc,1}}{p_{nc,2}} \right) - (n_{i,2} - n_{i,1})_{vessel}$$

$$E_{n-i} = (0.1608) \ln \left( \frac{688.873}{270.57} \right) - (0.09544 - 0.01623) = 0.07106 \text{ lb-moles}$$

Table Containing the Final Calculated Results for this problem.

Compound	avg $p_i$ (mm Hg)	Fraction To total	$n_i$ (lb-moles)	MW $t_i$	wt $t_i$ (lbs)
Toluene	67.67	0.242	0.0172	92.13	1.58
Methyl Ethyl Ketone	94.566	0.337	0.0240	72.1	1.73
Methylene Chloride	118.037	0.421	0.02992	84.94	2.54
Totals	280.273	1.000	0.0687		

**Illustration 18: Heatup losses from a vessel with a volatile mixture and nitrogen sweep**

A 1250 gallon reactor containing 750 gallons of a solution of a raw material in toluene is heated from 20°C to 70°C over a one hour period. The vessel has a known gas sweep of 3 scfm of air. The reactor is vented to the atmosphere during the heat up. Assuming a 25% vapor saturation of the gas sweep vapors, how much toluene will be emitted?

This problem differs from the prior heating illustration because we wish to take into account air or nitrogen that is entering the head space of the vessel during the operation. The basic approach used is to first calculate the vent losses of toluene and air (as in the prior example) and then calculate the total toluene losses based on the relative net change in the exit air flow rate due to the gas sweep while at the same time taking into account the saturation level.

**Step 1. Calculate the average molar volume of the vessel headspace.**

$$\begin{aligned} T_i &= 20^\circ\text{C} = 293.15^\circ\text{K} && \text{(Initial temperature)} \\ T_f &= 70^\circ\text{C} = 343.15^\circ\text{K} && \text{(Final temperature)} \\ P_T &= 1.0 \text{ atm} = 760 \text{ mm Hg} && \text{(Total system pressure)} \\ V_{\text{gas}} &= 500 \text{ gal} = 66.843 \text{ ft}^3 && \text{(Gas space volume)} \\ R &= 998.9 \text{ (mmHg-ft}^3\text{)/(lb-mole-}^\circ\text{K)} && \text{(Universal gas constant)} \end{aligned}$$

Gas Law:  $n = \frac{PV}{RT}$ , also  $n_i = \frac{p_i V}{RT}$  for a single component,  $i$ , in the gas space.

$$N_{avg} = \frac{1}{2}(n_1 + n_2)$$

$$N_{avg} = \frac{1}{2} \left[ \left( \frac{PV}{RT} \right)_1 + \left( \frac{PV}{RT} \right)_2 \right] = \frac{760 \times 66.843}{2 \times 998.9} \left( \frac{1}{293.15} + \frac{1}{343.15} \right) = 0.1608 \text{ lb-moles}$$

**Step 2. Calculate the initial and final partial pressures of nitrogen.**

Use the Antoine equation to calculate the partial pressure of toluene:

$$P_{\text{toluene}, 20^{\circ}\text{C}} = \exp\left(16.0137 - \frac{3096.52}{293.15 - 53.67}\right) = \exp(3.0835) = 21.84 \text{ mmHg}$$

$$P_{\text{toluene}, 70^{\circ}\text{C}} = \exp\left(16.0137 - \frac{3096.52}{343.15 - 53.67}\right) = \exp(5.317) = 203.74 \text{ mmHg}$$

The partial pressure of nitrogen is the difference between the total system pressure and the partial pressure of toluene:

$$p_{nc,1} = 760 - p_{\text{toluene},1} = 760 - 21.84 = 738.16 \text{ mmHg}$$

$$p_{nc,2} = 760 - p_{\text{toluene},2} = 760 - 203.74 = 556.26 \text{ mmHg}$$

**Step 3: Calculate the initial and final number of moles of toluene and air in the vessel headspace.**

Use the Gas Law to calculate the moles of toluene and air:

$$n_{\text{toluene},1} = \left(\frac{p_{\text{toluene},1} V}{RT_1}\right) = \frac{21.84 \times 66.843}{998.9 \times 293.15} = 0.00499 \text{ moles}$$

$$n_{nc,1} = \left(\frac{p_{nc,1} V}{RT_1}\right) = \frac{738.16 \times 66.843}{998.9 \times 293.15} = 0.1685 \text{ moles}$$

$$n_{\text{toluene},2} = \left(\frac{p_{\text{toluene},2} V}{RT_2}\right) = \frac{203.74 \times 66.843}{998.9 \times 343.15} = 0.0397 \text{ moles}$$

$$n_{nc,2} = \left(\frac{p_{nc,2} V}{RT_2}\right) = \frac{556.26 \times 66.843}{998.9 \times 343.15} = 0.1085 \text{ moles}$$

**Step 4: Calculate the toluene emission using Eq-9.20.**

The number of moles of toluene displaced from the vessel is equal to the moles of nitrogen that are displaced from the vessel during the heating operation multiplied by the average molar ratio.

$$E_{n-i} = N_{\text{avg}} \ln\left(\frac{p_{nc,1}}{p_{nc,2}}\right) - (n_{i,2} - n_{i,1})_{\text{vessel}}$$

$$E_{n-\text{toluene}} = (0.1608) \ln\left(\frac{738.16}{556.26}\right) - (0.0397 - 0.00499) = 0.0108 \text{ lb - moles}$$

$$E_{\text{wt-toluene}} = (0.0108 \text{ lb - moles})(92.13 \text{ lb / lb - mole}) = 0.995 \text{ lbs}$$

**Step 5: Calculate the emission of air without the gas sweep present.**

$$E_{n-nc} = n_{nc,1} - n_{nc,2} = 0.1685 - 0.1085 = 0.06 \text{ moles}$$

**Step 6: Calculate the moles of gas sweep.**

$$E_{n-\text{gas sweep}} = \left[\frac{760 \times (3 \text{ scfm} \times 60 \text{ min})}{998.9 \times 273.15}\right] = 0.501 \text{ moles air}$$



**Step 7: Calculate the toluene emissions while taking the gas sweep into account with a 25% saturation level.**

$$E_{n\text{-toluene}} = \left( \frac{0.06 + (0.25 \times 0.501)}{0.06} \right) \times 0.0108 = 3.08 \times 0.0108 = 0.0333 \text{ lb moles}$$

$$E_{wt\text{-toluene}} = (0.0333 \text{ lb - moles})(92.13 \text{ lb / lb - mole}) = 3.068 \text{ lbs}$$

$$E_{n\text{-nc}} = 0.06 + 0.501 = 0.561 \text{ lb - moles}$$

$$E_{wt\text{-nc}} = (0.561 \text{ lb - moles})(28.97 \text{ lb / lb - mole}) = 16.25 \text{ lbs}$$

### 3.7 Evaporation Models

#### 3.7.1 Evaporation From an Open Top Vessel or a Spill

The rate of vaporization of a liquid can be modeled as a function of several characteristic factors of the compound being considered. [Crowl & Louvar, 2002]

$$E_{n-i} = \frac{M_i K_i A (P_i^{sat} - P_i)}{RT_L} \quad (9.23)$$

where  $E_n$  is the evaporation rate (mass/time),  
 $M_i$  is the molecular weight of the volatile substance,  
 $K_i$  is a mass transfer coefficient (length/time),  
 $A$  is the evaporation surface area,  
 $P_i^{sat}$  is the saturated solvent vapor pressure,  
 $P_i$  is the actual vapor pressure near the liquid surface,  
 $R$  is the ideal gas constant, and  
 $T_L$  is the absolute temperature of the liquid.

For many cases,  $P_{sat} \gg p$ , and Eq-9.22 may be simplified to

$$E_{n-i} = \frac{M_i K_i A P_i^{sat}}{RT_L} \quad (9.24)$$

Eq-9.23 may be used to estimate the vaporization rate of a volatile liquid from an open vessel or a liquid spill.

The ratio of the mass transfer coefficients between the compound of interest  $K$  and reference compound  $K_o$  is expressed as follows:

$$\frac{K_i}{K_o} = \left( \frac{D_i}{D_o} \right)^{2/3} \quad (9.25)$$

The gas-phase diffusion coefficient  $D$  for a compound is estimated from the ratio of molecular weight of the compound of interest and a known compound (normally water) as follows:

$$\frac{D_i}{D_o} = \left( \frac{M_o}{M_i} \right)^{1/2} \quad (9.26)$$

Combining Eq-9.24 and Eq-9.25 results in a relationship that can be used to estimate the mass transfer coefficient of a given volatile compound.

$$K_i = K_o \left( \frac{M_o}{M_i} \right)^{1/3} \quad (9.27)$$

Water is commonly used as a base reference for estimating the mass transfer coefficient for many compounds of interest. The mass transfer coefficient of water at 77 F and 760 mm Hg. is 0.83 cm/s.

**Illustration 19: Evaporation from a vessel with an open top.**

A large open top vertical tank with a 6-ft diameter contains heptane. Estimate the evaporation rate from the tank at 25 C and 1 atm pressure.

The molecular weight of heptane is 100.2. The mass transfer coefficient is estimated using Eq-9.24 with the known mass transfer coefficient for water of 0.83 cm/s.

$$K_i = K_o \left( \frac{M_o}{M_i} \right)^{1/3} = 0.83 \frac{cm}{s} \left( \frac{18.02}{100.2} \right)^{1/3} = 0.4685 \frac{cm}{s} \times \frac{3600 \cdot s \cdot ft}{30.48 \cdot hr \cdot cm} = 55.33 \frac{ft}{hr}$$

$$P_{heptane}^{sat} = 45.86 mmHg.$$

$$A = \frac{\pi d^2}{4} = \frac{3.14 \cdot 36 ft^2}{4} = 28.26 ft^2$$

$$E_{n-i} = \frac{M_i K_i A P_i^{sat}}{RT_L} = \frac{(100.2 lb / lb - mole)(55.33 ft / hr)(28.26 ft^2)(45.86 mmHg)}{(998.9 ft^3 atm / lb - mol^{\circ}K)(298.15^{\circ}K)}$$

$$E_{wt-i} = 24.42 lb / hr$$

**Illustration 20: Evaporation losses from a spill.**

Toluene is spilled onto the ground outside of a building. Determine the toluene evaporation rate based on the following data:

The ambient temperature (T) is 25°C or 298.15°K. ( °K = °C + 273.15)

The surface area (A) of the spill is 100 ft<sup>2</sup>.

