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Procedures for Establishing Emissions for Early Reduction Compliance Extensions

DRAFT

Volume 1 -- Synthetic Organic Chemical Manufacturing, Ethylene Oxide Sterilization, and Chromium Electroplating

NESHAP

EPA-450/3-91-012a

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Procedures for Establishing Emissions for Early Reduction Compliance Extensions

Volume 1 -- Synthetic Organic Chemical Manufacturing, Ethylene Oxide Sterilization, and Chromium Electroplating

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1. INTRODUCTION

On June 13, 1991, EPA proposed "Regulations Governing Compliance Extensions for Early Reductions of Hazardous Air Pollutants" (56 FR 27338). The proposed rule implements the provisions in Section 112(i)(5) of the Clean Air Act (Act), as amended in 1990. Those provisions allow an existing source of hazardous air pollutant emissions to obtain a six-year extension of compliance with an emission standard promulgated pursuant to Section 112(d) of the Act, if the source has achieved a reduction of 90 percent or more of hazardous air pollutants emitted (95 percent or more for particulate pollutants) by certain dates specified in the Act. If a source is granted a compliance extension, an alternative emission limitation will be established by permit to ensure continued achievement of the 90 (95) percent reduction. The proposed rule establishes requirements and procedures for source owners and operators to follow in order to obtain compliance extensions and for reviewing agencies to follow in evaluating requests for extensions.

One requirement is that requests for a compliance extension must be submitted to a reviewing agency (EPA or a State agency with authority to implement this program) and must contain documentation that the emission reduction has been achieved. To document the reduction, the owner or operator must provide emission data for base year (pre-control) and post-control emissions of hazardous air pollutants emitted by the source. The proposed rule establishes a presumption that source test results must be used to satisfactorily document either base year or post-control emissions. However, the rule also lists circumstances under which an owner or operator would be allowed to use methods other than source testing to document emissions for a source (for example, methods employing engineering calculations, material balances, or emission factors).

This draft document contains procedures for establishing emissions for three categories of sources. The three categories

covered in this document are synthetic organic chemical manufacturing, chromium electroplating and chromic acid anodizing, and ethylene oxide sterilization. Documents covering additional industries which will be regulated under Section 112(d) of the Act will be issued periodically by EPA.

The intent of this document, and additional documents in this series, is to provide methods for establishing emissions for the purposes of the early reduction program, with an emphasis on methods that can be used when source tests are not required. Owners or operators may use this document as a guide to preparing satisfactory emission reduction demonstrations for compliance extension requests. However, it is not the intent of this document to specify the only acceptable methods, other than source tests, for establishing emissions from a source. EPA recognizes that, depending on the circumstances, there may be other ways of satisfactorily showing that hazardous air pollutants have been controlled sufficiently to qualify for a compliance extension, and owners or operators are not precluded from using them. No matter what methods are used, the emissions established for a source and submitted in a compliance extension request will undergo review to determine whether they are adequate for the purposes of the early reduction program.

As a result of comments that may be received relating to the content of this document, this draft may undergo some revision before being issued in final form. It is anticipated that a final version of the document will be available to the public by September of this year. If a source owner or operator makes a submittal for the early reduction program based on the information contained in this draft document and this draft is revised in a way that invalidates the emission data submitted, the owner or operator will be given the opportunity to revise the emission data to conform to the procedures in the final document. Such revision will be accomplished as part of the review process for early reduction submittals, as delineated in the proposed rule.

2.0 ESTABLISHING HAP EMISSIONS FROM SOCMI SOURCES

Air emission sources in the SOCMI industry can be divided into five source types. These source types, along with a brief description, are listed below:

Process Vent Emissions - Emissions from vented process equipment such as reactors and distillation systems.

Storage Tank Emissions - Emissions from fixed roof and floating roof storage tanks.

Equipment Leak Emissions - Emissions that occur due to the escape of process materials through faulty seals in pumps, valves, compressors, flanges and other connectors, agitators, sample connections, and open-end process lines.

Transfer Emissions - Emissions that occur when loading product into tank trucks, rail cars, and marine vessels.

Wastewater Collection and Treatment Emissions - Emissions that result from the volatilization of organic hazardous air pollutants (HAP) contained in process wastewater streams.

This section describes the acceptable techniques for establishing HAP emissions from each of these emission source types. The basic approaches considered in prescribing acceptable techniques for each source type included:

(1) Measurement - Calculations based on measured concentration of the HAP in a waste stream and the flow rate of the stream.

(2) Established EPA Protocols - Engineering calculation methods presented in the US EPA publications, Compilation of Air Pollutant Emission Factors (EPA-AP-42) and Protocols for Generating Unit-Specific Emission Estimates for Equipment Leaks of VOC and VHAP (450/3-88-010). These publications provide engineering calculation approaches for sources such as storage tanks, transfer operations, and equipment leaks when direct measurement is not feasible.

(3) Engineering Calculations - These are calculations based on physical properties of the HAP, an understanding of

the process, and accepted engineering relationships such as the ideal gas law. The distinction between this technique and (2) above is that the calculation procedure has not been previously published as an accepted EPA procedure for estimating source specific emissions.

(4) Material Balance - A mass balance around the entire process or piece of equipment. The amount of chemical leaving the process equals the amount entering. If input and product stream values are known and all losses are to air, then air emissions can be computed by difference. Any accumulation or depletion of the HAP by reaction must be accounted for. In general, material balances produce emission estimates with high levels of uncertainty. However, in certain situations, material balances can be used to produce accurate emission estimates. Material balance can be used, for example, where the HAP emitted is used as a process solvent and is not involved in chemical reactions.

(5) Emission Factors - Calculations based on average measured emissions at numerous facilities in the same industry. Emission factors can be expressed as a ratio of emissions to process throughput or an emission rate independent of throughput. The distinction between this technique and (2) above is that the factor has not been previously published as an accepted EPA procedure for estimating source specific emissions.

The preferred method for determining HAP emissions is measurement of the emission stream flow and HAP concentration using published EPA Methods. However, measurement can be expensive and even impractical in cases where there are large numbers of individual sources or when the base year conditions no longer exist at an emission point and cannot be duplicated. When direct measurement is not feasible, the preferred approach is the use of established EPA computation methods in AP-42 and Protocols for Generating Unit-Specific Emission Estimates for Equipment Leaks of VOC and VHAP (450/3-88-010). In most cases, it should be feasible to establish HAP emissions data for a source using only the first two approaches. However, certain situations may require the use of engineering calculations; and in certain situations material balances can be used to establish baseline

emissions. Specific guidance on the acceptable methodologies for each source type are provided in the following subsections.

2.1 PROCESS VENTS

Process vents are the vapor exhaust devices on process equipment in a manufacturing or processing operation. In most chemical processes, impurities and inerts contained in the raw materials necessitate the continuous or periodic venting of noncondensible gases. When released to the atmosphere, volatile HAPs are carried from the process along with these noncondensible gases.

Process vents are most commonly associated with reactors and distillation systems. Direct observation of the piping and instrument diagrams should indicate if process vents exist for a given unit operation.

2.1.1 Acceptable Techniques for Establishing HAP Emissions From Process Vents.

The preferred technique for establishing HAP emissions from process vents is direct measurement. The stream flow should be determined using EPA Methods 1 through 4; and, when possible, the HAP concentration should be determined using one of the EPA Reference methods (prescribed in 40 CFR 60, Appendix A or 40 CFR 61, Appendix A) or an EPA Conditional Method. In many cases, a validated EPA method will not exist for emissions of the subject HAP from a specific source type. In such cases, the validation protocol prescribed in EPA Method 301, Field Validation of Emission Concentrations From Stationary Sources (450/4-90-015) should be used to validate the method of choice.[1]

Establishing HAP emissions for process vents is basically the same for all process vents, regardless of the unit operation. The following parameters are required through direct measurement:

- Volumetric flow rate of vent gas,

- Vent gas discharge temperature,
- Concentration of individual or aggregate HAP,
- Operating hours per year of unit operation, and
- Molecular weight of individual or aggregate HAP.

Emissions of each HAP are calculated as follows:

$$E_U = \frac{3.94E\text{-}08\ Q\ C\ h\ MW}{T + 460}$$

where,

E_U = uncontrolled HAP emission rate in Mg/yr,

Q = average vent stream flow rate in cubic feet per minute,

C = HAP concentration in ppm volume,

h = annual hours of operation,

T = vent stream discharge temperature in degrees fahrenheit,

MW = HAP molecular weight HAP, and

3.94E-08 = conversion factor to yield Mg/yr.

The total HAP emissions are determined by summing the calculated emissions of each HAP.

In cases where there is a control device present and the control device was present prior to 1987, the control device efficiency should be accounted for in determining emissions. The control device efficiency can be accounted for by: (1) measuring the stream flow and concentration at the exit of the existing control device, or (2) using the following expression:

$$E_B = E_U\ (1 - eff/100)$$

where,

E_B = emissions in Mg/yr,

E_U = uncontrolled emissions in Mg/yr, and

eff = measured HAP control efficiency of the control device.

The latter method actually requires three sets of sampling and analysis (the individual vent stream, the control device inlet, and the control device outlet), but may be necessary in situations where the vent stream is combined with other vent streams prior to control.

In cases where the control efficiency differs for individual HAPs, it is necessary to perform the above calculations separately for each HAP and then sum the emissions.

Under certain situations, emissions from process vents can be established by material balance, in lieu of sampling and analysis. Material balances can provide accurate determinations of emissions in cases where the HAP is used as a solvent, there is no reaction of the HAP, and all losses are to the air or can be accurately accounted for. In this case, the accuracy of computed HAP emissions can be as accurate as the determination of HAP usage. However, material balances are generally inaccurate in applications outside of the case where the HAP is a process solvent.

Calculations based on engineering principles are acceptable only in situations where:

(1) No applicable EPA Reference Method, EPA Conditional Method, or other source test method exists;

(2) It is not technically or economically feasible to perform source tests;

(3) It can be demonstrated to the satisfaction of the reviewing agency that the calculation will provide emission estimates of accuracy comparable to any applicable source test method;

(4) The base year conditions no longer exists and cannot be reproduced and testing under the current conditions and extrapolating will not produce results more accurate than an estimate base on engineering principles; or

(5) The emissions from one or a set of emission points in the source are small compared to total source emissions

and errors in estimating emissions from such points will not have a significant effect on the accuracy of estimated total emissions from the source.

The significance of an emission point contributes to the determination of what is technologically or economically feasible or whether the calculated value is comparable to testing. To apply the above reasons to a particular source, the owner or operator and reviewer need to use a common sense approach along with a knowledge of the emission point to determine if a calculation procedure is appropriate for establishing emissions. In general, the owner/operator and reviewer should consider how much uncertainty in total source emissions would be introduced through the calculation procedure versus source testing. In some cases, the reviewer may be able to quantify the relative uncertainty. In other situations it may only be possible to make a qualitative judgement on the accuracy. If the uncertainty in emissions is insignificant when compared to the total emissions from the facility or when compared to the uncertainty from source tests, then a calculation procedure is acceptable. For example, a source has defined three emission points. Total emissions from two of the three emission points are established by source testing to be 100 TPY. Emissions from the third emission point are calculated to be 0.5 TPY using a measured flow along with a concentration calculated using the ideal gas law and process conditions prior to discharge. Testing for this emission point is not necessary. Even if the calculations significantly underestimated the emissions, the resulting emissions would not significantly affect the total emissions.

The applicant and the reviewer should not lose site of the overall goal of the reductions demonstration which is to determine whether or not the source has made the necessary 90 (95) percent reduction in emissions of HAP. The major emission points within the source are the critical data points. The most accurate means of establishing emissions should be used for these

emissions. The most accurate means may or may not be testing. Smaller, insignificant emissions should be established using reasonable but not necessarily the most accurate procedures. The applicant is responsible for providing sufficient data to the reviewer to determine if calculations are acceptable in lieu of testing.

2.1.2 Documentation of HAP Emissions From Process Vents

In establishing emissions, the following information should be provided with the computed emission rate:

- Stream identification;
- Vent stream flow rate, method of measurement, and date of measurement;
- Vent stream discharge temperature;
- Vent stream HAP concentration, method of measurement; and date of measurement; and
- A statement that the measured flow and concentration are believed to be representative of normal operation.

A form for reporting information used to establish emissions is provided in Appendix A. In addition, detailed test data and calibration data collected during sampling and analysis of the stream should be available upon request.

2.2 STORAGE TANKS

Storage tanks for organic liquids are categorized into five basic designs: fixed roof, external floating roof, internal floating roof, variable vapor space, and pressure (high and low). For the purposes of this document variable vapor space and pressure tanks are assumed to have insignificant emissions which may be estimated as zero. Thus variable vapor space and pressure tanks are not discussed any further in this document.