The molecular weight of toluene is 92.13 lb/lb-mole.

The vapor pressure of toluene is 28.445 mm Hg.

$$K_i = K_o \left( \frac{M_o}{M_i} \right)^{1/3} = 0.83 \frac{cm}{s} * \left( \frac{18.02}{92.13} \right)^{1/3} = 0.58 \frac{cm}{s} \times \frac{3600 \cdot s \cdot ft}{30.48 \cdot hr \cdot cm} = 68.50 \frac{ft}{hr}$$

$$E_{n-i} = \frac{M_i K_i A P_i^{sat}}{RT_L} = \frac{(92.13 lb / lb - mole)(68.50 ft / hr)(100.0 ft^2)(28.44 mmHg)}{(998.9 ft^3 mmHg / lb - mol^{\circ}K)(298.15^{\circ}R)}$$

$$E_{n-i} = 60 lb / hr$$

### 3.8 Emission Model for Liquid Material Storage

The preferred method for calculating emissions from storage tanks is the use of equations presented in AP-42. EPA has developed a software package (TANKS) for calculating these types of emissions. The reader is referred to Chapter 1 of this volume, *Introduction to Stationary Point Source Emissions Inventory Development*, for more information on using the TANKS program. Additionally, the reader should consult their state agency and/or the EPA's Clearinghouse for Inventories and Emission Factors (CHIEF) website for the most recent version of TANKS.

### 3.9 Emission Model for Wastewater Treatment

VOC emissions from a wastewater treatment system may be estimated using equations presented in Air Emissions Models for Waste and Wastewater (EPA, 1994a), and Chapter 5, Preferred and Alternative Methods for Estimating Air Emissions from Wastewater Collection and Treatment Facilities, of this volume. These documents, as well as models such as WATER9 are available on the EPA's CHIEF website.

### 3.10 Using Sampling and Test Data to Validate Emission Studies

Use of stack and/or industrial hygiene test data is likely to be the most accurate method of quantifying air emissions from chemical manufacturing operations. However, collection and analysis of air samples from manufacturing facilities can be very expensive and especially complicated for chemical manufacturing facilities where a variety of VOCs are emitted and where most of the emissions may be fugitive in nature. Test data from one specific process may not be representative of the entire manufacturing operation and may provide only one example (a snapshot) of the facility's emissions.

To be representative, test data would need to be collected over a period of time that covers production of multiple chemical formulations. It may be necessary to sample multiple production areas. In addition, these methods do not address fugitive emissions that occur outside of a building. If testing is performed, care should be taken to ensure that a representative operational cycle has been selected. If possible, full cycles should be monitored as opposed to portions of cycles.

For example, in some facilities the typical process vessel used in mixing or dispersion operations may have hinged lids or other covers that are loosely fitting. Additionally, these vessels may have top mounted agitators that can be raised or lowered depending upon mixing elevation requirements. A gas tight agitator seal may not be practical for this type of process vessel. In other cases, the mixing vessel may have a completely open top. Quantifying the gas sweep rate and volatile vapor saturation level for the overall emission process would not be possible in these cases. Developing a reliable emission model using classic modeling techniques presented in this document may not be reliable in this case.

US EPA Method 204D (Fugitive VOCs from Temporary Total Enclosure) may be used as a means of quantifying air emissions from specific equipment systems for one or more processes. Results from temporary total enclosure testing is considered to be more accurate than from using standardized emission models since the data is from accurate measurement sources. The results from validated emission measurement studies can be used in developing emission standards that in turn can be used to estimate emissions from partial or complete production operations.

**Illustration 21: Using emission measurements to represent production operations**

A large mixing tank is used as part of a solvent blending operation. The vessel has a flat lid that contains several smaller hinged covers for hand holes and charge shoots. Additionally, the vessel has an agitator but no agitator seal. The tank vent is loosely connected to a large duct system that is powered by a remote exhaust fan near the roof. The exhaust manifold is monitored for air flow rate and solvent concentration using standardized instrumental analysis. During the time of testing the atmospheric pressure is measured to be 760 mm Hg (1.0 atm). The flow rate and temperature of the exhaust gas are measured to be 10 ft<sup>3</sup>/min (or 600 ft<sup>3</sup>/hr) and 25°C, respectively. Analytical measurements made during the process operation show the toluene and heptane content to be 2.8 mm Hg and 3.7 mm Hg in the exhaust gas, respectively. Calculate the average toluene and heptane emission rate during this process operation.

Using the partial pressure for each compound in conjunction with the ideal gas law and exhaust gas flow rate the following expression can be used to calculate the emission rate for a given pollutant.

$$Q_i = \frac{M_i p_i F}{RT}$$

where  $M_i$  = molecular weight of the pollutant,

$p_i$  = partial pressure of the pollutant in mm Hg,

$F$  = exhaust gas flow rate in ft<sup>3</sup>/hr,

$T$  = exhaust gas temperature in °K,

$R$  = universal gas constant for mm Hg, ft<sup>3</sup>, and °K.

$$\text{For Toluene: } Q_{\text{toluene}} = \frac{M_{\text{toluene}} p_{\text{toluene}} F}{RT} = \frac{92.13 * 2.8 * 600}{998.9 * 298.15} = 5.2 \frac{\text{lbs}}{\text{hr}}$$

$$\text{For Heptane: } Q_{\text{heptane}} = \frac{M_{\text{heptane}} p_{\text{heptane}} F}{RT} = \frac{100.21 * 3.7 * 600}{998.9 * 298.15} = 7.5 \frac{\text{lbs}}{\text{hr}}$$

Note that the actual concentration and temperature of the process mixture that is contained in the process vessel are not required in this calculation since the emissions from the process are being entirely characterized from the analysis of the exhaust gas from the system. Also, it is important that only the process being studied be in operation during the measurement study and that contaminants from other parts of the facility not be present.

**Correlating Standard Emission Models to Test Results**

Results from total enclosure testing can then be used to correlate with conventional batch modeling formulas. Process variables such as vessel gas sweep rate and/or saturation levels may be estimated based on the test data.

For example, Eq-9.27 relates the evaporation rate for a volatile compound *i* within a vessel to its molecular weight, mass transfer coefficient, surface area, and other known variables. [Crowl & Louvar, 2002]

$$Q_m = \frac{MKA}{RT} (P_i^{Sat} - p_i) \quad (9.28)$$

where  $Q_m$  = evaporation rate (lb/min)  
 $M$  = molecular weight of compound *i*  
 $K$  = mass transfer coefficient (ft/min)  
 $A$  = surface area (ft<sup>2</sup>)  
 $R$  = ideal gas constant  
 $T$  = temperature of liquid  
 $P^{Sat}$  = saturated vapor pressure of compound *i*  
 $p_i$  = actual vapor pressure of compound *i* next to the liquid surface.

Eq-9.28 is the basic equation for calculating the emission rate for compound *i* from a gas sweep or purge operation based on the exit gas flow rate, partial pressure of compound *i*, molecular weight, and other known variables.

$$Q_v = \frac{FP_T}{RT} \frac{p_i}{P_T} M = \frac{MFp_i}{RT} \quad (9.29)$$

where  $Q_v$  = emissions from vessel vent (lb/min)  
 $F$  = exit gas flow rate (ft<sup>3</sup>/min)  
 $P_T$  = overall system pressure  
 $R$  = ideal gas constant  
 $T$  = temperature of liquid  
 $p_i$  = actual vapor pressure of compound *i*.  
 $M$  = molecular weight of compound *i*.

For a vessel at steady state conditions, the emission rate from the gas sweep activity is equal to the evaporation rate or compound *i* from the liquid within the vessel. [Hatfield, 2003a] These two equations can be set equal and solved for the saturation level  $S_i$  as follows:

$$Q_m = Q_v$$

Substitute basic expressions

$$\frac{MKA}{RT} (P_i^{Sat} - p_i) = \frac{MFp_i}{RT}$$

Cancel out common terms

$$KA(P_i^{Sat} - p_i) = Fp_i$$

Expand expression

$$KAP_i^{Sat} - KAp_i = Fp_i$$

Rearrange terms

$$KAP_i^{Sat} = Fp_i + KAp_i = (F + KA)p_i$$

Divide by (F+KA)

$$p_i = \frac{KAP_i^{Sat}}{F + KA}$$

$$S_i = \frac{p_i}{P_i^{Sat}} = \frac{KA}{F + KA}$$

Rearrange to obtain saturation.

(9.30)

Eq 9.20 is consistent with respect to units. If K (ft/min), A (ft<sup>2</sup>), and F (ft<sup>3</sup>/min) then S<sub>i</sub> is dimensionless and represents the level of saturation as a decimal fraction between 0 and 1.0. When the purge rate becomes zero, the saturation level inside the tank becomes 1.0. The resulting emissions through the vent becomes zero because a purge does not exist through the vessel. When the purge rate increases to the point that F = KA then the saturation level becomes 0.5 (or 50%).

Eq 9.20 relates the saturation level of a volatile component the exit gas sweep rate (F) and the evaporation rate (KA). However, Eq 8.20 represents a worst case condition because it assumes that the gas space in the vessel is perfectly mixed. When F is equal to KA then the partial pressure of the volatile component is only 50% of the saturated vapor pressure. When F is greater than KA then the saturation level is greater than 50% and when F is smaller than KA then the saturation level is less than 50%.