Fixed roof tanks are designed as a cylindrical steel shell with a permanent roof. The roof may be flat or shaped as a cone

or dome. Fixed roof tanks have a pressure/vacuum vent which allows the tanks to operate at a slight internal pressure or vacuum. However, with significant changes in temperature, pressure, or liquid level, vapors are released through the vent. For fixed roof tanks, the vapors emitted are categorized as breathing losses and working losses. Breathing loss is the expulsion of vapor from a tank through vapor expansion and contraction, which results from changes in temperature and barometric pressure. Breathing loss occurs regardless of the throughput of the tank. Working loss is due to emptying and filling of the tank. As the tank empties, air is drawn into the tank. The outside air becomes saturated with organic vapor and expands, causing an emptying loss through the relief valve.

Floating roof tanks have a floating deck which rests on the surface of the organic liquid. The floating deck may also be the roof of the tank (external floating roof tanks) or the tank may have a permanent roof with a floating deck inside (internal floating roof). For internal floating roof tanks, the space between the floating deck and permanent roof is vented to the outside to prevent the possibility of explosion. The internal floating deck either floats directly on the liquid surface or rests on pontoons several inches above the liquid surface. The floating deck restricts the evaporation of the organic liquid. However, evaporation losses may occur between deck fittings, seams, and the space between the deck and the tank wall.

2.2.1 Acceptable Techniques For Establishing HAP Emissions From Fixed Roof Storage Tanks

The accepted technique for establishing HAP emissions from fixed roof storage tanks is the computation technique prescribed in AP-42.[2] This computation technique, along with methods for obtaining or estimating the necessary input parameters is provided in Tables 2-1 through 2-3.

The calculation techniques provided in Tables 2-1 through 2-3 are for pure component materials. In cases where the HAP is

TABLE 2-1. EQUATIONS FOR ESTIMATING FIXED-ROOF STORAGE TANK EMISSIONS[a]

$$L_T = L_B + L_W$$

$$L_B = 1.02 \times 10^{-5} M_V \left(\frac{P}{P_A - P}\right)^{0.68} D^{1.73} H^{0.51} \Delta T^{0.5} F_P C K_C$$

$$L_W = 1.09 \times 10^{-8} M_V P V N K_N K_C$$

where,

L_T = total HAP emissions in Mg/yr,

L_B = breathing loss emissions in Mg/yr,

L_W = working loss emissions in Mg/yr,

M_V = molecular weight of the HAP,

P = true vapor pressure of the HAP in psia at the stored material temperature (see Table 2-2),

P_A = atmospheric pressure in psia,

D = tank diameter in feet,

H = average vapor space height in feet (use tank specific values or an assumed value of one-half the tank height),

T = average diurnal temperature change in ^{o}F ($20^{o}F$ can be used as a typical value),

F_P = dimensionless paint factor from Table 2-3,

C = dimensionless tank diameter factor:

$C = 1$ for diameter $\geq$ 30 feet

$C = 0.0771D - 0.0013D^2 - 0.1334$ for diameter < 30 feet,

K_C = product factor = 1.0 for volatile organic HAPs,

V = tank capacity in gallons

N = number of turnovers per year,

K_N = dimensionless turnover factor:

$K_N = \frac{180 + N}{6N}$ for turnovers > 36

$K_N = 1$ for turnovers $\leq$ 36

[a]References 2 and 3.

TABLE 2-2. AVERAGE STORAGE TEMPERATURE (T_S) AS A FUNCTION OF TANK PAINT COLOR[a]

Tank Color	Average storage temperature, T_S
White	T_A[b] + 0
Aluminum	T_A + 2.5
Gray	T_A + 3.5
Black	T_A + 5.0

[a]Reference 2.
[b]T_A is the average annual ambient temperature in degrees Fahrenheit.

TABLE 2-3. PAINT FACTORS FOR FIXED ROOF TANKS[a]

Tank color		Paint factors (F_P)	
		Paint condition	
Roof	Shell	Good	Poor
White	White	1.00	1.15
Aluminum (specular)	White	1.04	1.18
White	Aluminum (specular)	1.16	1.24
Aluminum (specular)	Aluminum (specular	1.20	1.29
White	Aluminum (diffuse)	1.30	1.38
Aluminum (diffuse)	Aluminum (diffuse)	1.39	1.46
White	Gray	1.30	1.38
Light gray	Light gray	1.33	1.44[b]
Medium gray	Medium gray	1.40	1.58[b]

[a]Reference 3.
[b]Estimated from the ratios of the seven preceding paint factors.

part of a mixture, the partial pressure of the HAP should be used in place of the pure component vapor pressure. For mixtures where the HAP concentration is greater than 1 percent, Raoult's Law is deemed appropriate for computing the partial pressure. For mixtures where the HAP concentration is less than 1 percent, Henry's Law is deemed appropriate for computing the partial pressure.

2.2.2 Acceptable Techniques For Establishing HAP Emissions From Floating Roof Storage Tanks

The preferred technique for establishing HAP emissions from floating roof storage tanks is the computation technique prescribed in Estimating Air Toxics Emissions From Organic Liquid Storage Tanks (EPA-450/4-88-004).[2] These equations are provided in Tables 2-4 and 2-5. The calculation procedures prescribed are the same as those provided in AP-42, with the addition of fitting loss calculations for external floating roofs. This additional component of the external floating roof calculations was obtained from a study recently completed by the American Petroleum Institute, Evaporative Loss From External Floating-Roof Tanks (API Publication 2517).[4]

The equations provided in this Section are applicable only to freely vented internal floating roof tanks and external floating roof tanks. The equations are not intended to be used in the following applications: to estimate losses from closed internal floating roof tanks (tanks vented only through a pressure-vacuum vent); or to estimate losses from tanks in which the materials used in the seal system and/or deck construction are either deteriorated or significantly permeated by the stored liquid.[5]

Some notes and guidance for obtaining the less obvious inputs are provided in the following paragraphs.

Welded roofs. Floating roof tank emissions are the sum of rim seal, withdrawal, deck fitting, and deck seam losses. However, it should be noted that external floating roof tanks and

TABLE 2-4. EQUATIONS FOR ESTIMATING INTERNAL FLOATING ROOF STORAGE TANK EMISSIONS[a]

$$L_T = L_W + L_R + L_F + L_D$$

where:

L_T = the total loss (Mg/yr)

$$L_W = \frac{(0.943)\ Q\ C\ W_L}{D}\ [1 + (\frac{N_C F_C}{D})]/2205$$

where D = tank diameter (ft)

Q = product average throughput (bbl/yr)

C = product withdrawal shell clingage factor ($bbl/10^3\ ft^2$), see Table 2-9

W_L = density of the product (lb/gal)

N_C = number of columns (dimensionless)

F_C = effective column diameter (ft)

L_R = the rim seal loss (Mg/yr) = $(K_R D)\ P^*\ M_V\ K_C/2205$

L_F = the fitting loss (Mg/yr) = $(F_F)\ P^*\ M_V\ K_C/2205$

L_D = the deck seam loss (Mg/yr) = $(F_D\ K_D\ D^2)\ P^*\ M_V\ K_C/2205$

K_R = the rim seal loss factor (lb mole/ft yr) that for an average fitting seal is as follows:

Seal system description	K_R (lb mole/ft yr)
Vapor-mounted primary seal only	6.7
Liquid-mounted primary seal only	3.0
Vapor-mounted primary seal plus secondary seal	2.5
Liquid-mounted primary seal plus secondary seal	1.6

D = the tank diameter (ft)

TABLE 2-4. EQUATIONS FOR ESTIMATING INTERNAL FLOATING ROOF STORAGE TANK EMISSIONS (CONCLUDED)

P^* = the vapor pressure function (dimensionless)

$$P^* = 0.068\ P/((1 + (1 - 0.068\ P)^{0.5})^2)$$

P = true vapor pressure of the HAP stored (psia)

M_V = the average molecular weight of the product vapor (lb/lb mole). A typical value for VOL liquids is 80 lb/lb mole.

K_C = the product factor (dimensionless) = 1.0 for VOL

2205 = constant (lb/Mg)

F_F = the total deck fitting loss factor (lb mole/yr)

$$= \sum_{i=1}^{n} (N_{F_i}\ K_{F_i}) = [(N_{F_1}\ K_{F_1}) + (N_{F_2}\ K_{F_2}) + \ldots + (N_{F_n}\ K_{F_n})]$$

where:

N_{F_i} = number of fittings of a particular type (dimensionless). N_{F_i} is determined for the specific tank or estimated from Tables 2-6 and 2-10

K_{F_i} = deck fitting loss factor for a particular type fitting (lb mole yr). K_{F_i} is determined for each fitting type from Table 2-10

n = number of different types of fittings (dimensionless)

F_D = the deck seam length factor (ft/ft^2); see Table 2-7

K_D = the deck seam loss factor (lb mole/ft yr)
= 0 for welded decks
= 0.34 for non-welded roofs

[a]References 2 and 3.

TABLE 2-5. EQUATIONS FOR ESTIMATING EXTERNAL FLOATING ROOF STORAGE TANK EMISSIONS

$$L_T = L_W + L_{SE} + L_{RF}$$

$$L_W = 4.28 \times 10^{-4}\ QCW_L/D$$

$$L_{SE} = K_S V^N P^* D M_V K_C/2205$$

$$L_{RF} = F_F P^* M_V K_C/2205$$

$$F_F = [(N_{F_1}\ K_{F_1}) + (N_{F_2}\ K_{F_2})\ .\ .\ .\ + (N_{F_{n_f}}\ K_{F_{n_f}})]$$

where, L_T = total loss (Mg/yr)

L_W = withdrawal loss (Mg/yr)

L_{RF} = roof fitting loss (Mg/yr)

L_{SE} = seal loss from external floating roof tanks (Mg/yr)

Q = product average throughput (bbl/yr); tank capacity (bbl/turnover) x turnovers/yr

C = product withdrawal shell clingage factor (bbl/10^3 ft^2); use 0.0015 bbl/10^3 ft^2 for VOL in a welded steel tank with light rust (0.0075 for dense rust)

W_L = density of product (lb/gal); 7.4 to 8.0 lb/gal assumed as typical range for VOL liquids

D = tank diameter (ft)

K_S = seal factor: obtain from Table 3-4

V = average windspeed for the tank site (mph); 10 mph assumed average windspeed

N = seal windspeed exponent (dimensionless): obtain from Table 3-4

P* = the vapor pressure function (dimensionless); $P^* = 0.068P/((1 + (1 - 0.068P)^{0.5})^2)$
P = the true vapor pressure of the materials stored (psia)

TABLE 2-5. EQUATIONS FOR ESTIMATING EXTERNAL FLOATING ROOF STORAGE TANK EMISSIONS (CONCLUDED)

M_V = molecular weight of product vapor (lb/lbmole)

K_C = product factor (dimensionless) = 1.0 for VOL

F_F = total roof fitting loss factor, lb-mol/yr

N_{F_i} = number of deck fittings of a particular type ($i = 0,1,2,...,n_f$), dimensionless, see Table 2-11, 2-12, and 2-13)

K_{F_i} = roof fitting loss factor for a particular type fitting ($i = 0,1,2,...,n_f$), lb-mol/yr, see Table 2-11

n_f = total number of different types of fittings, dimensionless

welded internal floating roofs do not have deck seam losses. There are no procedures in AP-42 for estimating emissions from external floating roof tank deck fittings. However, the newly developed API procedures do include factors for deck fittings.

Number of columns. For a self-supporting fixed roof or external floating roof, no columns are used. If the number of columns is not known, Table 2-6 gives a typical number of columns based on tank diameter. If the diameter of the columns is unknown, the following values may be used:

1.1 for 9 inch by 7 inch built-up columns;
0.7 for 8 inch diameter pipe columns; and
1.0 if column construction details are not known.

Deck seam length. For internal floating roof tanks with bolted decks, the deck seam length factor (S_D) may be approximated if the total length of deck seams is unknown. The factors are presented in Table 2-7. If no specific information is available, an S_D of 0.20 ft/ft^2 can be assumed.

Rim seal losses. For the rim seal loss, the seal factors and seal related wind speed exponents are listed in Table 2-8. If no data are available for the type of rim seal, a default of 1.0 may be used.

Clingage factors. For withdrawal loss, the shell clingage factors are presented in Table 2-9. If no shell condition information is available, the light rust condition may be assumed.

Fitting loss factors. Once the number and type of deck fittings are known for an internal floating roof tank, Table 2-10 is can be used to obtain individual deck fitting loss factors. For external floating roof tanks, fitting loss factors and the typical number of roof fittings are provided in Tables 2-11, 2-12, and 2-13.

Mixtures. In case where the HAP is part of a stored mixture, the partial pressure of the HAP should be substituted

TABLE 2-6. TYPICAL NUMBER OF COLUMNS AS A FUNCTION OF TANK DIAMETER FOR INTERNAL FLOATING ROOF TANKS WITH COLUMN SUPPORTED FIXED ROOFS[a]

Tank diameter range D (ft)	Typical number of columns, N_C
$0 < D \leq 85$	1
$85 < D \leq 100$	6
$100 < D \leq 120$	7
$120 < D \leq 135$	8
$135 < D \leq 150$	9
$150 < D \leq 170$	16
$170 < D \leq 190$	19
$190 < D \leq 220$	22
$220 < D \leq 235$	31
$235 < D \leq 270$	37
$270 < D \leq 275$	43
$275 < D \leq 290$	49
$290 < D \leq 330$	61
$330 < D \leq 360$	71
$360 < D \leq 400$	81

[a]Reference 2. This table was derived from a survey of users and manufacturers. The actual number of columns in a particular tank may vary greatly with age, fixed roof style, loading specifications, and manufacturing perogatives. Data in this table should not supersede information on actual tanks.

TABLE 2-7. DECK SEAM LENGTH FACTORS (S_D) FOR TYPICAL DECK CONSTRUCTIONS FOR INTERNAL FLOATING ROOF TANKS[a]

Deck Construction	Typical deck seam length factor, S_D (ft/ft^2)
Continuous sheet construction[b]	0.20[c]
5 ft wide	0.17
6 ft wide	0.14
7 ft wide	
Panel construction[d]	
5 x 7.5 ft rectangular	0.33
5 x 12 ft rectangular	0.28

[a]Reference 2. Deck seam loss applies to bolted decks only.

[b]$S_D = \frac{1}{W}$, where W = sheet width (ft)

[c]If no specific information is available, these factors can be assumed to represent the most common bolted decks currently in use.

[d]$S_D = \frac{(L+W)}{LW}$, where W = panel width (ft) and L = panel length (ft)

TABLE 2-8. SEAL RELATED FACTORS FOR FLOATING ROOF TANKS[a]

Tank and seal type	Welded Tank		Reveted Tank	
	K_S	N	K_S	N
External floating roof tanks[b]				
Metallic shoe seal	1.2	1.5	1.3	1.5
Primary seal only	0.8	1.2	1.4	1.2
With shoe mounted secondary seal	0.2	1.0	0.2	1.6
With rim mounted secondary seal				
Liquid mounted resilient seal	1.1	1.0	NA[c]	NA
Primary seal only	0.8	0.9	NA	NA
With weather shield	0.7	0.4	NA	NA
With rim mounted secondary seal				
Vapor mounted resilient seal	1.2	2.3	NA	NA
Primary seal only	0.9	2.2	NA	NA
With weather shield	0.2	2.6	NA	NA
With rim mounted secondary seal				
Internal floating roof tanks[d]				
Liquid mounted resilient seal	3.0	0	NA	NA
Primary seal only	1.6	0	NA	NA
With rim mounted secondary seal[e]				
Vapor mounted resilient seal	6.7	0	NA	NA
Primary seal only	2.5	0	NA	NA
With rim mounted secondary seal[e]				

[a]Based on emissions from tank seal systems in reasonably good working condition, no visible holes, tears, or unusually large gaps between the seals and the tank wall. The applicability of K_S decreases in cases where the actual gaps exceed the gaps assumed during development of the correlation.

[b]Reference 3.

[c]NA = Not Applicable.

[d]Reference 2.

[e]If tank specific information is not available about the secondary seal on an internal floating roof tank, then assume only a primary seal is present.

TABLE 2-9. AVERAGE CLINGAGE FACTORS (C) (bbl/1,000 ft^2)[a]

Liquid	Shell condition		
	Light rust[b]	Dense rust	Gunite lined
Gasoline	0.0015	0.0075	0.15
Single component stocks	0.0015	0.0075	0.15
Crude oil	0.0060	0.030	0.60

[a]Reference 2.
[b]If no specific information is available, these values can be assumed to represent the most common condition of tanks currently in use.

TABLE 2-10. SUMMARY OF INTERNAL FLOATING DECK FITTING LOSS FACTORS (K_F) AND TYPICAL NUMBER OF FITTINGS (N_F)[a]

Deck fitting type	Deck fitting loss factor, K_F (lb-mole/yr)	Typical number of fittings N_F
Access hatch		1
Bolted cover, gasketed	1.6	
Unbolted cover, gasketed	11	
Unbolted cover, ungasketed	25[b]	
Automatic gauge float well		1
Bolted cover, gasketed	5.1	
Unbolted cover, gasketed	15	
Unbolted cover, ungasketed	28[b]	
Column well		(see Table 2-5)
Builtup column-sliding cover, gasketed	33	
Builtup column-sliding cover, ungasketed	47[b]	
Pipe column-flexible fabric sleeve seal	10	
Pipe column-sliding cover, gasketed	19	
Pipe column-sliding cover, ungasketed	32	
Ladder well		1
Sliding cover, gasketed	56	
Sliding cover, ungasketed	76[b]	
Roof leg or hanger well		$(5 + \frac{D}{10} + \frac{D^2}{600})$[c]
Adjustable	7.9[b]	
Fixed	0	
Sample pipe or well		1
Slotted pipe-sliding cover, gasketed	44	
Slotted pipe-sliding cover, ungasketed	57	
Sample well-slit fabric seal, 10 percent open area	12[b]	
Stub drain, 1 inch diameter[d]	1.2	$(\frac{D^2}{125})$[c]
Vacuum breaker		1
Weighted mechanical actuation, gasketed	0.7[b]	
Weighted mechanical actuation, ungasketed	0.9	

[a]Reference 2.
[b]If no specific information is available, this value can be assumed to represent the most common/typical deck fittings currently used.

TABLE 2-10. SUMMARY OF INTERNAL FLOATING DECK FITTING LOSS FACTORS (K_F) AND TYPICAL NUMBER OF FITTINGS (N_F)[a] (CONCLUDED)

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[c]D = tank diameter (ft).
[d]Not used on welded contact internal floating decks.

TABLE 2-11. EXTERNAL ROOF FITTING LOSS FACTORS (K_{fa}, K_{fb}) AND TYPICAL NUMBER OF ROOF FITTINGS (N_F)[a]

Roof fitting type and construction details	Roof fitting loss factors: K_{fa} $\left(\frac{\text{lb-mole}}{\text{yr}}\right)$	K_{fb} $\left(\frac{\text{lb-mole}}{[\text{mi/h}]^n\ \text{yr}}\right)$	m (dimensionless)	Typical No. of fittings, N_F[b]
1. Access hatch (24-inch diameter well)				1
a. Bolted cover, gasketed	0	0	0[b]	
b. Unbolted cover, ungasketed	2.7	7.1	1.0	
c. Unbolted cover, gasketed	2.9	0.41	1.0	
2. Guide pole well (8-inch diameter unslotted pole, 21-inch diameter well)				1
a. Ungasketed sliding cover, without float	0	67	0.98[b]	
b. Gasketed sliding cover	0	3.0	1.4	
3. Guide pole/sample well (8-inch diameter slotted pole, 21-inch diameter well)				c
a. Ungasketed sliding cover, without float	0	310	1.2	
b. Ungasketed sliding cover, with float	0	29	2.0	
c. Gasketed sliding cover, without float	0	260	1.2	
d. Gasketed sliding cover, with float	0	8.5	2.4	
4. Gauge float well (20-inch diameter well)				1
a. Unbolted cover, ungasketed	2.3	5.9	1.0[b]	
b. Unbolted cover, gasketed	2.4	0.34	1.0	
c. Bolted cover, gasketed	0	0	0	
5. Gauge hatch/sample well (8-inch diameter well)				1
a. Weighted mechanical actuation, gasketed	0.95	0.14	1.0[b]	
b. Weighted mechanical actuation, ungasketed	0.91	2.4	1.0	
6. Vacuum breaker (10-inch diameter well)				See Table 2-12
a. Weighted mechanical actuation, gasketed	1.2	0.17	1.0[b]	
b. Weighted mechanical actuation, ungasketed	1.1	3.0	1.0	
7. Roof drain (3-inch diameter)				See Table 2-12
a. Open	0	7.0	1.4[e]	
b. Closed, 90 percent	0.51	0.81	1.0[e]	

(continued)

TABLE 2-11. EXTERNAL ROOF FITTING LOSS FACTORS (K_{fa}, K_{fb}) AND TYPICAL NUMBER OF ROOF FITTINGS (N_F)[a] (CONCLUDED)

Roof fitting type and construction details	Roof fitting loss factors: K_{fa} $\left(\frac{\text{lb-mole}}{\text{yr}}\right)$	K_{fb} $\left(\frac{\text{lb-mole}}{[\text{ml/h}]^n\ \text{yr}}\right)$	m (dimensionless)	Typical No. of fittings, N_F[b]
8. Roof leg (3-inch diameter leg)				See Table 2-13
a. Adjustable, pontoon area	1.5	0.20	1.0[b]	
b. Adjustable, center area	0.25	0.067	1.0[b]	
c. Adjustable, double-deck roofs	0.25	0.067	1.0	
D. Fixed	0			
Roof leg (2 1/2 inch diameter leg)				
e. Adjustable, pontoon area	1.7	0	0	
f. Adjustable, center area	0.41	0	0	
g. Adjustable, double-deck roofs	0.41	0	0	
h. Fixed	0	0	0	
9. Rim vent (6-inch diameter)				1.0[d]
a. Weighted mechanical actuation, gasketed	0.71	0.10	1.0[b]	
b. Weighted mechanical actuation, ungasketed	0.68	1.8	1.0	

[a]The roof fitting loss factors (K_{fa}, K_{fb}, m) may be used only for wind speeds from 2 to 15 ml/h.

[b]If no specific information is available, this value can be assumed to represent the most common or typical roof fittings currently in use.

[c]Guide pole/sample well is an optional fitting not typically used.

[d]Rim vents are used only with mechanical shoe primary seals.

[e]Roof drains that drain excess rainwater into the product are not used on pontoon floating roofs. They are, however, used on double-deck floating roofs and are typically left "open."

TANK 2-12. TYPICAL NUMBER OF VACUUM BREAKERS AND ROOF DRAINS, N_F

Tank Diameter, D (feet)[a]	Number of Vacuum Breakers, N_F		Number of Roof Drains, N_F (Double-deck Roof)[b]
	Pontoon Roof	Double-deck Roof	
50	1	1	1
100	1	1	1
150	2	2	2
200	3	2	3
250	4	3	5
300	5	3	7
350	6	4	-
400	7	4	-

[a]If the actual diameter is between the diameters listed, the closet diameter listed should be used. If the actual diameter is midway between the diameters listed, the next larger diameter should be used.

[b]Roof drains that drain excess rainwater into the product are not used on pontoon floating roofs. They are, however, used on double-deck floating roofs and are typically left open.

TANK 2-13. TYPICAL NUMBER OF EXTERNAL FLOATING ROOF LEGSa

Tank diameter, d(ft)[b]	Pontoon Roof		Double-deck roof legs
	Pontoon legs	Center legs	
30	4	2	6
40	4	4	7
50	6	6	8
60	9	7	10
70	13	9	13
80	15	10	16
90	16	12	20
100	17	16	25
110	18	20	29
120	19	24	34
130	20	28	40
140	21	33	46
150	23	38	52
160	26	42	58
170	27	49	66
180	28	56	74
190	29	62	82
200	30	69	90
210	31	77	98
220	32	83	107
230	33	92	115
240	34	101	127
250	35	109	138
260	36	118	149
270	36	128	162
280	37	138	173
290	38	148	186
300	38	156	200
310	39	168	213
320	39	179	226
330	40	190	240
340	41	202	255
350	42	213	270
360	44	226	285
370	45	238	300
380	46	252	315
390	47	266	330
400	48	281	345

[a]This table was derived from a survey of users and manufacturers. The actual number of roof legs may vary greatly depending on age, floating roof style, loading specifications, and manufacturing prerogatives. This table should not supersede information based on actual tank data.

[b]If the actual diameter is between the diameters listed, the closest diameter listed should be used. If the diameter is midway between the diameters listed, the next larger diameter should be used.

for the pure component vapor pressure as described above for fixed roof tanks.

2.2.3 Documentation of HAP Emissions From Storage Tanks

All storage tank characteristics, tank throughput data, and HAP physical property data used to perform storage tank emission calculations should be provided for each tank. A set of forms listing the required computation inputs is provided in Appendix A. The appropriate form in Appendix A should be completed and submitted for each storage tank.

2.3 EQUIPMENT LEAKS

Leaks occur from plant equipment that have a point of interface of the process fluid with the atmosphere. These points of interface such as seals, packings, and gaskets have a tendency to fail mechanically and thereby leak process fluid. The major sources of equipment leaks include pumps, valves, flanges and other connectors, compressors, sampling connection systems, open-ended lines, agitators, and pressure relief valves. Detailed discussions of these emission sources are presented in two EPA reports.[6,7] A brief discussion of these sources is presented below.

Pumps. Pumps are used extensively in process units for the movement of organic liquids. The centrifugal pump is the most widely used pump. However, other types, such as the positive-displacement, reciprocating and rotary action, and special canned and diaphragm pumps, are also used. Chemicals transferred by pumps can leak at the point of contact between the moving shaft and stationary casing. Consequently, all pumps except the shaftless type (canned-motor and diaphragm) require a seal at the point where the shaft penetrates the housing in order to isolate the pump's interior from the atmosphere.

Two generic types of seals, packed and mechanical, are currently in use. Packed seals can be used on both reciprocating

and rotary action types of pumps. A packed seal consists of a cavity ("stuffing box") in the pump casing filled with special packing material that is compressed with a packing gland to form a seal around the shaft, Deterioration of the packing results in process liquid leaks.