Suppose a vessel with a diameter of 5 ft is partially filled with toluene at 25 C. The vapor pressure and molecular weight of toluene are 28.2 mm Hg and 92.13 lb/lb-mole, respectively. The cross sectional area of the tank or liquid surface area is calculated to be 19.6 ft<sup>2</sup>. Assuming that the gas space in the vessel is mixed then the following calculations can be made.

$$K_i = K_o \left( \frac{M_o}{M_i} \right)^{1/3} = 0.83 \frac{cm}{s} \left( \frac{18.02}{92.13} \right)^{1/3} = 0.482 \frac{cm}{s} \times \frac{60 \cdot s \cdot ft}{30.48 \cdot min \cdot cm} = 0.949 \frac{ft}{min}$$

$$S_i = \frac{K_i A}{F + K_i A} = \frac{(0.949)(19.6)}{F + (0.949)(19.6)} = \frac{18.59}{F + 18.59}$$

Saturation S<sub>i</sub> is be plotted for this vessel as a function of F in Figure 8.2-1 and shows the relationship between exit gas sweep rate and saturation level of the exit vent gas with respect to toluene vapor pressure.

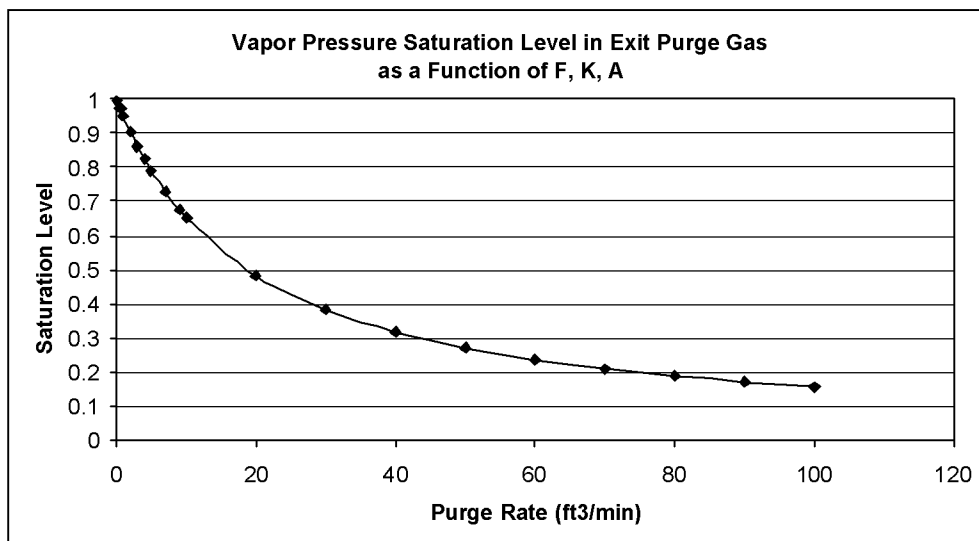


Figure 9-1: Saturation Level (S) Plotted as a Function of Exit Vent Gas Flow Rate.

Once the saturation factor  $S$  is known for any exit vent gas flow rate then the estimated emission rate for compound  $i$  can be plotted as a function of  $F$  as by substituting  $p_i = S_i p_i^{Sat}$ .

$$Q_v = \frac{MF p_i}{RT} = \frac{MFS_i p_i^{Sat}}{RT} \quad (9.31)$$

The emission rate for this specific toluene example is plotted in Figure 9.2-2 in lb/hr as a function of exit gas sweep rate in SCFM.

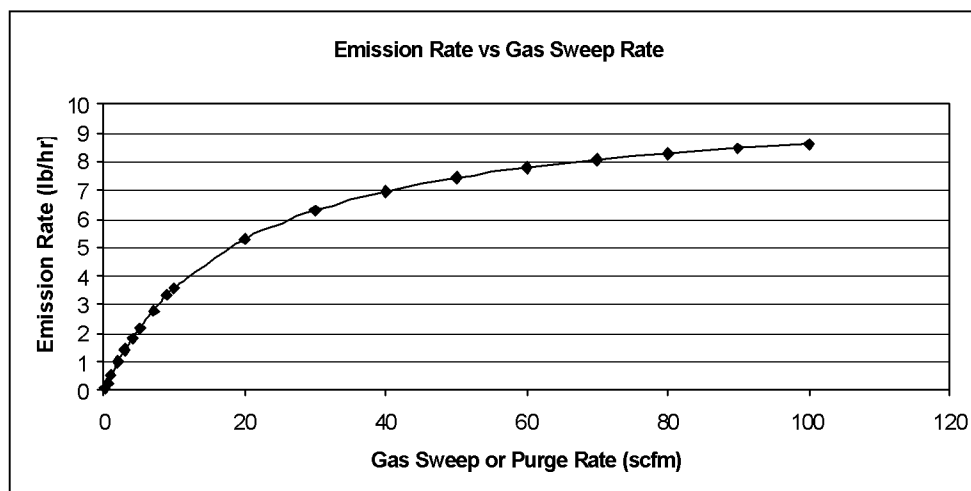


Figure 9-2: Toluene Emission Rate Plotted as a Function of Exit Gas Sweep Rate and Saturation Level.

The vessel had a loose fitting hinged cover and an over sized hole in the top where the agitator entered the vessel. The exit vent gas rate for the vessel could not be determined due to this equipment configuration. A Temporary

Total Enclosure test was conducted on this vessel as it was holding toluene at 25 C while mixing was underway. A steady state toluene emission rate was measured to be 5.14 lb/hr. From Figure 8.2-2, a 5.14 lb/hr toluene emission rate corresponds to an exit vent gas rate of 20 scfm. From Figure 8.2-1, a 20 scfm exit gas rate corresponds to a saturate level of 0.48 (or 48%).

If the process material is changed with respect to solvent composition then the established gas sweep and saturation level can be used in support of a re-evaluation of the revised operation. In this case the vapor pressure and other physical properties of the new process material would be incorporated into the basic purge model for emission estimates.

### 3.11 Emission Calculations Using Material Balance

If the equipment or process operation is such that standard modeling techniques can not be applied then a material balance approach may be used to estimate air emissions. Processes that fall into this category might include parts cleaning or degreasing systems where the equipment is open to the atmosphere and/or does not fit typical process vessel designs.

In such cases, the quantity of initial cleaning solvent would be weighed prior to being charged to the equipment system. Once the process operation has been completed then all remaining spent solvent would be collected and weighed. If non-volatile compounds such as oil or other materials are contained in the residual spent solvent then the material would need to be assayed for volatile solvent content.

If the test results are to be used for developing emission standards for a specific process operation then additional tests should be implemented to arrive at a statistically relevant emission estimation.

***Illustration 22: Using material balance to estimate emissions from operations.***

Fresh toluene solvent is charged to an equipment parts degreaser/cleaning unit. The initial amount of toluene charged is 350 lb. At the conclusion of the operation 347.5 lb. of spent toluene (contaminated with waste oil) is collected. A sample of the spent toluene is assayed using loss on drying (LOD) analysis to be 98.8% toluene by weight. Calculate the toluene evaporation losses from the operation.

Stream	Weight (lbs.)	Purity	Weight (lbs.)
Initial Toluene Charge	350.00	100.0%	350.00
Residual Toluene	347.50	98.8%	343.33
Toluene Emitted			6.67

### 3.12 Emission Calculations Using Emission Factors

Emission factors are commonly used to calculate emissions from chemical manufacturing facilities. EPA maintains a compilation of approved emission factors in *AP-42* for criteria pollutants and hazardous air pollutants (HAPs). Emission factors for equipment leaks may be found in *Protocol for Equipment Leak Emission Estimates* (EPA, 1995g). Chapter 4 of this volume discusses emission estimates from equipment leaks.

The most comprehensive source for toxic air pollutant emission factors is the Factor Information and Retrieval (FIRE) data system, which also contains criteria pollutant emission factors (EPA, 1995h).



## 4 Basic process operations

### 4.1 Emission Calculations from Solvent Reclamation Systems

After being collected from manufacturing processes, waste solvents are frequently purified and reused in the factory. Distillation is one of the most common means of purifying solvents for reuse. Many forms of distillation are used including simple batch, continuous, or steam distillation.

For emissions modeling, a typical distillation process involves several separate emission modeling steps:

1. The initial filling step when waste solvent is charged to the empty distillation vessel.
2. A heating step when the waste solvent is raised to the solvent boiling point temperature.
3. The recovery phase when purified distillate is collected in the receiving vessel.
4. At the completion of the distillation process any remaining waste solvent in the still is normally cooled. The emissions from cooling are assumed to be zero unless a nitrogen sweep that would overcome gas contraction is being applied.
5. A final drumming step when the recovered solvent is transferred to a solvent holding area or to drums.

**Illustration 23: Estimating emissions from a batch distillation operation.**

One hundred gallons of waste toluene are to be charged to a batch still for distillation recovery. The toluene to be charged is at 18°C and contains 1.5% (mole/mole) dissolved non-volatile waste solids. A boiling point check shows that the waste toluene has a normal boiling point of 111.2°C. The still vessel has a gas space volume of 220 gallons when empty. An overhead heat exchanger is used to condense the pure toluene distillate at 20°C. What are the vent emissions from this event?

**Emissions from charging the distillation vessel with cold solvent for recovery.**

The standard charging model is used to calculate the vent emissions that occur from charging the cold waste solvent to the distillation vessel. Basic values that will be used in the calculation are first calculated.