Mechanical seals are limited in application to pumps with rotating shafts and can be further categorized as single and double mechanical seals. Depending on the condition and flatness of the seal faces, the leakage rate from a mechanical seal can be quite low (as small as a drop per minute) and the flow is often not visually detectable. In order to minimize emissions due to seal leakage, an auxiliary sealing device such as packing can be employed.

Valves. The types of valves commonly used in organic chemical plants are globe, gate, plug, ball, relief, and check valves. All except the relief valve (to be discussed further below) and check valve are activated by a valve stem, which may have either a rotational or linear motion, depending on the specific design. This stem requires a seal to isolate the process fluid inside the valve from the atmosphere. The possibility of a leak through this seal makes it a potential source of emissions. Since a check valve has no stem or subsequent packing gland, it is not considered to be a potential source of emissions.

Compressors. Gas compressors used in process units are similar to pumps in that they can be driven by rotary or reciprocating shafts. They are also similar to pumps in their need for shaft seals to isolate the process gas from the atmosphere. As with pumps, these seals are likely to be the source of emissions from compressors.

Shaft seals for compressors may be chosen from several different types: labyrinth, restrictive carbon rings, mechanical contact, and liquid film. All of these seal types are leak restriction devices; none of them completely eliminate leakage.

Many compressors may be equipped with ports in the seal area to evacuate gases collecting there.

Safety Relief Devices. Engineering codes require that pressure-relieving devices or systems be used in applications where the process pressure may exceed the maximum allowable working pressure of the vessel. The most common type of pressure-relieving device used in process units is the pressure relief valve. Typically, safety relief valves are spring-loaded and designed to open when the process pressure exceeds a set pressure, allowing the release of vapors or liquids until the system pressure is reduced to its normal operating level. When the normal pressure is reattained, the valve reseats, and a seal is again formed. The seal is a disk on a seat, and the possibility of a leak through this seal makes the pressure relief valve a potential source of emissions. Two potential causes of leakage from safety relief valves are: "simmering or popping," a condition due to the system pressure being close to the set pressure of the valve, and improper reseating of the valve after a relieving operation.

Open-Ended Lines. Some valves are installed in a system so that they function with the downstream line open to the atmosphere. Examples are purge valves, drain valves, and vent valves. A faulty valve seat or incompletely closed valve would result in leakage through the valve and emissions to the atmosphere.

Sampling Connections. The operation of a process unit is checked periodically by routing analyses of feedstocks and products. To obtain representative samples for these analyses, sampling lines must first be purged prior to sampling. The purged liquid or vapor is sometimes drained onto the ground or into a sewer drain, where it can evaporate and release emissions to the atmosphere.

Flanges. Flanges are bolted, gasket-sealed junctions used wherever pipe or other equipment such as vessels, pumps, valves, and heat exchangers may require isolation or removal. Normally,

flanges are employed for pipe diameters of 50 mm or greater and are classified by pressure and face type.

Flanges may become emission sources when leakage occurs due to improperly chosen gaskets or a poorly assembled flange. The primary cause of flange leakage is due to thermal stress that piping or flanges in some services undergo; this results in the deformation of the seal between the flange faces.

Agitators. Agitators are technologically similar to pumps and, like pumps, can be controlled using seal technology. Although agitators have longer and larger diameter shafts than pumps and produce greater tangential shaft loadings, the emission factors used for calculating leaks from pumps are currently acceptable for use in calculating leaks from agitators, due to the lack of emissions data for agitators.

2.3.1 Accepted Techniques For Establishing HAP Emissions From Equipment Leaks

There are five methods for establishing emissions from equipment leaks. These methods, in increasing order of complexity and accuracy, are:

- Average emission factor method;
- Leak/no-leak emission factor method;
- Three-strata emission factor method;
- Application of EPA correlations; and
- Development of new correlations.

A detailed discussion of the above methods is presented in the EPA report Protocols for Generating Unit-Specific Emission Estimates for Equipment Leaks of VOC and VHAP.[8] All methods start with obtaining an accurate identification and count of equipment to be included. The equipment counts can simply be used with the EPA's previously developed emission factors. The next step in complexity and refinement is the use of a portable organic analyzer to find the number of leaking and nonleaking

sources. Leaking and nonleaking emission factors developed by the EPA can then be applied to generate the emissions. These factors are presented in Table 2-14.

A final refinement is a method employing discrete emission factors. In this approach emission factors are applied to represent three different ranges of screening values. This has been called the stratified emission factor approach, or the three-strata approach. Applying the stratified emission factors requires more rigorous measurement of organic vapor concentrations with a portable instrument because actual concentration readings must be recorded instead of noting whether a piece of equipment is classified as leaking or not leaking. stratified emission factors developed by the EPA can then be applied to generate the emission estimate. These factors are presented in Table 2-15.

The remaining two methods make use of correlations relating mass emissions to organic concentrations measured with a portable organic analyzer. The EPA's previously developed correlations are offered for use, and finally, if a process unit's emissions are statistically different from those represented by the EPA's correlations, provision is made for development of correlations specifically for that process unit.

For the purpose of establishing emission levels for the early emission reduction program, EPA does not consider the average emission factor method to be appropriate. These emission factors were based on data from process units with a wide range of equipment leak frequencies. A given process unit may not have leak frequencies similar to the average leak frequencies of these process units. The application of these factors could, therefore, result in erroneous emission estimates.

The other four emission estimate methods are considered acceptable for the purpose of establishing baseline emissions. The most accurate estimates are obviously made through development of new correlations. However, requiring the use of

TABLE 2-14. LEAKING AND NON-LEAKING EMISSION FACTORS FOR FUGITIVE EMISSIONS (kg/yr/source)[a]

Equipment	Service	Leaking (>10,000 ppmv) Emission Factor	Non Leaking (<10,000 ppmv) Emission Factor
Valves	Gas/Vapor[b]	0.0451	0.00048
	Light liquid	0.0852	0.00171
	Heavy liquid	0.00023[c]	0.00023
Pump Seals	Light liquid	0.437	0.0120
	Heavy liquid	0.3885	0.0135
Compressor Seals[d]	Gas/Vapor	1.608	0.0894
Pressure Relief Valves	Gas/Vapor	1.691	0.0447
Flanges	All	0.0375	0.00006
Open-Ended Lines	All	0.01195	0.00150

[a]Reference 8.

[b]The leaking and non-leaking emission factors for valves in gas/vapor service are based upon the emission factors determined for gas valves in ethylene, cumene, and vinyl acetate units during the SOCMI Maintenance Study.

[c]Leaking emission factor assumed equal to non-leaking emission factor since the computed leaking emission factor (0.00005 kg/hr/source) was less than the non-leaking emission factor.

[d]Emission factor reflects existing control level of 60 percent found in the industry; control is through the use of barrier fluid/degassing reservoir/vent-to-flare or other seal leakage capture system.

TABLE 2-15. STRATIFIED EMISSION FACTORS FOR EQUIPMENT LEAKS[a] (kg/hr/source)

Source	Service	Emission Factors (kg/yr/source) for Screening Value Range, ppmv		
		0-1,000	1,001-10,000	>10,000
Compressor Seals[d]	Gas/vapor	0.01132	0.264	1.608
Pump seals	Light liquid	0.00198	0.0335	0.437
	Heavy liquid	0.00380	0.0926	0.3885
Valves	Gas/vapor[b]	0.00014	0.00165	0.0451
	Light liquid	0.00028	0.00963	0.0852
	Heavy liquid	0.00023[c]	0.00023[c]	0.00023
Flanges, connections	All	0.00002	0.00875	0.0375
Pressure Relief devices	Gas/vapor	0.0114	0.279	1.691
Open-ended Lines	All	0.00013	0.00876	0.01195

[a]Reference 8.

[b]The leaking and non-leaking emission factors for valves in gas/vapor service are based upon the emission factors determined for gas valves in ethylene, cumene, and vinyl acetate units during the SOCMI Maintenance Study.

[c]Leaking emission factor assumed equal to non-leaking emission factor since the computed leaking emission factor (0.00005 kg/hr/source) was less than the non-leaking emission factor.

[d]Emission factor reflects existing control level of 60 percent found in the industry; control is through the use of barrier fluid/degassing reservoir/vent-to-flare or other seal leakage capture system.

this method can be costly and may discourage many facilities from pursuing the early emission reduction program.

The leak/no-leak emission factor method, while a significant improvement over the average emission factor method, may yield estimates that are not completely accurate. However, these estimates are considered to be within reasonable ranges of accuracy. In addition, many facilities are expected to have leak/no-leak frequency data already available which may encourage them to implement an early emission reduction program.

2.3.2 Documentation of HAP Emissions From Equipment Leaks

The documentation requirements discussed in this section relate to the leak/no leak emission factor method. If a facility chooses to use one of the more refined methods, the documentation requirements will be considered on a case by case basis.

For the leak/no leak or stratified method, the following information should be provided along with the computed emissions:

- Equipment count by equipment type (i.e., vapor valves, liquid valves, etc.),
- Period during which screening was conducted,
- A description of any deviations from EPA Method 21 procedures,
- Percent of sources found leaking (by source type) or measured concentration,
- HAP content as percent of VOC,
- Number of sources in facility that were considered difficult to monitor and not screened.

Forms for reporting this information and computing baseline emissions are provided in Appendix A for both the leak/no leak approach and the stratified emission factor approach.

2.4 TRANSFER OPERATIONS

Loading losses are the primary source of evaporative emissions from rail tank car, tank truck and marine vessel transfer operations. Loading losses occur as organic vapors in "empty" cargo tanks are displaced to the atmosphere by the liquid being loaded into the tanks. These vapors are a composite of (1) vapors formed in the empty tank by evaporation of residual product from previous loads, (2) vapors transferred to the tank in vapor balance systems as product is being unloaded, and (3) vapors generated in the tank as the new product is being loaded. The quantity of evaporative losses from loading operations is, therefore, a function of the following parameters.

- Physical and chemical characteristics of the previous cargo,
- Method of unloading the previous cargo,
- Method of loading the new cargo, and
- Physical and chemical characteristics of the new cargo.

The three principal loading methods are splash loading, submerged loading, and vapor balance loading. In the splash loading method, the fill pipe dispensing the cargo is lowered only partway into the cargo tank. Significant turbulence and vapor/liquid contact occur during the splash loading operation, resulting in high levels of vapor generation and loss. If the turbulence is great enough, liquid droplets will be entrained in the vented vapors.

A second method of loading is submerged loading. Two types are the submerged fill pipe method and the bottom loading method. In the submerged fill pipe method, the fill pipe extends almost to the bottom of the cargo tank. In the bottom loading method, a permanent fill pipe is attached to the cargo tank bottom. The fill pipe opening is below the liquid surface level, during most of the loading operation. Liquid turbulence is controlled significantly, resulting in much lower vapor generation than encountered during splash loading.

The recent loading history of a cargo carrier is just as important a factor in loading losses as the method of loading. If the carrier has carried a nonvolatile liquid such as fuel oil, or has just been cleaned, it will contain vapor free air. If it has just carried a volatile HAP and has not been vented, the air in the carrier tank will contain volatile organic vapors, which are expelled during the loading operation along with newly generated vapors.

Cargo carriers are sometimes designated to transport only one product, and in such cases are practicing "dedicated service". Dedicated cargo tanks return to a loading terminal containing air fully or partially saturated with vapor from the previous load. Cargo tanks may also be "switch loaded" with various products, so that a nonvolatile product being loaded may expel the vapors remaining from a previous load of a volatile product. These circumstances vary with the type of cargo tank and with the ownership of the carrier, the petroleum liquids being transported, geographic location, and season of the year.

One control measure for tank truck loading is called "vapor balance service", in which the cargo tank retrieves the vapors displaced during product unloading, and transports the vapors back to the loading terminal. A cargo tank in vapor balance service normally is saturated with organic vapors, and the presence of these vapors at the start of submerged loading results in greater loading losses than encountered during nonvapor balance, or "normal", service. Vapor balance service is usually not practiced with marine vessels, although some vessels practice emission control by means of vapor transfer within their own cargo tanks during ballasting operations.

2.4.1 Accepted Techniques for Establishing Emissions from Transfer Operations

Emissions of each HAP can be established using the following expression for each type of loading operation:[9]

$$L_L = 5.65E-03 \frac{SPMG}{T}$$

where: L_L = loading loss, Mg/yr,

M = molecular weight of the HAP, lb/lb-mole

P = true vapor pressure of the HAP loaded, psia

G = annual volume of liquid loaded, gallons,

T = temperature of bulk liquid loaded, ^{o}R (^{o}F + 460),

S = saturation factor (see Table 2-16)

The saturation factor, S, represents the expelled vapor's fractional approach to saturation, and it accounts for the variations observed in emission rates from the different unloading and loading methods. Table 2-16 lists the saturation factors for various cargo vessels and modes of operation.

In cases where the HAP is part of a mixture rather than a pure component, the partial pressure of the HAP should be used in place of the pure component vapor pressure. For mixtures where the HAP concentration is greater than 1 percent by volume, Raoult's Law is deemed appropriate for computing the partial pressure. For mixtures where the HAP concentration is less than 1 percent, Henry's Law is deemed appropriate for computing the partial pressure.

Total HAP emissions from loading are computed by summing the loading losses of individual HAPs from each material loaded via each loading method. In cases where numerous materials are loaded during the year by various loading techniques (i.e., submerged fill, splash fill, vapor balance), it is important that the HAP emissions are calculated separately for each set of conditions and then summed.

2.4.2 Documentation of HAP Emissions From Loading Operations

Loading operation characteristics, volumes loaded into each vessel type, and the HAP physical property data used to perform

TABLE 2-16. SATURATION (S) FACTORS FOR CALCULATING ORGANIC LIQUID LOADING LOSSES[a]

Cargo Carrier	Mode of Operation	S Factor
Tank trucks and rail tank cars	Submerged loading of a clean cargo tank	0.50
	Submerged loading: dedicated normal service	0.60
	Submerged loading: dedicated vapor balance service	1.00
	Splash loading of a clean cargo tank	1.45
	Splash loading: dedicated normal service	1.45
	Splash loading: dedicated vapor balance service	1.00
Marine vessels	Submerged loading: ships	0.2
	Submerged loading: barges	0.5

[a]Reference 9.

loading operation emission calculations should be provided for each material/vessel type. A set of forms listing the required computation inputs is provided in Appendix A. The form provided in Appendix A should be completed and submitted for each combination of material loaded, cargo carrier, and mode of operation.

2.5 WASTEWATER COLLECTION AND TREATMENT

In the manufacture of chemical products, wastewater streams are generated which contain volatile organics. These wastewaters are collected and treated in a variety of ways. Some of these collection and treatment steps result in the emission of volatile organics from the wastewater into the ambient air. This subsection provides a discussion of the potential sources of emissions during wastewater collection and treatment, and techniques for establishing air emissions from wastewater sources.

The industries covered by the Hazardous Organic NESHAP differ in structure and manufacture a wide variety of products. However, many of the chemical processes employed within these industries use similar organic compounds as raw materials, solvents, catalysts, and extractants. In addition, many of these processes also generate similar organic by-products during reaction steps. Consequently, many of the wastewater streams generated by the targeted industries are similar in organic content. These organic containing wastewater streams result from both the direct and indirect contact of water with organic compounds.

Water comes in direct contact with organic compounds due to many different chemical processing steps. As a result of this contact, wastewater streams are generated which must be discharged for treatment or disposal. A few sources of process wastewater are:[10]

- Water used to wash impurities from organic products or reactants;
- Water used to cool or quench organic vapor streams;
- Condensed steam from jet eductor systems pulling vacuum on vessels containing organics;
- Water used as a carrier for catalysts and neutralizing agents (e.g., caustic solutions); and
- Water formed as a by-product during reaction steps.

Two additional types of direct contact wastewater are landfill leachate and water used in equipment washes and spill cleanups. These two types of wastewater are normally more variable in flow and concentration than the streams previously discussed. In addition, landfill leachate and spill cleanups may be collected for treatment differently than the wastewater streams discharged from process equipment such as scrubbers, decanters, evaporators, distillation columns, reactors, and mixing vessels.

Wastewater streams which do not come in contact with organic compounds in the process equipment are defined as "indirect-contact" wastewater. However, a potential exists for organic contamination of these wastewater types. Water streams which are contaminated as a result of leaks from heat exchangers, condensers and pumps (pump seal water) are examples of non-contact wastewater. These indirect contact wastewaters may or may not be collected and treated in the same manner as direct contact wastewaters. Pump seal water is normally collected in area drains which tie into the process wastewater collection system. This wastewater is then combined with direct contact wastewater and transported to the wastewater treatment plant. Wastewater contaminated from condenser and heat exchanger leaks are often collected in different systems and bypass some of the treatment steps used in the treatment plant.

Wastewater streams are collected and treated in a variety of ways. Generally, wastewater passes through a series of collection and treatment units before being discharged from a

facility. Table 2-17 presents a list of components that may be sources of emissions in facility collection and treatment systems. 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 air 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 emissions depends greatly on many factors such as the physical properties of the pollutants, 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 an effect on air emissions.

2.5.1 Accepted Techniques for Establishing HAP Emissions From Wastewater Collection and Treatment

The accepted approach for establishing emissions from wastewater sources is direct measurement of the volatile organic HAP content and measurement or estimation of the wastewater flow. However, considering the expense of sampling and analysis, only those streams with average annual flows greater than 10 liters per minute (lpm) must be sampled. A more detailed description of the accepted approach is provided below.

Identification of wastewater sources. The first step towards establishing emissions from wastewater sources is the identification of all wastewater streams within the process or facility. As described above, there are two general types of organic containing wastewaters: direct contact and indirect contact. In general direct contact wastewaters account for the majority of HAP loadings in facility wastewaters. Therefore, the focus should be on direct contact process wastewater streams. Examples of direct contact wastewater streams are water used to wash impurities from organic reactants or products; water formed

TABLE 2-17. EMISSION SOURCES IN WASTEWATER COLLECTION AND TREATMENT SYSTEMS[a]

Wastewater Collection System:
Drains
Junction Boxes
Lift Stations
Manholes
Trenches
Sumps
Surface Impoundments
Wastewater Treatment Units:
Weirs
Oil/Water Separators
Equalization Basins or Neutralization Basins
Clarifiers
Aeration Basins
pH Adjustment Tanks
Flocculation Tanks

[a]Reference 10.

as a reaction by-product; water used as a carrier for catalyst, reactants, oxidizing agents, or neutralizing agents; and steam jet vacuum condensates. These wastewater streams may be discharged to the wastewater collection system from scrubbers, decanters, distillation columns, or reactors.

In identifying wastewater streams, it is important to identify the wastewater stream at the point of generation, prior to contact with ambient air and prior to mixing with other . Since volatilization of HAPs in the wastewater occurs upon contact with ambient air, the point of generation represents the point at which the greatest emission potential exists. In most cases, the first point of atmospheric exposure is when the wastewater stream is discharged into the process area sewer system. These sewer systems are typically underground, but are open to the atmosphere.

Measurement of stream flow and concentration. After identifying all facility or process wastewater streams, both continuous and intermittent, the next step is to either measure or estimate the average flowrate (annual basis). This must be done for each wastewater stream, at the point of generation. In cases where measurement is not feasible, an average annual flow rate can be estimated based on engineering calculations such as heat and material balances.

It is preferable to measure the HAP concentration of each stream. However, calculations based on engineering principles or material balance data are acceptable in situations where:

(1) No applicable EPA Reference Method, EPA Conditional Method, or other source test method exists;

(2) It is not technically or economically feasible to perform source tests;

(3) It can be demonstrated to the satisfaction of the reviewing agency that the calculation will provide emission estimates of accuracy comparable to any applicable source test method;

(4) The base year conditions no longer exists and cannot be reproduced and testing under the current conditions and extrapolating will not produce results more accurate

than an estimate base on engineering principles or material balance; or

(5) The emissions from one or a set of emission points in the source are small compared to total source emissions and errors in estimating emissions from such points will not have a significant effect on the accuracy of estimated total emissions from the source.

The burden of adequately demonstrating one of these reasons for not source testing is placed on the source owner or operator.

If source tested, a representative grab sample of each stream should be obtained at the point of generation. It is important that the sample be taken at a time representative of normal flow. Additionally, attempts should be made to collect a sample representative of average annual concentrations. In the case of highly variable flow and concentration, a sufficient number of samples need to be taken to characterize the stream with respect to a flow-weighted annual average.

Each sample should be collected and analyzed using EPA Method 25D in combination with Method 18. Method 25D is a method developed specifically for quantifying the organic emission potential of a wastewater stream. Since Method 25D was developed for VOC quantification, the analytical instruments employed are a flame ionization detector (FID) and halogen detector. Specific HAP concentrations can be quantified by running Method 18 on the vent stream by replacing the FID/halogen detector with a gas chromatograph and following the procedures prescribed in Method 18. It is important that the sampling and purge procedures prescribed in Method 25 are followed.

In cases where all volatile organics suspected to be present in the wastewater stream are HAPs, it is acceptable to use Method 25D alone. In this case, the measured VOC concentration is accepted as the HAP concentration.

Compute emission potential. After both the average annual flow and concentration have been determined for each stream, the potential HAP emissions can be computed as:

$$WE_S = \frac{0.63\ Q\ C\ H}{1.67E07}$$

where,

WE_S = potential emissions, Mg/yr,

Q = average flow rate during discharge, lpm,

C = VO concentration as determined by Method 25 or HAP concentration as determined by Method 25D/Method 18, mg/l, and

H = annual hours of stream flow, hrs

0.63 = Theoretical factor to account for the fraction of HAP that would potentially volatilize during collection and treatment.[11]

Notice that the term "potential" emissions is used. A number of factors can affect the fraction of HAP which is volatilized during collection and treatment. However, it is not feasible to prescribe a method that takes all factors into account.

Since Method 25D is a recently developed method, most existing concentration data were developed using other analytical methods. Method 25D is clearly the preferred method for sampling and analysis. However, concentration data developed via EPA Method 624, SW 846, and CARB Method 401 are acceptable for years prior to 1991. In such cases, the following equation should be used to compute HAP emissions:

$$WE_S = [Q\ H\ C\ (1.061 + 6.54E\text{-}02 * \ln(H_{Law})]/1.67E07$$

where, H_{Law} = Henry's Law Constant (atm m^3/g-mole)

The total HAP emissions from wastewater sources is computed by simply summing the potential emissions of individual streams.

2.5.2 Documentation of HAP Emissions From Wastewater Sources

In establishing HAP emissions from wastewater sources, the following information should be provided with the computed emission rate for each stream:

- Stream identification,
- Stream flow rate, method of measurement, and date of measurement,
- Stream discharge temperature,
- Stream HAP concentration, method of measurement, and date of measurement, and
- A statement that the measured flow and concentration are believed to be representative of normal operation.

The form provided in Appendix A should be completed and submitted for each wastewater stream.

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11. Memorandum from Chuck Zukor, Radian Corporation, to Penny Lassiter, EPA. Approach for Estimation of Emission Reductions of HAPs from HON Model Wastewater Streams. October 12, 1990. 7p.

3.0 ESTABLISHING CHROMIUM EMISSIONS FROM CHROMIUM ELECTROPLATING OPERATIONS

Chromium electroplating includes chromium electroplating and chromic acid anodizing operations. Chromium electroplating is the process by which chromium is electrochemically deposited from a solution of chromic acid onto a metal or plastic part. Conventional plating solutions contain 32 ounces of chromic acid per gallon of water and a small amount of sulfuric acid or fluoride compounds as a catalyst. In the chromium plating process, the part to be plated is connected as the cathode in the electrical circuit and lead alloys are typically used as the anode. There are two types of chromium plating processes: hard chromium plating and decorative chromium plating. In hard chromium plating, a relatively thick layer of chromium (0.05 to 30 mils) is deposited directly on a base metal (usually steel) to provide a surface with wear resistance, a low coefficient of friction, hardness, and corrosion resistance. Hard chromium plating is typically performed in stand alone plating tanks. Hard plating also called functional plating is used for items such as hydraulic cylinders and rods, industrial rolls, zinc die castings, and marine hardware. In decorative plating, the base material generally is plated with a layer of nickel followed by a relatively thin layer (less than 0.1 mil) of chromium to provide a bright tarnish resistant surface. Decorative chromium plating is performed as the last step in a series of plating and metal finishing operations. Decorative chromium plating is used for items such as automotive trim, metal furniture, bicycles, hand tools, and plumbing fixtures.

Emissions of chromic acid mist from the electrodeposition of chromium in chromic acid plating baths occur because of the inefficiency of the hexavalent chromium plating process; only about 10 to 20 percent of the current applied actually is used to deposit chromium on the item plated. Eighty to ninety percent of

the current applied is consumed by the evolution of hydrogen and oxygen gas at the cathode and anode with the resultant liberation of gas bubbles. As the bubbles burst at the surface of the plating solution, a substantial amount of fine chromic acid mist is formed.

Numerous factors affect the amount of misting generated from chromium plating tanks. These factors include: (1) current density applied; (2) surface area of the part plated; (3) plate thickness; and (4) plating time. These factors are all interrelated and are determined by using the electrochemical equivalent of chromium, which is:

$$\frac{\text{(Current, amperes)(Plating time, h)}}{\text{(Thickness, mil)(Surface area of part, ft}^2\text{)}} = 51.8 \qquad (3\text{-}1)$$

The electrochemical equivalent is derived from Faraday's law. The equation above is based on a cathode efficiency of 100 percent and means that 51.8 ampere-hours are required to deposit 1 mil of chromium per square foot of part surface area. As discussed previously, the cathode efficiency for actual chromium plating baths is only 10 to 20 percent. The known variables in the equation above for all platers are the surface area of the part and the minimum plate thickness. The unknowns are then calculated by modifing the equation to account for the actual cathode efficiency. In the majority of cases, the plating time is the factor that is adjusted to account for the lower cathode efficiency. It is common practice to set the current based on a current density of 2 amperes per square inch (A/in^2) for hard chromium plating and approximately 1 A/in^2 for decorative chromium plating. The low cathode efficiency means that 80 to 90 percent of the current supplied to the bath goes to form hydrogen gas, which entraps the chromium solution. The amount of misting then becomes directly proportional to the amount of current supplied over a given time period. Therefore, hard chromium plating operations tend to have higher emissions than decorative

chromium plating operations because hard chromium plating is performed at higher current densities and for longer periods of time than decorative chromium plating operations.