Determine T(°K):  $T(^{\circ}\text{K}) = 18.0^{\circ}\text{C} + 273.15 = 291.25^{\circ}\text{K}$

Antoine Equation:  $P_{\text{toluene}} = \exp\left(16.0137 - \frac{3096.52}{291.15 - 53.67}\right) = \exp(2.975) = 19.582 \text{ mmHg}$

Raoult's Law:  $p_{\text{toluene}} = 0.985 P_{\text{toluene}} = (0.985)(19.582 \text{ mm Hg}) = 19.288 \text{ mm Hg.}$

Displacement Vol.  $V \text{ (ft}^3\text{)} = 100 \text{ gallons} * 0.13368 \text{ (ft}^3\text{/gal)} = 13.368 \text{ ft}^3$

Ideal Gas Constant  $R = 998.9 \text{ mmHg} \cdot \text{ft}^3 / \text{lb-mole} \cdot ^{\circ}\text{K}$

Moles of toluene emitted per batch:  $n_i = \frac{19.288 \cdot 13.368}{998.9 \cdot 291.15} = 0.000887 \text{ lb-moles}$

Weight of toluene emitted per batch:  $\text{wt}_i = (0.000887 \text{ lb-moles})(92.13 \text{ lb/lb-mole}) = 0.082 \text{ lbs}$

**Heating the solvent for distillation**

Since the distillation system contains a process condenser operating at 20°C then we can assume that the exit vent gas caused by heating will leave the equipment system saturated with toluene vapors at the 20°C temperature. It should be noted that during the initial heating process between 18°C and 20°C that the toluene content of the condenser exit gas will be less than the 20°C saturation level. However, this error is considered to be insignificant when compared to the total emissions that occur while heating to the final 111.2°C boiling point temperature prior to distillation.

$T_i$	=	18°C	=	291.15°K	(Initial temperature)
$P_T$	=	1.0 atm	=	760 mm Hg	(Total system pressure)
$V_{gas}$	=	120 gallons	=	16.04 ft <sup>3</sup>	(Gas space volume)
$R$	=	998.9 (mmHg-ft <sup>3</sup> )/(lb-mole-°K)			(Universal gas constant)
$P_{toluene, 18°C}$	=	19.906 mm Hg.			(Antoine Equation)

The partial pressure of nitrogen at 18°C is the difference between the total system pressure and the partial pressure of toluene:

$$p_{n_2,1} = 760 - p_{toluene,1} = 760 - 19.6 = 740.4 \text{ mmHg}$$

Gas Law:  $n = \frac{PV}{RT}$ , also  $n_i = \frac{p_i V}{RT}$  for a single component,  $i$ , in the gas space.

Calculate the total amount of nitrogen that is displaced from the still during the heating activity using the ideal gas law at the initial conditions. When the waste toluene temperature reaches the boiling point, it is assumed that all of the nitrogen has been expelled and that the head space in the distillation vessel contains only saturated toluene vapors. Therefore the ideal gas law is used to calculate the moles of nitrogen that is displaced.

$$\text{Nitrogen discharged from heating: } n_{N_2} = \frac{p_{n_2} V}{RT} = \frac{740.4 * 16.04}{998.9 * 291.15} = 0.041 \text{ lb-moles}$$

The condenser has an outlet vent temperature of 20°C. It is assumed that the outlet vent gas is saturated with toluene vapors. Therefore the quantity of toluene that is finally emitted from the process system is calculated by multiplying the moles of nitrogen by the ratio of the toluene and nitrogen partial pressures.

Partial pressure of toluene at 20°C (Antoine Equation): 21.8 mm Hg

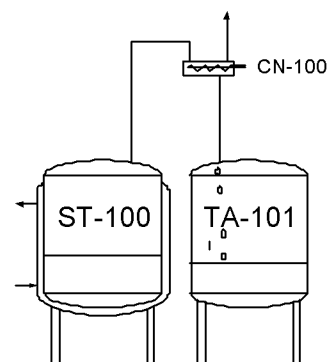
Partial pressure of nitrogen at 20°C by difference: (760 – 21.8) = 738.2 mm Hg.

$$\text{Final toluene emission: } n_{toluene} = \left( \frac{21.8 \text{ mmHg}}{738.2 \text{ mmHg}} \right) 0.041 = 0.00121 \text{ lb-moles}$$

$$\text{Final toluene emission: } wt_{toluene} = (0.00121 \text{ lb-moles})(92.13 \text{ lb/lb-mole}) = 0.0012 \text{ lbs}$$

**Receiving the solvent from distillation**

If the initial waste toluene to be distilled contains 1.5% non-volatile impurities and the composition of the final still bottoms is estimated to be 50% toluene and 50% non-volatile impurities, then the expected volume of toluene to be recovered will be 97 gallons. The emissions that are associated with the actual distillation operation are calculated using the filling or charging model for TA-101. It is estimated that the distillate toluene enters TA-101 from the condenser at 20°C based on earlier discussions.



Vapor pressure of toluene at 20°C: 21.85 mm Hg.

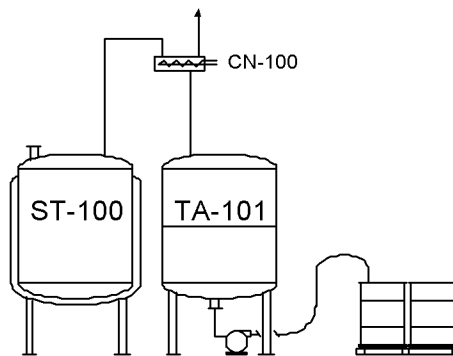
Displacement volume: 97 gallons \* 0.133680555 (gal/ft<sup>3</sup>) = 12.967 ft<sup>3</sup>

Toluene emitted per batch:  $n_i = \frac{P_i V}{RT} = \frac{21.85 * 12.967}{998.9 * 291.15} = 0.001048 \text{ lb-moles}$

Toluene emitted per batch:  $wt_{\text{toluene}} = (0.001048 \text{ lb-moles})(92.13 \text{ lb/lb-mole}) = 0.097 \text{ lbs}$

**Drumming the purified toluene.**

Once the 97 gallons of toluene have been purified and collected in TA-101, the batch will be drummed in 50 gallon drums. Unless spot ventilation is provided for the drums then the emission losses that occur during drumming would be considered to be fugitive emissions. Emissions for this operation are calculated as a simple filling operation. As the 97 gallons of toluene are transferred from the receiver into drums then 97 gallons of saturated solvent vapor are displaced from the drums. The emissions are calculated using the ideal gas law as before.



Toluene emitted per batch:

$n_i = \frac{P_i V}{RT} = \frac{21.85 * 12.967}{998.9 * 291.15} = 0.001048 \text{ lb-moles}$

Toluene emitted per batch:  $wt_{\text{toluene}} = (0.001048 \text{ lb-moles})(92.13 \text{ lb/lb-mole}) = 0.097 \text{ lbs}$

**Solvent emissions from the overall toluene recovery process.**

Solvent emissions from the overall toluene recovery process are estimated by adding the emissions from each of the individual steps.

Activity Description	Amount
Initial charging of 100 gallons of waste toluene solvent:	0.0820 lbs
Heating the batch for distillation:	0.0012 lbs
Receiving toluene in receiver TA-101:	0.0970 lbs
Drumming 97 gallons of recovered toluene:	0.0970 lbs
Total Emissions from process:	0.2772 lbs

## 4.2 Filtration Operations

Filtration is an operation that is commonly used when it is desired to separate the solids portion of a process slurry from the liquid portion. Most filtrations involve a slurry feed vessel, a filter, and a filtrate receiving vessel. In some cases the slurry is passed through the filter by pressurizing the feed tank while in other operations the slurry may be pumped. Different types of filters may be used depending upon the processing requirements. For example, the filter may be a bag filter, filter press, leaf filter, centrifuge, or another design.

Examples of batch filtration might include processing when crystalline product that has formed during the process must be isolated from the batch slurry. Other filtration operations are performed when the product is dissolved in the primary processing solvent and the solids are either waste compounds or materials that have added to help purify the dissolved product such as diamatious earth or activated carbon.

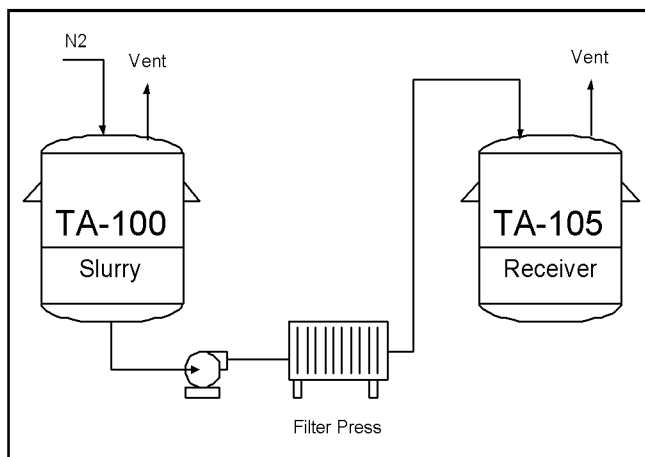


Figure 9-3: Example filtration equipment arrangement.

Batch filtration consists of at least three separate modeling activities including Sending the process slurry to the filter initially with process mother liquors being directed into the receiver. The charging or filling model is used to calculate the process vent emissions that occur during this processing step. Since the filter is connected directly to the filtrate receiving vessel then all emissions exit through the receiver process vent. In this case the emissions from the operation are based on the total volume of slurry being processed forward.

A fresh solvent (normally the same solvent that is contained in the process) is passed through the filter cake to the filtrate receiver. The emissions from this operation may also be calculated using a filling model for the filtrate receiver based on the volume of solvent that is used during the wash. Air or nitrogen gas is usually passed through the filter to displace the residual liquid from the solids filter cake. Displaced liquid from the filter cake is sent to the filtrate receiver. Emissions that occur from this operation may be calculated using the standard filling model that also includes a gas sweep for the filtrate receiver. An exit gas saturation level of 100% is used based on the process filtrate composition.

### 4.3 Centrifuge Operations

Centrifugation is an operation that is commonly used when it is desired to separate the solids portion of a process slurry from the liquid portion. Most centrifuge operations contain a slurry feed vessel, a centrifuge, and a filtrate receiving vessel. In most cases the slurry is passed to the centrifuge by way of a centrifugal pump. Centrifuge operations normally include a feed step (when slurry is feed to the centrifuge so that the internal basket can be loaded), a spin step (when filtrate is permitted to exit the centrifuge cake), a washing step (when water or process solvent is feed to the centrifuge), a final spin step (when the wash liquor is allowed to separate from the centrifuge cake), followed by a plowing step (when the solid cake is removed from the centrifuge).