Chromic acid anodizing is a process by which a film of aluminum oxide is formed on the surface of aluminum electrolytically to enhance the corrosion resistance of the part. Chromic acid anodizing is used primarily for aircraft parts that are subject to high stress and corrosive conditions. Conventional anodizing solutions contain 7 to 8 ounces of chromic acid per gallon of water. In chromic acid anodizing, the part is connected as the anode in the electrical circuit instead of the cathode as in chromium plating. Unlike the chromium plating process, the anodizing process is a voltage controlled process rather than a current controlled process. Voltage is applied to the tank in a step-wise fashion until a level of 20 or 40 volts is reached and is then maintained for the remainder of the anodizing time (about 1 hour). Higher voltages are needed in chromic acid anodizing than in chromium plating to overcome the resistance of the oxide layer built up on the surface of the aluminum. As in chromium plating, chromic acid emissions are formed in the anodizing tank as a result of the evolution of hydrogen and oxygen gas. The amount of gassing or chromium misting decreases over the anodizing times as the current decreases. In chromium plating, the amount of gassing or chromium misting is constant over the plating time because the current remains relatively constant. In general, emissions from anodizing tanks are similar in magnitude to those measured at decorative chromium plating facilities.

3.1 CONTROL TECHNIQUES/PERFORMANCE

The principal techniques used to control emissions of chromic acid mist from chromium plating and chromic acid anodizing operations include mist eliminators, wet scrubbers and chemical fume suppressants.

Chevron-blade and mesh-pad mist eliminators are the types of mist eliminators most frequently used to control chromic acid mist. The most important mechanism by which mist eliminators remove chromic acid droplets from gas streams is the inertial impaction of droplets onto a stationary set of blades or a mesh pad. Mist eliminators typically are operated as dry units that are periodically washed down with water to clean the impaction media.

The wet scrubbers typically used to control emissions of chromic acid mist from chromium plating and chromic acid anodizing operations are single and double packed-bed scrubbers. Other scrubber types used less frequently include fan-separator packed-bed and centrifugal-flow scrubbers. The mechanism by which scrubbers remove chromic acid droplets from the gas streams is wetting the gas stream to increase the particles mass followed by impingement on a packed bed. Once-through water or recirculated water typically is used as the scrubbing liquid because chromic acid is highly soluble in water.

Chemical fume suppressants are added to decorative chromium plating and chromic acid anodizing baths to reduce chromic acid mist. Although chemical agents alone are effective control techniques, many plants use them in conjunction with a control device. Chemical fume suppressants are surface-active compounds that are added directly to plating and anodizing baths to reduce or control misting. Fume suppressants are classified as foam blankets, wetting agents, and combinations of foam blankets and wetting agents. Foam blankets are depleted mainly by dragout of the plating solution and wetting agents are depleted mainly by decomposition of the fume suppressant and, to a lesser extent, by dragout of the plating solution. Wetting agents reduce misting by lowering the surface tension of the plating or anodizing bath, foam blankets reduce misting by entrapping the chromic acid mist as it forms at the surface of the plating solution, and combinations wetting agents/foam blankets reducing misting by both methods. Fume suppressants are used widely by decorative

chromium electroplaters. In contrast, hard chromium platers seldom use fume suppressants. Fluorinated wetting agents have a tendency to aggravate pitting, which affects the quality of the hard chromium plate. Also, when foam blankets are used, there is a potential for explosion of the entrapped hydrogen gas. These tendencies are more pronounced in hard chromium plating than in decorative chromium plating because of the higher current densities and longer plating times associated with hard chromium plating operations.

The performance capabilities of the control devices used to control chromic acid mist were determined through an extensive source test program. The general findings from the test program were:

- Chevron-blade mist eliminators perform less well than packed-bed scrubbers and mesh-pad mist eliminators.

- Packed-bed scrubbers perform marginally better than mesh-pad mist eliminators.

- Fume suppressants are highly effective at eliminating misting at decorative chromium plating operations.

The key finding from the test program was that all the control devices performed as constant outlet devices. Consequently, control efficiency is a poor indicator of performance (unless the comparison is made at similar inlet conditions). Therefore, the percent reduction values presented in the following paragraph are based on representative inlet conditions for each of the three processes.

The percent reduction of chevron-blade mist eliminators is approximately 90 to 95 percent for hard chromium plating and chromic acid anodizing operations (chevron-blade mist eliminators are rarely used at decorative chromium plating operations). The percent reduction for packed-bed scrubbers and mesh-pad mist eliminators ranges from 97 to 99 percent with the higher percent reductions being achieved at hard chromium plating operations

where the inlet loadings are higher. For decorative chromium plating operations, the percent reduction for fume suppressants is greater than 99 percent if strict adherence to vendor recommendations on the application of the fume suppressant are followed.

3.2 ACCEPTABLE TECHNIQUES FOR ESTABLISHING EMISSIONS

The two acceptable approaches for determining emissions are:

(1) Measurement - Measured hexavalent chromium mass emission rate in stack gas.

(2) Emission Factors - Calculations based on average measured emissions at numerous plating facilities. Emission factors are expressed as milligrams of hexavalent chromium per ampere-hour of current applied for chromium plating operations or as milligrams of hexavalent chromium per square meter of tank surface area for chromic acid anodizing operations.

The preferred method for determining chromium emissions is measurement of the mass emission rate using published EPA Methods. However, in some cases (as discussed in the following sections), the use of process emission factors is acceptable for determining baseline emissions.

Although the focus of this section is on establishing emissions, it is important to keep in mind that the reason for establishing baseline emissions is to enable the facility to demonstrate early reductions. Therefore, consistent or at least compatible methodologies should be used to establish baseline emissions and emissions after control.

3.2.1 Hard Chromium Plating Operations

The preferred techniques for establishing baseline chromium emissions from hard chromium plating operations is direct measurement. Sample locations and gas stream characteristics should be determined using EPA Methods 1, 2, and 4; and the

hexavalent chromium concentration should be determined using modified EPA Method 5. The Method 5 sampling train is modified for chromium by eliminating the filter and using 0.1N sodium hydroxide in the impingers. The collected samples should be analyzed for hexavalent chromium by using the diphenylcarbazide colorimetric method. The chromium emission sampling method has not been published in the Federal Register. For copies of the draft method, please contact Mr. Frank Clay of the Emission Measurement Branch at (919) 541-5236.

Establishing baseline chromium emissions for chromium plating and anodizing tanks is basically the same for all three processes. The following parameters are required through direct measurement:

(1) volumetric flow rate of stack gas, dscmm
(2) hexavalent chromium concentration, mg/dscm
(3) operating hours per year for plating tank(s)

Annual baseline chromium emissions can then be calculated using the following equation:

$$ER = (C)(Q)(60)(t)/1.0 \times 10^9, \qquad (3\text{-}2)$$

where,

ER = annual chromium emissions, Mg/yr;
C = chromium concentration, mg/dscm;
Q = volumetric gas flow rate, dscmm; and
t = operating time, h/yr.

For operations where no control device was present prior to 1987, the application of a packed-bed scrubber is believed to be an adequate demonstration of 95 percent control with no emission testing required. The baseline emissions can be estimated using process emission factors developed from the chromium electroplating NESHAP source test data and published in the EPA supplement to "Locating and Estimating Air Emission Sources of

Chromium".[1] For hard chromium electroplating operations, the average process emission factor of 10 milligrams per ampere-hour is recommended for use in establishing the baseline emissions. The baseline emissions can be calculated using this factor in either of the following equations:

$$ER = (PER)(C)(t)/1.0 \times 10^9, \quad \text{or} \qquad (3\text{-}3)$$

$$ER = (PER)(A)/1.0 \times 10^9, \qquad (3\text{-}4)$$

where,

ER = annual emission rate, Mg/yr;

PER = process emission rate, mg/Ah;

C = average current applied to plating tank, amperes;

t = tank operating time, h/yr; and

A = estimated ampere-hours applied in base year.

For operations where no control device was present in 1987 and a control technique, other than a packed-bed scrubber, was applied to the operation, baseline emissions and the percent reduction achieved by the control device would need to be established through direct measurement of the inlet and outlet chromium emission levels. The annual baseline emissions would then be calculated by inputting the inlet chromium concentration into Equation 3-2. The percent reduction achieved by the control device can be determined using the following equation:

$$\% \text{ reduction} = \frac{MR_i - MR_o}{MR_i} \times 100 \qquad (3\text{-}5)$$

For facilities where there is a control device present and the control device was present prior to 1987, the control device efficiency should be accounted for in determining the baseline emissions. To determine the annual baseline emissions, the outlet chromium concentration should be measured and input into

Equation 3-2. A 95 percent reduction over the annual baseline emission rate would then need to be demonstrated.

3.2.2 Decorative Chromium Plating Operations

The preferred techniques for establishing baseline chromium emissions from decorative chromium plating operations is direct measurement. For an overview of the sampling methods and analytical methods for chromium emission testing, please refer to the Section 3.2.1 for hard chromium plating operations.

For operations where no control device was present prior to 1987, the application of a chemical fume suppressant or a packed-bed scrubber is believed to be an adequate demonstration of 95 percent control with no emission testing required. The baseline emissions can be estimated using process emission factors developed from the chromium electroplating NESHAP source test data and published in the EPA supplement to "Locating and Estimating Air Emission Sources of Chromium".[1] For decorative chromium electroplating operations, the average process emission factor of 2 milligrams per ampere-hour is recommended for use in establishing the baseline emissions. The baseline emissions can be calculated using Equations 3-3 or 3-4 given above.

For operations where no control device was present in 1987 and a control technique, other than chemical fume suppressants or packed-bed scrubbers, was applied to the operation, baseline emissions and the percent reduction achieved by the control device would need to be established through direct measurement of the inlet and outlet chromium emission levels. The annual baseline emissions would then be calculated by inserting the inlet chromium concentration into Equation 3-2. The percent reduction achieved by the control device can be determined using Equation 3-5.

For facilities where there is a control device present and the control device was present prior to 1987, the control device efficiency should be accounted for in determining the baseline emissions. To determine the annual baseline emissions, the

outlet chromium concentration should be measured and inputted into Equation 3-2. A 95 percent reduction over the annual baseline emission rate would then need to be demonstrated.

3.2.3 Chromic Acid Anodizing Operations

The preferred techniques for establishing baseline chromium emissions from chromic acid anodizing operations is direct measurement. For an overview of the sampling methods and analytical methods for chromium emission testing, please refer to the Section 3.2.1 for hard chromium plating operations.

For operations where no control device was present prior to 1987, the application of a chemical fume suppressant or a packed-bed scrubber is believed to be an adequate demonstration of 95 percent control with no emission testing required. The baseline emissions can be estimated using process emission factors developed from the chromium electroplating NESHAP source test data and published in the EPA supplement to "Locating and Estimating Air Emission Sources of Chromium".[1] For chromic acid anodizing operations, the average process emission factor of 0.6 grams per hour per square meter of tank surface area is recommended for use in establishing the baseline emissions. The baseline emissions can then be calculated by using the process emission factor in the following equations:

$$ER = (PER)(SA)(t)/1.0 \times 10^6, \qquad (3\text{-}6)$$

where,

ER = annual emission rate, Mg/yr;
PER = process emission rate, $g/h/m^2$;
SA = surface area of plating tank(s), ft^2; and
t = tank operating time, h/yr.

For operations where no control device was present in 1987 and a control technique, other than chemical fume suppressants or packed-bed scrubbers, was applied to the operation, baseline

emissions and the percent reduction achieved by the control device would need to be established through direct measurement of the inlet and outlet chromium emission levels. The annual baseline emissions would then be calculated by inserting the inlet chromium concentration into Equation 3-2. The percent reduction achieved by the control device can be determined using Equation 3-5.

For facilities where there is a control device present and the control device was present prior to 1987, the control device efficiency should be accounted for in determining the baseline emissions. To determine the annual baseline emissions, the outlet chromium concentration should be measured and inserted into Equation 3-2. A 95 percent reduction over the annual baseline emission rate would then need to be demonstrated.

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4.0 ETHYLENE OXIDE STERILIZATION

Ethylene oxide (EO) is used as a sterilant/fumigant in the production of medical equipment supplies, in miscellaneous sterilization and fumigation operations, and at hospitals. Practically all of the EO used in the steriliztion/fumigation process is estimated to be emitted from three sources: (1) the main sterilizer exhaust (i.e., the vent from the vacuum pump/liquid separator), the aeration room or chamber, and the chamber exhaust vent. Uncontrolled emissions from these sources are assumed to be 95, 3, and 2 percent of the EO use, respectively.

Available control techniques including acid scrubbers, catalytic oxidizers, and flares can achieve emission reductions of approximately 99%. Therefore, a 90% emission reduction of total EO emissions can be achieved by controlling the main sterilizer exhaust stream.

4.1 TECHNIQUES FOR ESTABLISHING BASELINE HAP EMISSIONS

For facilities without add-on controls, emissions are equal to the amount of EO used in the sterilization chamber; an estimate of annual EO use can be made by using annual inventory data. Facilities with existing add-on controls must estimate the effectiveness of the existing control system and estimate emissions using the amount of EO used in the sterilization chamber.

4.2 TECHNIQUES FOR ESTABLISHING 90% HAP EMISSION REDUCTION

Uncontrolled Facilities

An emission mass-in/mass-out approach will be used to estimate control efficiency for both catalytic oxidizers and scrubbers. Tests should be run on an empty chamber.

Mass-in

Mass into the control unit can be estimated by weighing the EO supply cylinders before and after use to determine the amount of EO in the chamber. Alternatively, mass in the chamber after evacuation can be calculated by using concentration and chamber volume. Concentration can be obtained by either using the ideal gas law or a gas chromatograph. Mass into the control unit is the difference between the EO charged to the chamber and the EO remaining in the chamber. The test need be run only on the first evacuation cycle.

Mass-out

Mass out of the control unit is estimated by measuring flow rate and EO concentration with EPA methods 2,2A,2C,or 2D and 18 respectively. For packed-bed scrubbers and catalytic oxidizers flow rate and concentration can be measured directly. However, for a reaction/detoxification tower, a flow must be induced to increase the exit flow to a measureable rate.

Control Efficiency

The control efficiency is calculated by the following equation:

$$\text{Control Efficiency} = (1 - (MO/MI)) \times 100$$

where MO = mass out of control device
MI = mass into control device

APPENDIX A

CALCULATION WORKSHEETS FOR ESTABLISHING BASE YEAR AND POST-REDUCTION HAP EMISSIONS FROM SOCMI SOURCES

Source:_____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS FROM PROCESS VENTS

HAP:_____ Date:_____
Year:_____ Calculator:_____

Process Vent Identification:_____
Description:_____

Process Conditions/Sampling

Date of flow measurement _____
Method of flow measurement _____
Date of concentration measurement _____
Method of concentration measurement
(if not an EPA Method give a brief description and attach protocol) _____
Describe any problems encountered during testing_____
Production rate during flow determination (lbs/hr) _____
Production rate during sampling (lbs/hr) _____
Average production rate during base year (lbs/hr) _____

Stream Characteristics

Average vent stream flow rate (ft^3/min)	_____	= Q
HAP concentration (ppmv)	_____	= C
Annual hours of operation (hrs)	_____	= h
Vent stream discharge temperature (^oF)	_____	= T
HAP molecular weight (lb/lb-mole)	_____	= MW
HAP high-risk weighting factor	_____	= F_{HR}

Control

Control device _____
HAP control efficiency (%) _____ = eff

Calculations[a]

$$\text{Uncontrolled Emissions } (E_U) = \frac{3.94E\text{-}08\ Q\ C\ h\ MW}{T + 460}$$

$$\text{Uncontrolled Emissions } (E_U) = \frac{3.94E\text{-}08(\quad)(\quad)(\quad)(\quad)}{(\quad) + 460}$$

$$= \boxed{\quad\quad} \text{ Mg/yr}$$

$$\text{HAP Emissions } (E_{HAP}) = E_U\ (1 - eff/100)$$

Source:_____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS FROM PROCESS VENTS (CONCLUDED)

HAP Emissions (E_{HAP}) = _____(1 - _____/100)

= [ ] Mg/yr

Weighted HAP Emissions = E_{HAP} F_{HR}

Weighted HAP Emissions = ( ) ( )

= [ ] Mg/yr

If the conditions during testing are not representative of base year operation, make the appropriate extrapolation below and explain:

If the flow or concentration were not measured using an EPA reference method, EPA conditional method or validated using Method 301, provide justification and supporting calculations:

---

[a]Expression provided in "Procedures for Establishing Base Year and Post-Reduction HAP Emissions" to convert flow and concentration into an annual mass rate; the 3.94E-08 constant is based on the ideal gas law.

Source: _____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS FROM FIXED ROOF STORAGE TANKS

HAP: _____ Date: _____

Year: _____ Calculator: _____

Tank designation: _____

Product: _____

Tank Characteristics

Inside diameter, (ft)	_____	$=D$
Height, (ft)	_____	$=H_T$
Capacity, (gal) $= \Pi \frac{D^2 h}{4} * 7.48 \frac{gal}{ft^3}$, if not known	_____	$=V$
Roof color _____		
Shell color _____		
Vapor space height, (ft)[a]	_____	$=H$

Ambient Conditions

Average atmospheric pressure (psia) (defaults 14.7 psia)	_____	$=P_A$
Average ambient diurnal temperature (^oF)[b]	_____	$=\Delta_T$
Average annual ambient temperature (^oF)	_____	$=T_A$

Bulk Liquid Characteristics

Stored liquid temperature (^oF)[c]	_____	$=T_S$
Total throughput per year (gal)	_____	$=A_N$
Number of turnovers per year[d]	_____	$=N$
Molecular weight of vapor (lb/lb mole)	_____	$=M_V$
Mole percent of HAP	_____	
Partial pressure of the HAP at liquid conditions (psia)	_____	$=P$
HAP high-risk weighting factor	_____	$=F_{HR}$

Adjustment Factors

Paint factor (see Table 2-3)	_____	$=F_P$
Small diameter tank factor[e]	_____	$=C$
Turnover factor[f]	_____	$=K_N$
Product factor[g]	_____	$=K_C$

Source: _____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS
FROM FIXED ROOF STORAGE TANKS (continued)

Control

Control device _____
HAP control efficiency (%) _____ =eff

Calculations[h]

Breathing Loss (Mg/yr) =

$$L_B = 1.02E\text{-}05 M_V \left(\frac{P}{P_A - P}\right)^{0.68} D^{1.73} H^{0.51} \Delta T^{0.50} F_P C K_C$$

$$= 1.02E\text{-}05 (\quad) \left(\frac{\quad}{\quad) - (\quad}\right)^{0.68} (\quad)^{1.73} (\quad)^{0.51} (\quad)^{0.50} (\quad)(\quad)(\quad)$$

$$= \boxed{\quad} \text{ Mg/yr}$$

Working Loss (Mg/yr) = $L_W = 1.09E\text{-}08\ M_V P V N K_N K_C$

$$= 1.09E\text{-}08\ (\quad)(\quad)(\qquad)(\quad)(\quad)(\quad)$$

$$= \boxed{\quad} \text{ Mg/yr}$$

Total Loss (Mg/yr) =

$$T_L = L_B + LW = (\quad) + (\quad) = \boxed{\quad} \text{ Mg/yr}$$

If a control device is employed,

HAP Emissions (E_{HAP}) = Total Loss (1 - eff/100)

= _____ (1 - ___/100)

= $\boxed{\quad}$ Mg/yr

Source:_____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS
FROM FIXED ROOF STORAGE TANKS (continued)

Weighted HAP Emissions = E_{HAP} F_{HR}

= ( ) ( )

= [ ] Mg/yr

---

[a]If vapor space height is unknown or shell, assume H equals one half tank height. If tank has a cone roof, adjust vapor space height by adding 1/3 of height of cone.

[b]If average ambient diurnal temperature change is unknown, assume 20°F.

[c]Stored liquid temperature may be approximated from average annual ambient temperature. See Table 2-2.

[d]$N = \frac{AN}{V}$ where N = number of turnovers per year
AN = total throughput per year (gal)
V = tank capacity (gal)

[e]For $D \geq 30$ft, C=1; For $6 \leq D < 30$ft, C=0.0771D-0.0013D2-0.1334.

[f]For turnovers > 36, $K_N = (180 + N)/(6 * N)$
where K_N = turnover factor (dimensionless)
N = number of turnovers per year
For turnovers ≤ 36, $K_N = 1$

[g]K_C = 1.0 for volatile organic liquids

[h]Expression for computing HAP emissions are from "Procedures for Establishing Base Year and Post-Reduction HAP Emissions." The calculation procedure is consistent with AP-42.

Source: _____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS
FROM INTERNAL FLOATING ROOF STORAGE TANKS

HAP: _____ Date: _____
Year: _____ Calculator: _____
Tank designation: _____
Product: _____

Tank Characteristics

Inside diameter, (ft)	_____	= D
Rim Seal type: _____		
Number of columns[a]	_____	= N_C
Effective column diameter (ft)[b]	_____	= F_C

Ambient Conditions

Average atmospheric pressure (psia)	_____	= P_A
Average annual ambient temperature (^oF)	_____	= T

Bulk Liquid Characteristics

Stored liquid temperature (^oF)	_____	= T_S
Total throughput per year (bbl/yr) [Note: 42 gal/bbl]	_____	= Q
Molecular weight of HAP (lb/lb -mole)	_____	= M_V
True vapor pressure at bulk liquid conditions (psia)	_____	= P
HAP liquid density (lb/gal)	_____	= W_L
HAP high-risk weighting factor	_____	= F_{HR}

Factors

Rim seal loss factor (lb mole/ft yr); obtain from Table 2-4	_____	= K_R
Product factor (dimensionless)	_____	= K_C
Shell clinage factor (bbl/1000 ft^2); obtain from Table 2-9	_____	= C
Deck fitting loss factor	_____	= F_F
Deck seam loss factor (lb-mole/ft yr)[d]	_____	=K_D
Deck seam length factor; obtain from Table 2-7	_____	=F_D

Source: _____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS FROM INTERNAL FLOATING ROOF STORAGE TANKS (CONTINUED)

Control

Control device _____

HAP control efficiency (%) _____ =eff

Calculations[e]

$P^* = 0.068\ P\ (1 + (1 - 0.068\ P)^{0.5})^2)$

$= 0.068\ (\quad)/((1 + (1 - 0.068\ (\quad))^{0.5})^2) =$ [ ] psia

$L_W = \frac{(0.943)\ QCW_L}{D}\ [1 + \frac{N_C F_C}{D}]/2205$

$= \frac{(0.943)(\quad)(\quad)(\ )}{(\ )}\ [1 + \frac{(\ )(\ )}{(\ )}]/2205 =$ [ ]

$L_R = K_R\ D\ P^*\ M_v K_C/2205 = (\quad)(\quad)(\quad)(\quad)(\ )/2205 =$ [ ]

$L_F = F_F\ P^*\ M_v K_C/2205 = (\quad)(\quad)(\quad)(\ )/2205 =$ [ ]

$L_D = K_D F_D D^2\ P^*\ M_v K_C/2205 = (\quad)(\quad)(\quad)^2\ (\quad)(\quad)(\ )/2205$

$=$ [ ]

$L_T = L_R + L_W + L_F + L_D = (\quad) + (\quad) + (\quad) + (\quad)$

$=$ [ ] Mg/yr

If a control device is employed,

HAP Emissions (E_{HAP}) = Total Loss (1 - eff/100)

= _____ (1 - ___/100)

= [ ] Mg/yr

Source:_____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS FROM INTERNAL FLOATING ROOF STORAGE TANKS (CONCLUDED)

---

[a]For self-supported fixed roof or external floating roof tank, $N_C = 0$. If N_C is unavailable, see Table 2-6.

[b]If F_C is unavailable;
F_C = 1.1 for 9 inch by 7 inch built-up columns;
0.7 for 8 inch diameter pipe column;
1.0 if column construction details are not known

[c]F_F is determined using Table 2-10 and the following calculation

$$F_F = [N_{F_1} K_{F_1}] + [N_{F_2} K_{F_2}] + \ldots + (N_{F_N} + K_{F_N})]$$

[d]K_D = 0.0 for welded deck and 0.34 for non-welded deck.

[e]Expression for computing HAP emissions are from "Procedures for Establishing Base Year and Post-Reduction HAP Emissions." The calculation procedure is consistent with AP-42.