Processing when centrifugation might be used would be for situations when crystallized material that has formed during the process must be isolated from the batch. Several centrifuge loads must usually be processed from a single batch of slurry material depending upon the batch size.

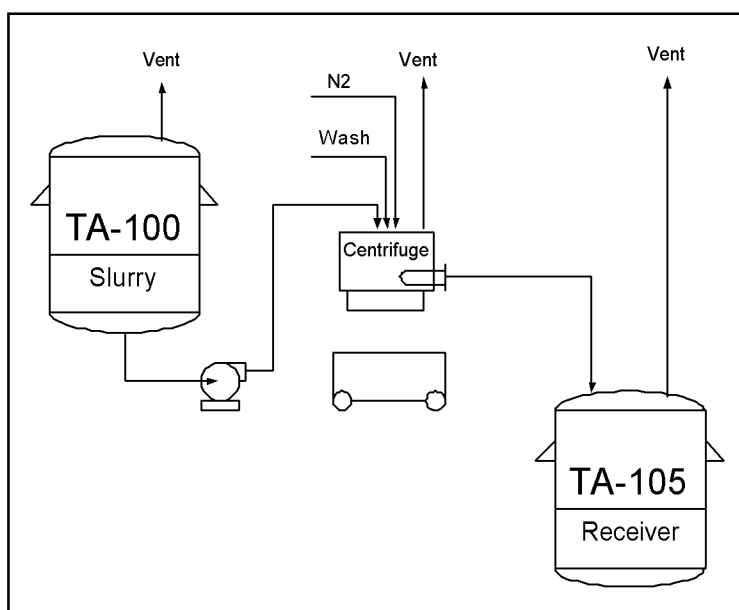


Figure 9-4: Typical Centrifuge Equipment Arrangement

Centrifugation consists of at least three separate modeling activities

**Feed Step** The initial feed step is when the centrifuge is being loaded with process slurry from the feed vessel and filtrate is being directed to the filtrate receiver from the centrifuge. The charging or filling with gas sweep model is used to calculate the process vent emissions that occur from the centrifuge as well as from the filtrate receiver.

The volumetric capacity of the centrifuge basket is used as the filling volume for the centrifuge and any additional ventilation rate (as established through plant data) is used for the gas sweep portion of the centrifuge emission calculation. If the centrifuge is tightly connected to other ancillary equipment such as an enclosed bottom hopper then the gas sweep rate may be negligible.

Similarly, the volume of filtrate that enters the filtrate receiver from the centrifuge in addition to any gas sweep that is present are the basis for the emission calculation for this vessel.

**Wash step** Fresh solvent (normally the same solvent as is contained in the process) is passed through the centrifuge cake to the filtrate receiver. During this phase of the operation the centrifuge basket is already full of product solids so the emissions that occur from the centrifuge would be from the gas sweep

assuming that a gas sweep exists. However, if the centrifuge is tightly connected to other ancillary equipment items and a gas purge is not being used at the centrifuge then the focus of the emission calculation would be placed on the filtrate receiver.

The volume of wash solvent that enters the filtrate receiver in conjunction with any gas sweep that also might be present forms the basis for the emission calculation from the filtrate receiver.

#### 4.4 Vacuum Dryer Model

Examples of vacuum drying include processing when final product solids are dried in a vacuum tray dryer or rotary dryer.

The vacuum drying process consists of at least four separate activities and includes (1) placing the process material into the dryer, (2) reducing the system pressure to the design level (3) heating the batch for evaporation to take place, and (4) collecting the solvent distillate in the receiver.

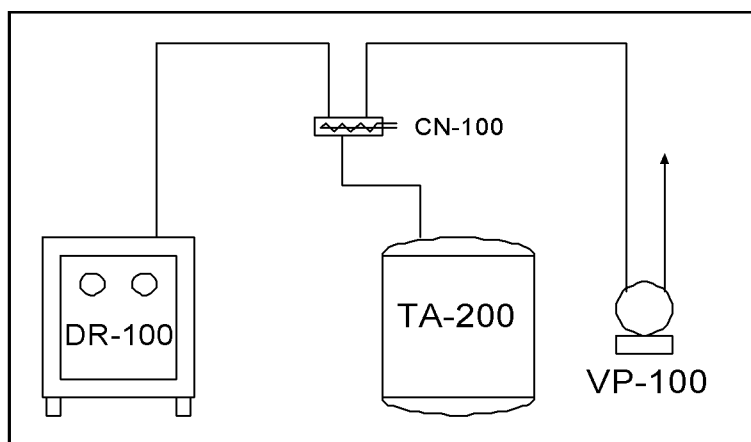


Figure 9-5: Diagram of a Typical Vacuum Tray Dryer System

#### **Information needed to model a vacuum tray drying operation**

##### **Placing the material to be dried into the vacuum oven**

Product solids that are wet with solvent from the prior filtration or centrifugation step will undergo evaporation losses as they are being prepared for the vacuum dryer. Material to be dried is physically transferred from a hopper, drum, or other container onto trays and then spread evenly so that the drying process will be uniform.

It is difficult to predict the evaporation rate from wet solids because each process is different and the material being processed varies with respect to particle size, solvent content, exposure condition, and other variables. A conservative approach to estimating the evaporation losses from a wet product solids cake would be to apply the basic evaporation model as presented in Section 3.6 of this document.

$$Q_m = \frac{M_i K_i A (P_i^{sat} - P_i)}{RT_L} \quad (9.20)$$

where  $Q_m$  is the evaporation rate (mass/time),  
 $M$  is the molecular weight of the volatile substance,  
 $K$  is a mass transfer coefficient (length/time),  
 $A$  is the evaporation surface area,  
 $P_i^{sat}$  is the saturated solvent vapor pressure,  
 $P_i$  is the actual vapor pressure near the liquid surface,  
 $R$  is the ideal gas constant, and  
 $T_L$  is the absolute temperature of the liquid.

Equation 9.20 would provide a conservative estimate of the evaporation rate because the solvent is distributed throughout the product cake as opposed to existing as a continuous liquid with a fixed surface area. As evaporation takes place the amount of solvent that is close to the surface of the cake becomes depleted and any remaining solvent must migrate to the surface for further evaporation. The evaporation process will also remove heat from the product cake and cause  $P_i^{sat}$  to reduce due to the lower temperature.

An alternative approach to quantifying the evaporation rate would be to perform a material balance study by making weight loss measurements using representative samples of wet cake. The results from wet loss studies could then be used to make future estimates.

#### Depressurization Step

The standard depressurization model is applied to calculate the solvent emissions from vacuum oven during the evacuation operation from one atmosphere down to the planned operating pressure. In many cases the planned operating pressure for the oven is less than the saturation vapor pressure of the solvent. In these cases, the depressurization model would be calculated between one atmosphere and the solvent saturated vapor pressure.

#### Heating Step

If the planned operating pressure of the vacuum oven is less than the solvent saturated vapor pressure at initial temperature conditions then the heating model can be used to estimate the emissions that occur during heat up. The heating model would be calculated between the initial temperature conditions and within 2°C of the boiling point temperature for the solvent at the planned operating pressure of the vacuum oven.

#### Distillation Step

Once the drying process is underway, solvent vapors are carried from the vacuum oven and into the heat exchanger where they condense and drain into the distillate receiver. The distillate receiver continues to fill with solvent as long as solvent is being removed from the product solids. Air emissions that occur while the vacuum drying process is ongoing originate from the distillate receiver. The vacuum pump continually removes air from the equipment to maintain the correct pressure of operation.

The filling model is used to estimate the solvent emissions during this part of the drying process. The composition and quantity of the distillate being collected is the same as the original amount of solvent that was contained in the wet cake. The fill volume is equal to the total volume of solvent that is

collected. The temperature and pressure of the distillate receiver is used in the calculations as well as any estimated leak rate that the vacuum pump must overcome as part of the process operation.



## 5 PHYSICAL PROPERTY RELATIONSHIPS

### 5.1 Basic Physical Properties Relationships

This section describes the equations and mathematical relationships that are used in calculating air emissions from point sources in chemical manufacturing processes.

#### 5.1.1 Unit Conversations

The following relationships are helpful when converting from one unit system to another for temperatures, pressures, and volumes.

##### **Temperature Conversions**

$$\begin{aligned} T (^{\circ}\text{R}) &= T (^{\circ}\text{F}) + 459.69 \\ T (^{\circ}\text{K}) &= T (^{\circ}\text{C}) + 273.15 \\ T (^{\circ}\text{K}) &= 1.8 * T (^{\circ}\text{R}) \\ T (^{\circ}\text{K}) &= [T (^{\circ}\text{F}) + 459.69] / 1.8 \\ T (^{\circ}\text{C}) &= T (^{\circ}\text{K}) - 273.15 \\ T (^{\circ}\text{C}) &= [T (^{\circ}\text{F}) - 32.0] / 1.8 \end{aligned} \tag{9.32}$$

##### **Pressure Conversions**

$$\begin{aligned} P (\text{mm Hg}) &= 760.0 * P (\text{atm}) \\ P (\text{mm Hg}) &= 51.7 * P (\text{psia}) \\ P (\text{mm Hg}) &= 25.4 * P (\text{in Hg}) \\ P (\text{mm Hg}) &= P (\text{Pa}) / 133.3 \end{aligned} \tag{9.33}$$

##### **Volume Conversions**

$$\begin{aligned} V \text{ ft}^3 &= 0.03531467 * V (\text{liter}) \\ V \text{ ft}^3 &= 0.133680555 * V (\text{gal}) \end{aligned} \tag{9.34}$$

### 5.2 Basic Physical Property Relationships

#### 5.2.1 Ideal Gas Law

The Ideal Gas Law is used to calculate the total number of moles in a gas space from known variables, such as pressure, volume, and temperature.

$$PV = nRT \tag{9.35}$$

where:

- n = moles of gas
- P = pressure (absolute)
- V = volume
- T = temperature (absolute)
- R = Universal Gas Constant

The following properties exist for ideal gases at the standard temperature and pressure condition:

Table 8.3-1: Standard Conditions for Ideal Gases

Mass	Pressure	Volume	Temperature	Ideal Gas Constant (R)
1.0 lb-mole	14.7 lb/in <sup>2</sup>	359.046 ft <sup>3</sup>	491.69°R	10.731
1.0 lb-mole	29.92 in Hg	359.046 ft <sup>3</sup>	491.69°R	21.8484
1.0 lb-mole	760 mm Hg	359.046 ft <sup>3</sup>	273.15°K	998.9
1.0 g-mole	760 mm Hg	22.414 liters	273.15°K	62.3637
1.0 g-mole	1.0 atm	22.414 liters	273.15°K	0.8206

**Illustration 24: Calculating the moles of gas from volume, temperature, and pressure.**

A process vessel has a void space volume of 1200 gallons when empty of liquid. Calculate the moles of gas that are discharged from the process vent if 550 gallons of liquid are charged into the vessel. Also calculate the moles of gas that are still contained in the vessel headspace at the completion of the filling operation. The batch temperature is 35°C and the system pressure is 760 mm Hg.

Assumptions: The vessel temperature and the batch temperature are the same 35°C before and after the addition is made. Additionally, any evaporation that may occur when the liquid enters the initially empty vessel is ignored.

Part A (Moles of gas displaced through the process vent).

$$\text{Displacement Volume } V_d = 550 \text{ gal} = 0.133680555 \text{ ft}^3/\text{gal} * 550 \text{ gal} = 73.52 \text{ ft}^3$$

$$\text{Temperature } T = 35^\circ\text{C} = 35^\circ\text{C} + 273.15^\circ\text{K} = 308.15^\circ\text{K}$$

$$\text{Moles } n = \left( \frac{PV}{RT} \right) = \left( \frac{760 * 73.52}{998.99 * 308.15} \right) = 0.182 \text{ lb - moles}$$

Part B (Moles of gas retained in the vessel headspace).

$$\text{Gas Space Volume } V_g = 1200 \text{ gal} - 550 \text{ gal} = 650 \text{ gal.}$$

$$\text{Volume conversion } V_g = 0.133680555 \text{ ft}^3/\text{gal} * 650 \text{ gal} = 86.89 \text{ ft}^3$$

$$\text{Moles } n = \left( \frac{PV}{RT} \right) = \left( \frac{760 * 86.89}{998.99 * 308.15} \right) = 0.215 \text{ lb - moles}$$

**5.2.2 Dalton's Law**

Equations based on Dalton's Law (*Eq-9.35*) of partial pressure and Amagat's law (*Eq-9.36*) of partial volume are used with the Ideal Gas Law to determine the number of moles of a specific compound in the vapor space of the vessel.

Dalton's Law 
$$n_i = \frac{p_i V}{RT} \quad (9.36)$$

Amagat's Law 
$$n_i = \frac{P v_i}{RT} \quad (9.37)$$

where: P = pressure  
 V = volume  
 T = temperature  
 R = Universal Gas Constant  
 $n_i$  = moles of  $i$   
 $p_i$  = partial pressure of  $i$   
 $v_i$  = partial volume of  $i$

**Illustration 25: Calculating molar quantities for gas mixtures.**

The headspace of a vessel contains the vapors of water (20 mm Hg), methanol (45 mm Hg), ethanol (40 mm Hg), and a non-condensable component nitrogen. How many moles of each compound are contained in the headspace if the batch temperature is 35°C, the head space volume is 453 gallons, and the total system pressure is 760 mm Hg.

Gas Volume  $V = 453 \text{ gal} * 0.133680555 \text{ ft}^3/\text{gal} = 60.56 \text{ ft}^3$

Temperature (°K)  $T = 35^\circ\text{C} = 35^\circ\text{C} + 273.15^\circ\text{K} = 308.15^\circ\text{K}$

Dalton's Law 
$$n_i = \frac{p_i V}{RT}$$

Moles of water 
$$n_{\text{water}} = \left( \frac{p_i V}{RT} \right) = \left( \frac{20 * 60.56}{998.99 * 308.15} \right) = 0.00393 \text{ lb - moles}$$

Moles of methanol 
$$n_{\text{methanol}} = \left( \frac{p_i V}{RT} \right) = \left( \frac{45 * 60.56}{998.99 * 308.15} \right) = 0.00885 \text{ lb - moles}$$

Moles of ethanol 
$$n_{\text{ethanol}} = \left( \frac{p_i V}{RT} \right) = \left( \frac{40 * 60.56}{998.99 * 308.15} \right) = 0.00787 \text{ lb - moles}$$

Partial pressure of nitrogen 
$$p_{\text{nitrogen}} = 760 - 20 - 40 - 45 = 655 \text{ mmHg}$$

Moles of nitrogen 
$$n_{\text{methanol}} = \left( \frac{p_i V}{RT} \right) = \left( \frac{45 * 60.56}{998.99 * 308.15} \right) = 0.00885 \text{ lb - moles}$$

**5.2.3 Mole Fraction in a Liquid**

The ratio of moles of  $i$  to the total moles in a single liquid phase is defined as mole fraction,  $X_i$ . The liquid mole fraction of a compound is used later for calculating the vapor pressure for the same compound using Raoult's Law.

$$\text{Mole fraction} \quad x_i = \frac{n_i}{n_{total}} \quad (9.38)$$

where:  $x_i$  = mole fraction for component  $i$

$n_i$  = moles of  $i$  in a single liquid phase

$n_{total}$  = total moles in a single liquid phase

**Illustration 26: Calculating mole fractions for liquid mixtures.**

A process batch consist of methanol (1,435 lb), isopropyl alcohol (546 lb), and acetone (584 lb). Determine the mole fraction ( $X_i$ ) of each compound in the solution.

Compound	Weight	Molecular Weight
Methanol	1,435 lb	32.04
Isopropyl alcohol	546 lb	60.096
Acetone	584 lb	58.08

$$\text{moles of methanol:} \quad n = \frac{1,435 \text{ lb}}{32.04 \text{ mwt}} = 44.79 \text{ lb - moles}$$

$$\text{moles of isopropyl alcohol:} \quad n = \frac{546 \text{ lb}}{60.096 \text{ mwt}} = 9.09 \text{ lb - moles}$$

$$\text{moles of acetone:} \quad n = \frac{584 \text{ lb}}{58.08 \text{ mwt}} = 10.06 \text{ lb - moles}$$

$$\text{Total moles in the batch:} \quad 44.79 + 60.096 + 10.03 = 69.93 \text{ lb-moles}$$

$$\text{mole fraction of methanol:} \quad n = \frac{546 \text{ lb}}{60.096 \text{ mwt}} = 9.09 \text{ lb - moles}$$

$$\text{mole fraction of isopropyl alcohol:} \quad X_i = \frac{9.09 \text{ lb - moles}}{69.93 \text{ lb - moles}} = 0.142$$

$$\text{mole fraction of acetone:} \quad X_i = \frac{10.06 \text{ lb - moles}}{69.93 \text{ lb - moles}} = 0.157$$

### 5.3 Pure Component Vapor Pressure

#### 5.3.1 Clapeyron Vapor Pressure Equation

Essentially, all liquids and some solids exhibit a vapor pressure that can be measured. The vapor pressure for any compound is a function of temperature and composition within a given solution. If the compound exists in pure form then the vapor pressure becomes only a function of temperature.

Many mathematical relationships have been formulated over the years that enable the pure component vapor pressure of a compound to be accurately estimated within a given temperature range. The Clapeyron Vapor Pressure Model (Eq-9.38) is based upon the equality of chemical potential, temperature, and pressure in both liquid and gas phases. [Reid, Prausnitz, & Sherwood, 1977]

$$\text{Clapeyron model} \quad \ln(P_i) = A - \frac{B}{T} \quad (9.39)$$

where  $P_i$  = pure component vapor pressure

$T$  = temperature, degrees Kelvin

$A$  = empirical constant

$B = \Delta H_v / R \Delta Z_v$  ( $\Delta H_v$  - heat of vaporization,  $\Delta Z_v$  - compressibility factor).

Although the Clapeyron Vapor Pressure model is based on the heat of vaporization and the compressibility factor for a compound, this thermodynamic data is not needed. If two reliable vapor pressure data points can be obtained then  $A$  and  $B$  can be determined mathematically. However, one disadvantage to using this model is that the vapor pressure correlation may not be as accurate as other models that contain a greater number of empirical coefficients.

**Illustration 27: Estimating Clapeyron vapor pressure model coefficients.**

Toluene has a boiling point of 110.6 C at 760 mm Hg. and a boiling point of 31.8 C at 40 mm Hg.

Determine  $A$  and  $B$  for the Clapeyron Vapor Pressure model and then calculate the vapor pressure of toluene at 51.9 C.

$$\text{Clapeyron model} \quad \ln(P) = A - \frac{B}{T}$$

$$(a) \text{ Solve for } B \quad \ln(P_2) - \ln(P_1) = -B(T_2^{-1} - T_1^{-1})$$

$$T_1 = 31.8 \text{ C} = 31.8 + 273.15 = 304.95 \text{ K} \quad 1/T_1 = 0.0032792$$

$$\ln(P_1) = \ln(40) = 3.6888795 \quad \ln(P_1) = 3.6888795$$

$$T_2 = 110.6 \text{ C} = 110.6 + 273.15 = 383.75 \text{ K} \quad 1/T_2 = 0.0026059$$

$$\ln(P_2) = \ln(760) = 6.6333184 \quad \ln(P_2) = 6.6333184$$

$$\text{Solve for } B: \quad B = - \left[ \frac{\ln(P_2) - \ln(P_1)}{T_2^{-1} - T_1^{-1}} \right]$$

$$B = - \left[ \frac{6.6333184 - 3.6888795}{0.0026059 - 0.0032792} \right] = 4372.7371$$

Solve for A

$$A = \ln(P_2) + \frac{B}{T_2} = 6.6333184 + \frac{4372.7371}{383.75} = 18.0281$$

Calculate the vapor pressure of toluene at 59.9 C (325.05 K)

$$\ln(P) = A - \frac{B}{T} = 18.0281 - \frac{4372.7371}{325.05} = 4.575567$$

$$P_{51.9\text{ C}} = 97.1 \text{ mm Hg.}$$

Note that the vapor pressure of toluene from literature sources is 100 mm Hg for 51.9 C or 3% higher than the Clapeyron model prediction using this technique.

### 5.3.2 Antoine Equation

The Antoine equation is a modification of the Clapeyron model and is one of the most frequently used equations for estimating the vapor pressure of a pure compound. [Reid, Prausnitz, & Sherwood, 1977]

The Antoine equation is shown in the following general form:

$$\ln(P_i) = \left( a_i - \frac{b_i}{T + c_i} \right) \quad (9.40)$$

where:  $P_i$  = pure component pressure of compound  $i$

$T$  = absolute temperature

$a_i, b_i, c_i$  = Antoine constants

Coefficients  $a_i$ ,  $b_i$ , and  $c_i$  are published in several literature sources for many compounds. It is important to note the specific temperature and pressure units that are associated with the Antoine coefficients that are listed in the literature.

The reader should keep in mind that the Antoine equation is a general mathematical relationship and can be used with temperatures in either Centigrade, Kelvin, Fahrenheit, or Rankin units. Additionally, the equation can be used for calculating vapor pressures in different units (atm, mm Hg, and psia) and in the natural log (ln) or base 10 log form. It is always a good idea to calculate one or more known vapor pressure data points as a means of verifying that the model is consistent with respect to coefficients, temperature units, and pressure units being used.

#### **Illustration 28: Calculating pure component vapor pressures from the Antoine model.**

The Antoine coefficients for toluene are  $a = 16.0137$ ,  $b = 3096.52$ , and  $c = -53.67$ . These coefficients were obtained from a source where the Antoine equation is in the natural log form, pressure is in mm Hg, and temperature is in Kelvin units. Additionally, these coefficients are valid between 7°C and 137°C. What is the pure component vapor pressure for toluene at 35°C and 70°C?

Antoine Equation

$$\ln(P_i) = \left( a_i - \frac{b_i}{T + c_i} \right)$$

Temperature (35°C)

$$T = 35^\circ\text{C} = 35.0^\circ\text{C} + 273.15^\circ\text{K} = 308.15^\circ\text{K}$$

$$\ln(P_i) = \left( 16.0137 - \frac{3096.52}{308.15 - 53.67} \right) = 3.8457$$

$$P_{35^{\circ}\text{C}} = e^{3.8457} = 46.79 \text{ mm Hg.}$$

Temperature (70°C)

$$T = 70^{\circ}\text{C} = 70.0^{\circ}\text{C} + 273.15^{\circ}\text{K} = 343.15^{\circ}\text{K}$$

$$\ln(P_i) = \left(16.0137 - \frac{3096.52}{343.15 - 53.67}\right) = 5.3169$$

$$P_{70^{\circ}\text{C}} = e^{5.3169} = 203.74 \text{ mm Hg.}$$

### 5.3.3 Other Vapor-Pressure Equation Forms

Over the years researchers have published many different equations for calculating the vapor pressure of pure compounds as a function of temperature. [Reid, Prausnitz, & Sherwood, 1977] Among these include:

Riedel-Plank-Miller Equation: 
$$\ln P_{vp} = A + \frac{B}{T} + CT + DT^3 \quad (9.41)$$

Rankine-Kirchhoff Equation: 
$$\ln P_{vp} = A + \frac{B}{T} + C \ln T \quad (9.42)$$

Riedel Equation: 
$$\ln P_{vp} = A + \frac{B}{T} + C \ln T + DT^6 \quad (9.43)$$

Coefficients that apply to each equation are normally provided through commercially available databases. The DIPPER Database (AIChE) provides modeling coefficients for an equation of the general form:

$$\ln P_{vp} = A + \frac{B}{T} + C \ln T + DT^E \quad (9.44)$$

Where  $P_{vp}$  = vapor pressure in Pascal (Pa) units.  
T = temperature in degrees Kelvin.

#### **Illustration 29: Calculating vapor pressures using the AIChE DIPPR database model.**

According to the AIChE DIPPR Database, the vapor pressure coefficients for acetone are as follows:

$$A = 69.006$$

$$B = -5599.6$$

$$C = -7.0985$$

$$D = 0.0000062237$$

$$E = 2.0000$$

What is the vapor pressure of acetone if the temperature of the liquid is 25 °C?

$$T = 25^{\circ}\text{C} + 273.15 = 298.15^{\circ}\text{K}$$

$$\ln P_{vp} = 69.006 - \frac{5599.6}{T} - 7.098 \ln T + 0.0000062237 T^2$$

$$\ln P_{vp} = 69.006 - 18.781 - 40.444 + 0.553 = 10.334$$

$$P_{vp} = 3.074 \times 10^4 \text{ Pa} \times \frac{1 \text{ mmHg}}{133.35 \text{ Pa}} = 230.697 \text{ mmHg}$$

## 5.4 Component Vapor Pressure over Solutions

### 5.4.1 Equilibrium Conditions (Ideal) and Raoult's Law

Ideal vapor pressure conditions normally exist for a solution when strong molecular associations between molecules are not present. This is normally the case when the molecular sizes are approximately equal and the attractive forces between like and unlike molecules are equal as well. Ideal equilibrium conditions are typically present when the solution is made up completely of nonpolar compounds such as organic solvents (toluene, heptane, hexane, etc.).

A generalization known as Raoult's Law states that the equilibrium vapor pressure that is observed for a compound is proportional to the mole fraction of that compound in solution. For example, given an equal molar solution (0.5:0.5) of toluene and heptane at 35°C, the equilibrium vapor pressure of the toluene would be 101.87 mm Hg or one half of its pure component vapor pressure of 203.74 mm Hg at 35°C.

Raoult's Law

$$p_i = X_i P_i$$

where:  $p_i$  = effective vapor pressure of i  
 $P_i$  = pure component pressure i  
 $X_i$  = mole fraction of component i

### **Illustration 30: Estimating component vapor pressures using Raoult's Law.**

A solution contains 20% toluene (wt/wt), 50% heptane (wt/wt), 30% acetone. The solution temperature is 35°C. The pure component vapor pressures for toluene, heptane, and acetone are 46.79 mm Hg, 74.04 mm Hg, and 347.1 mm Hg respectively for the 35°C condition. The molecular weights for toluene, heptane, and acetone are 92.13, 100.205, and 58.08, respectively.

Calculate the moles and mole fraction of each component in the solution on a 100 lb basis.

Moles of toluene 
$$n_{\text{toluene}} = \left( \frac{wt_{\text{toluene}}}{MW_{\text{toluene}}} \right) = \left( \frac{20 \text{ lb}}{92.13} \right) = 0.22 \text{ lb - moles}$$

Moles of heptane 
$$n_{\text{heptane}} = \left( \frac{wt_{\text{heptane}}}{MW_{\text{heptane}}} \right) = \left( \frac{50 \text{ lb}}{100.205} \right) = 0.50 \text{ lb - moles}$$

Moles of acetone 
$$n_{\text{acetone}} = \left( \frac{wt_{\text{acetone}}}{MW_{\text{acetone}}} \right) = \left( \frac{30 \text{ lb}}{58.08} \right) = 0.52 \text{ lb - moles}$$

Sum of moles 
$$n_{\text{total}} = 0.22 + 0.50 + 0.52 = 1.23 \text{ lb-moles}$$

Mole fraction of toluene 
$$X_{\text{toluene}} = \left( \frac{\text{moles}_{\text{toluene}}}{\text{total moles}} \right) = \left( \frac{0.22}{1.23} \right) = 0.176$$



Mole fraction of heptane 
$$X_{heptane} = \left( \frac{\text{moles}_{heptane}}{\text{total moles}} \right) = \left( \frac{0.50}{1.23} \right) = 0.405$$

Mole fraction of acetone 
$$X_{acetone} = \left( \frac{\text{moles}_{acetone}}{\text{total moles}} \right) = \left( \frac{0.52}{1.23} \right) = 0.419$$

Calculate the equilibrium vapor pressure for each component.

Vapor pressure for of toluene 
$$P_{toluene} = 0.176 * 46.79 = 8.24 \text{ mm Hg}$$

Vapor pressure for of heptane 
$$P_{heptane} = 0.405 * 74.04 = 29.97 \text{ mm Hg}$$

Vapor pressure for of acetone 
$$P_{acetone} = 0.419 * 347.1 = 145.46 \text{ mm Hg}$$

### **Using Raoult's Law to determine molar concentration**

In special cases, Raoult's Law can be used to determine the molar concentration of a single solvent solution. For example, suppose waste solvent from a process contains dissolved non-volatile or very low volatile compounds (such as heavy oil). The boiling point temperature of waste solvent and the pure solvent is measured. The molar concentration of the primary solvent in the waste solvent solution may be determined by dividing 760 mm Hg by the calculated vapor pressure of the pure solvent at the elevated temperature.

#### **Illustration 31: Estimating liquid composition based on vapor pressure measurements.**

The boiling point temperature of a sample of waste toluene was measured to be 112.3°C. The boiling point temperature of a sample of pure toluene was measured to be 110.8°C. (Note that measuring the boiling point temperature of a pure solvent can result in a different reading than the value that is contained in the literature due to atmospheric elevation differences and measurement accuracy issues.)

Boiling point difference between the two samples (112.3°C – 110.8°C): 1.5°C.

Normal boiling point temperature of toluene from the literature: 110.6°C.

Corrected boiling point of the waste toluene sample (110.6°C + 1.5°C): 112.1°C

$$\ln(P_i) = \left( 16.0137 - \frac{3096.52}{385.25 - 53.67} \right) = 6.675$$

$$P_{112.1^\circ\text{C}} = e^{6.675} = 792.362 \text{ mm Hg.}$$

Raoult's Law

$$p_i = x_i P_i$$

Molar concentration:

$$x_i = \frac{p_i}{P_i} = \frac{760.0 \text{ mmHg}}{792.362 \text{ mmHg}} \times 100\% = 95.9\%$$

#### **Illustration 32: Determining the molar composition of a liquid from vapor pressure data.**

A mixture has been prepared for processing at 35 C. The contents contain 850 lbs of toluene, 525 lbs of heptane, and 2500 lbs of other non-volatile materials. Determine the vapor pressure of the mixture at 35 C and the mole fraction of toluene and heptane. The molecular weight of toluene is 92.13 and the molecular weight of heptane is 100.2.

The molar quantities of toluene and heptane are calculated

$$\text{Moles of toluene} \quad n_{\text{toluene}} = \left( \frac{wt_{\text{toluene}}}{MW_{\text{toluene}}} \right) = \left( \frac{850 \text{ lb}}{92.13} \right) = 9.22 \text{ lb - moles}$$

$$\text{Moles of heptane} \quad n_{\text{heptane}} = \left( \frac{wt_{\text{heptane}}}{MW_{\text{heptane}}} \right) = \left( \frac{525 \text{ lb}}{100.205} \right) = 5.24 \text{ lb - moles}$$

A sample of the process mixture is placed in a vacuum flask equip with a temperature probe, reflux condenser, vacuum pump, vacuum controller, and pressure gauge. The mixture is heated to 35 C and then placed under increasing vacuum until the mixture begins to boil with reflux present. The boiling point pressure is recorded from this experiment to be 40 mm Hg. The pure vapor pressures for toluene and heptane at 35 C are 45.79 mm Hg and 74.04 mm Hg, respectively.

For this mixture the volatile components have been identified to consist entirely of toluene and heptane. However, the mole fraction of these two components cannot be determined because the molecular weight data for the remaining components is not available. Therefore, the following general equation can be established that relates the unknown mole fraction to the partial pressure for each volatile compound.

$$\text{Raoult's Law} \quad p_i = x_i P_i = \frac{n_i}{\sum n} P_i$$

$$\text{Mole fraction in gas space} \quad y_i = \frac{p_i}{\sum p}$$

$$\text{Combining equations} \quad y_i = \frac{n_i P_i}{\sum n P_i} \quad (9.45)$$

Finally, the liquid mole fraction for each volatile component may be determined from Raoult's Law.

$$x_i = \frac{p_i}{P_i} = \frac{y_i P_T}{P_i} \quad (9.46)$$

For this problem only toluene and heptane need to be considered. Eq-9.44 is customized to accommodate only toluene and heptane.

$$\text{For toluene} \quad y_i = \frac{n_i P_i}{n_i P_i + n_j P_j} = \frac{(9.22 \times 45.79)}{(9.22 \times 45.79) + (5.24 \times 74.04)} = 0.521$$

$$\text{For heptane} \quad y_j = \frac{(5.24 \times 74.04)}{(9.22 \times 45.79) + (5.24 \times 74.04)} = 0.479$$

Finally,

$$\text{For toluene} \quad x_i = \frac{y_i P_T}{P_i} = \frac{0.521 \times 40.0}{45.79} = 0.455$$

For heptane

$$x_j = \frac{y_j P_T}{P_j} = \frac{0.479 \times 40.0}{74.04} = 0.258$$

The results of these calculations suggest that 0.286 (or  $1.0 - 0.455 - 0.258$ ) mole fraction of the process mixture consist of other nonvolatile components.

### 5.4.2 Non Ideal Equilibrium Conditions and Activity Coefficients

In many cases, ideal equilibrium relationships do not exist for solutions. This is especially true for solutions containing compounds that are polar in nature or have significant attraction to other compounds in the same solution. An example of a solution with highly non ideal equilibrium properties is aqueous hydrochloric acid with the vapor pressure of hydrogen chloride being orders of magnitude lower than expected by Raoult's Law. Other examples of solutions with non ideal vapor pressure behavior would include systems with azeotropic properties such as acetone – hexane.

Non ideal equilibrium systems should be calculated using an activity coefficient (or correction factor) as part of the basic equilibrium calculation. The equilibrium vapor pressure equation for ideal solutions has been modified to include the activity coefficient as part of the calculation. For solutions that exhibit ideal behavior the activity coefficient is defaulted to 1.0. For solutions that exhibit significant non ideal vapor pressure behavior the activity coefficient may be estimated from known vapor pressure data. *Eq-9.46* shows how the vapor pressure of a component in solution would be calculated using the Antoine vapor pressure model.

$$p_i = X_i \gamma_i P_i = X_i \gamma_i \exp\left(a_i - \frac{b_i}{c_i + T}\right) \quad (9.47)$$

where:

- $p_i$  = effective vapor pressure of i
- $P_i$  = pure component pressure i
- $X_i$  = mole fraction of component i
- $\gamma_i$  = activity coefficient for component i
- $T$  = absolute temperature
- $a_i, b_i, c_i$  = Antoine constants

#### **Illustration 33: Estimating activity coefficients from solution measurements.**

Using Raoult's Law the pure component vapor pressure of ammonia over a 19.1% (wt/wt) aqueous solution of ammonia acid at 21.1°C is 1308 mm Hg and the vapor pressure of water is 14.9 mm Hg. The measured vapor pressures of ammonia and water are 221.2 mm Hg and 14.5 mm Hg, respectively.

What are the activity coefficients for ammonia and water under these conditions?

Activity Coefficient  $\gamma_{NH_3} = \frac{221.3 \text{ mmHg}}{1308 \text{ mmHg}} = 0.16917$

Activity Coefficient  $\gamma_{Water} = \frac{14.47 \text{ mmHg}}{14.9 \text{ mmHg}} = 0.972$

Assuming that the activity coefficients remain constant between 10°C and 30°C, what would the vapor pressure of hydrogen chloride and water be for the same solution at 25°C?

Based on 100 lbs of solution,

$$\text{Mole fraction of NH}_3: \frac{19.1/17.031}{19.1/17.031 + 79.9/18.02} = 0.20$$

$$\text{Mole fraction of H}_2\text{O}: \frac{79.9/18.02}{79.9/18.02 + 19.1/17.031} = 0.80$$

At 25 C the calculated pure vapor pressure for NH<sub>3</sub> and H<sub>2</sub>O are 7370 mm Hg and 23.58 mm Hg, respectively.

$$\text{Vapor pressure of NH}_3: P_{\text{NH}_3} = P_{\text{NH}_3} \gamma_{\text{NH}_3} P_{\text{NH}_3} = 0.20 * 0.16917 * 7370 = 249.3 \text{ mm Hg}$$

$$\text{Vapor pressure of H}_2\text{O}: P_{\text{H}_2\text{O}} = X_{\text{H}_2\text{O}} \gamma_{\text{H}_2\text{O}} P_{\text{H}_2\text{O}} = 0.80 * 0.972 * 23.58 = 18.35 \text{ mm Hg}$$

**Illustration 34: Estimating activity coefficients from azeotropic mixtures.**

The azeotropic composition of a solution containing heptane and methanol is 48.5% (wt/wt) and 51.5% (wt/wt), respectively. The azeotropic boiling point for the solution is 59.1°C and the system pressure is 760 mm Hg. Based on Raoult's Law, the calculated vapor pressures for the same solution of heptane and methanol are 47.9 mm Hg and 470.1 mm Hg, respectively. Note that the liquid and vapor compositions for an azeotropic system are the same at the boiling point.

For this problem the composition of heptane and methanol must be converted from weight percent to mole percent. This may be accomplished by basing the calculations for an arbitrary 100 lb of solution and then calculating the moles of each compound using the molecular weight. Finally, the mole fraction of each compound is calculated by dividing the moles of each compound by the total moles in the solution. The 48.5% (wt/wt) for heptane is converted to 23.1% (mole/mole), and the 51.5% (wt/wt) for methanol becomes 76.9% (mole/mole).

Calculate the activity coefficients for heptane and methanol under these conditions.

$$\gamma_{\text{heptane}} = \frac{0.231 * 760 \text{ mmHg}}{47.9 \text{ mmHg}} = 3.672$$

$$\gamma_{\text{methanol}} = \frac{0.769 * 760 \text{ mmHg}}{470 \text{ mmHg}} = 1.243$$

**Illustration 35: Calculating vapor compositions using activity coefficients.**

A solution of heptane and methanol was distilled at its azeotropic composition for 1 atm pressure. If the temperature of the recovered distillate is 30°C, what would be the vapor composition for this solution? The system pressure is 760 mm Hg and the vessel is blanketed with nitrogen.

Vapor pressures at 30°C:

Heptane = 58.54 mm Hg.

Methanol = 163.8 mm Hg.

Azeotropic composition:

Heptane = 48.5% (wt/wt) = 23.1% (mole/mole)

Methanol = 51.5% (wt/wt) = 76.9% (mole/mole)

Component vapor pressure

$$P_{\text{heptane}} = X_{\text{heptane}} \gamma_{\text{heptane}} P_{\text{heptane}}^* = 0.231 * 3.672 * 58.54 = 50 \text{ mm Hg}$$

$$P_{\text{methanol}} = X_{\text{methanol}} \gamma_{\text{methanol}} P_{\text{methanol}}^* = 0.769 * 1.243 * 163.8 = 157 \text{ mm Hg}$$

$$P_{\text{nitrogen}} = 760 - 50 - 157 = 553 \text{ mm Hg}$$

Vapor space molal percentage compositions  $y_i$ :

$$y_{\text{heptane}} = \frac{50}{760} * 100\% = 6.6\%$$

$$y_{\text{methanol}} = \frac{156}{760} * 100\% = 20.5\%$$

$$y_{\text{nitrogen}} = \frac{553}{760} * 100\% = 72.9\%$$

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