Source: _____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS
FROM EXTERNAL FLOATING ROOF STORAGE TANK EMISSIONS

HAP: _____ Date: _____
Year: _____ Calculator: _____
Tank Designation: _____
Product: _____

Tank Characteristics

Inside tank diameter (ft)	_____	= D
Rim Seal Type: _____		
Tank color: _____		

Ambient Conditions

Ambient temperature (^{o}F)	_____	
Average windspeed for the tank site (mph)	_____	= V

Bulk Liquid Characteristics

Density of the HAP stored (lb/gal)	_____	= W_L
Molecular weight of the HAP (lb/lb mol)	_____	= M_V
Ture vapor pressure of the HAP (psia)	_____	= P
HAP high-risk weighting factor	_____	= F_{HR}

Factors

Seal factor; obtain from Table 2-8	_____	= K_S
Seal windspeed exponent; obtain from Table 2-8	_____	= N
Product withdrawal shell clingage factor; obtain from Table 2-9	_____	= C
Product factor; 1.0 for VOL	1.0	= K_C
Total Roof Fitting Loss Factor[a]	_____	= F_F

Calculation

$$P^* = 0.068P/((1 + (1 - 0.068P)^{0.5})^2)$$

$$= 0.068(\quad)/((1 + (1 - 0.068(\quad))^{0.5})^2)$$

$$= \boxed{} \text{ psia}$$

Source: _____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS FROM EXTERNAL FLOATING ROOF STORAGE TANK EMISSIONS (Cont.'d)

Calculations (cont.'d)

Withdrawal Loss = $L_W = 4.28 \times 10^{-4}\ QCW_L/D$

$= 4.28 \times 10^{-4}$ ( )( )( )/( )

= [ ] Mg/yr

Seal Loss = $L_{SE} = K_S V^N P^* DM_V K_C/2205$

= ( )( )( )( )( )( )( )/2205

= [ ] Mg/yr

Roof Fitting Loss = $F_F P^* M_V K_C/2205$

= ( )( )( )(1.0)/2205

= [ ] Mg/yr

Total Loss = $L_T = L_W + L_{SE} + L_{RF}$

= ( ) + ( ) + ( )

= [ ] Mg/yr

Weighted HAP Emissions = $E_{HAP}\ F_{HP}$

= ( ) ( )

= [ ] Mg/yr

---

[a] F_F is determined using Tables 2-11, 2-12, and 2-13 and the following calculation:

$$F_F = [(N_{F_1}\ K_{F_1}) + (N_{F_2}\ K_{F_2}) \ . \ . \ . \ (N_{F_{n_f}}\ K_{F_{n_f}})]$$

Source: _____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS FROM EQUIPMENT LEAKS[a]

HAP: _____ Date: _____
Year: _____ Calculator: _____

Process: _____

Equipment Counts

	Total Number		Average HAP Wt. Fract.			
Pump Seals (Light Liquid)						
0 -10 wt% HAP of VOC	_____	x	0.05	=	_____	
10-25 wt% HAP of VOC	_____	x	0.175	=	_____	
25-75 wt% HAP of VOC	_____	x	0.50	=	_____	
75-99 wt% HAP of VOC	_____	x	0.87	=	_____	
100 wt% HAP of VOC	_____	x	1.00	=	_____	
			Subtotal		_____	=PSLL
Pump Seals (Heavy Liquid)						
0 -10 wt% HAP of VOC	_____	x	0.05	=	_____	
10-25 wt% HAP of VOC	_____	x	0.175	=	_____	
25-75 wt% HAP of VOC	_____	x	0.50	=	_____	
75-99 wt% HAP of VOC	_____	x	0.87	=	_____	
100 wt% HAP of VOC	_____	x	1.00	=	_____	
			Subtotal		_____	=PSHL
Valves (Gas/Vapor)						
0 -10 wt% HAP of VOC	_____	x	0.05	=	_____	
10-25 wt% HAP of VOC	_____	x	0.175	=	_____	
25-75 wt% HAP of VOC	_____	x	0.50	=	_____	
75-99 wt% HAP of VOC	_____	x	0.87	=	_____	
100 wt% HAP of VOC	_____	x	1.00	=	_____	
			Subtotal		_____	=VGV
Valves (Light Liquid)						
0 -10 wt% HAP of VOC	_____	x	0.05	=	_____	
10-25 wt% HAP of VOC	_____	x	0.175	=	_____	
25-75 wt% HAP of VOC	_____	x	0.50	=	_____	
75-99 wt% HAP of VOC	_____	x	0.87	=	_____	
100 wt% HAP of VOC	_____	x	1.00	=	_____	
			Subtotal		_____	=VLL

Source:_____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS
FROM EQUIPMENT LEAKS (cont.'d)

Valves (Heavy Liquid)					
0 -10 wt% HAP of VOC	_____	x	0.05	= _____	
10-25 wt% HAP of VOC	_____	x	0.175	= _____	
25-75 wt% HAP of VOC	_____	x	0.50	= _____	
75-99 wt% HAP of VOC	_____	x	0.87	= _____	
100 wt% HAP of VOC	_____	x	1.00	= _____	
			Subtotal	_____	=VHL
Pressure Relief Valves (Gas/Vapor)					
0 -10 wt% HAP of VOC	_____	x	0.05	= _____	
10-25 wt% HAP of VOC	_____	x	0.175	= _____	
25-75 wt% HAP of VOC	_____	x	0.50	= _____	
75-99 wt% HAP of VOC	_____	x	0.87	= _____	
100 wt% HAP of VOC	_____	x	1.00	= _____	
			Subtotal	_____	=PRV
Open-Ended Lines					
0 -10 wt% HAP of VOC	_____	x	0.05	= _____	
10-25 wt% HAP of VOC	_____	x	0.175	= _____	
25-75 wt% HAP of VOC	_____	x	0.50	= _____	
75-99 wt% HAP of VOC	_____	x	0.87	= _____	
100 wt% HAP of VOC	_____	x	1.00	= _____	
			Subtotal	_____	=OEL
Compressor Seals					
0 -10 wt% HAP of VOC	_____	x	0.05	= _____	
10-25 wt% HAP of VOC	_____	x	0.175	= _____	
25-75 wt% HAP of VOC	_____	x	0.50	= _____	
75-99 wt% HAP of VOC	_____	x	0.87	= _____	
100 wt% HAP of VOC	_____	x	1.00	= _____	
			Subtotal	_____	=CS
Sampling Connections					
0 -10 wt% HAP of VOC	_____	x	0.05	= _____	
10-25 wt% HAP of VOC	_____	x	0.175	= _____	
25-75 wt% HAP of VOC	_____	x	0.50	= _____	
75-99 wt% HAP of VOC	_____	x	0.87	= _____	
100 wt% HAP of VOC	_____	x	1.00	= _____	
			Subtotal	_____	=SC

Source: _____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS
FROM EQUIPMENT LEAKS (Stratified) (cont.'d)

Flanges

0 -10 wt% HAP of VOC	_____	x	0.05	=	_____
10-25 wt% HAP of VOC	_____	x	0.175	=	_____
25-75 wt% HAP of VOC	_____	x	0.50	=	_____
75-99 wt% HAP of VOC	_____	x	0.87	=	_____
100 wt% HAP of VOC	_____	x	1.00	=	_____
			Subtotal		_____ =F

Annual hours process equipment contains the HAP _____ =H

Screening Calculations

	Number Screened	Number of Sources Screening (ppmv) 0-1000	1000-10000	>10000	Computed Emissions[b] (per source) kg/hr/source	
Pump Seals						
Light Liquid	_____	_____	_____	_____	_____	$=E_{PSLL}$
Heavy Liquid	_____	_____	_____	_____	_____	$=E_{PSHL}$
Valves						
Gas/Vapor	_____	_____	_____	_____	_____	$=E_{VGV}$
Light Liquid	_____	_____	_____	_____	_____	$=E_{VLL}$
Heavy Liquid	_____	_____	_____	_____	_____	$=E_{VHL}$
Pressure Relief Valves						
Gas/Vapor	_____	_____	_____	_____	_____	$=E_{PRV}$
Open-Ended Lines	_____	_____	_____	_____	_____	$=E_{OEL}$
Compressor Seals	_____	_____	_____	_____	_____	$=E_{CS}$
Sampling Connections	_____	_____	_____	_____	_____	$=E_{SC}$
Flanges	_____	_____	_____	_____	_____	$=E_F$

HAP Emission Calculation

PSLL	x	E_{PSLL}	x H =	_____	x	_____	x	_____	= _____
PSHL	x	E_{PSHL}	x H =	_____	x	_____	x	_____	= _____
VGV	x	E_{VGV}	x H =	_____	x	_____	x	_____	= _____
VLL	x	E_{VLL}	x H =	_____	x	_____	x	_____	= _____
VHL	x	E_{VHL}	x H =	_____	x	_____	x	_____	= _____
PRV	x	E_{PRV}	x H =	_____	x	_____	x	_____	= _____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS FROM EQUIPMENT LEAKS (Leak/No Leak) (cont.'d)

Screening Calculations

	Number Screened	Number Leaking	Percent Leaking	Computed Emissions[a] (per source) kg/hr/source	
Pump Seals					
Light Liquid	_____	_____	_____	_____	= E_{PSLL}
Heavy Liquid	_____	_____	_____	_____	= E_{PSHL}
Valves					
Gas/Vapor	_____	_____	_____	_____	= E_{VGV}
Light Liquid	_____	_____	_____	_____	= E_{VLL}
Heavy Liquid	_____	_____	_____	_____	= E_{VHL}
Pressure Relief Valves					
Gas/Vapor	_____	_____	_____	_____	= E_{PRV}
Open-Ended Lines	_____	_____	_____	_____	= E_{OEL}
Compressor Seals	_____	_____	_____	_____	= E_{CS}
Sampling Connections	_____	_____	_____	_____	= E_{SC}
Flanges	_____	_____	_____	_____	= E_F

Baseline Emission Calculation

PSLL	x	E_{PSLL}	x H =	_____	x	_____	x	_____	=	_____
PSHL	x	E_{PSHL}	x H =	_____	x	_____	x	_____	=	_____
VGV	x	E_{VGV}	x H =	_____	x	_____	x	_____	=	_____
VLL	x	E_{VLL}	x H =	_____	x	_____	x	_____	=	_____
VHL	x	E_{VHL}	x H =	_____	x	_____	x	_____	=	_____
PRV	x	E_{PRV}	x H =	_____	x	_____	x	_____	=	_____
OEL	x	E_{OEL}	x H =	_____	x	_____	x	_____	=	_____
CS	x	E_{CS}	x H =	_____	x	_____	x	_____	=	_____
SC	x	E_{SC}	x H =	_____	x	_____	x	_____	=	_____
F	x	E_F	x H =	_____	x	_____	x	_____	=	_____

Baseline Emissions = _____ kg/yr

[a]Compute based on values provided in Table 2-11, using:

$$E = [LEF * PCL + NLEF * (100 - PCL)]/100$$

where: E = Emission per source; LEF = leaking emission factor; NLEF = non-leaking emission factor; PCL = percent of sources found leaking.

Source: _____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS FROM EQUIPMENT LEAKS (Stratified) (cont.'d)

HAP Emission Calculation (continued)

OEL	x	E_{OEL}	x H =	_____	x	_____	x	_____	=	_____
CS	x	E_{CS}	x H =	_____	x	_____	x	_____	=	_____
SC	x	E_{SC}	x H =	_____	x	_____	x	_____	=	_____
F	x	E_F	x H =	_____	x	_____	x	_____	=	_____

HAP Emissions (E_{HAP}) = [ ] kg/yr

HAP high-risk weighting factor _____ = F_{HR}

Weighted HAP Emissions = E_{HAP} F_{HR}

= ( ) ( )

= [ ] Kg/yr

[a]Calculation worksheet and methodology from "Procedures for Establishing Base Year and Post-Reduction HAP Emissions." This procedure is consistent with the methodology presented in "Protocols for Generating Unit-Specific Emission Estimates for Equipment Leaks of VOC and VHAP" (EPA Publication No. 450/3-88-010).

[b]Compute using the stratified emission factors provided in Table 2-12:

$$E = [(NL_1 * SEF_1) + (NL_2 * SEF_2) + (NL_3 * SEF_3)]/(NL_1 + NL_2 + NL_3)$$

where: E = Emission per source; NL_1, NL_2, NL_3 = number leaking in first range, second range, and third range, respectively; SEF_1, SEF_2, SEF_3 = stratified emission factor for first, second, and third range, respectively.

Source: _____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS FROM LOADING OPERATIONS

HAP: _____ Date: _____
Year: _____ Calculator: _____

Loading Operation: _____

Loading Parameters

Cargo carrier (tank truck, rail car, etc.)	_____	
Mode of operation (choose from Table 2-16)	_____	
Annual volume of liquid loaded (gallons)	_____	= G
Temperature of liquid loaded (^{o}F)	_____	= T
Weight percent HAP in the loaded material	_____	
True vapor pressure of the HAP loaded (psia) [Note: For mixtures, use the HAP partial pressure]	_____	= P
Molecular weight of the HAP (lb/lb-mole)	_____	= M
Saturation factor (see Table 2-16)	_____	= S
HAP high-risk weighting factor	_____	= F_{HR}

Control

Control device	_____	
HAP control efficiency (%)	_____	= eff

Calculation[a]

$$\text{Uncontrolled Loading Loss } E_u = 5.65E\text{-}06 \frac{S\ P\ M\ G}{T + 460}$$

$$\text{Uncontrolled Loading Loss } E_u = 5.65E\text{-}06 \frac{(\quad)(\quad)(\quad)(\quad)}{(__) + 460}$$

$$= \boxed{} \text{ Mg/yr}$$

$$\text{HAP Emissions } (E_{HAP}) = E_u\ (1 - \text{eff}/100)$$

$$= \quad (1 - __/100)$$

$$= \boxed{} \text{ Mg/yr}$$

Source: _____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS FROM LOADING OPERATIONS (CONCLUDED)

Calculation (continued)

Weighted HAP Emissions = E_{HAP} F_{HP}

= ( ) ( )

= [ ] Mg/yr

[a]Calculation worksheet and procedure from "Procedures for Establishing Base Year and Post-reduction HAP Emissions." This procedure is consistent with AP-42.

Source:_____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS FROM WASTEWATER SOURCES

HAP:_____ Date:_____
Year:_____ Calculator:_____

Wastewater Stream Identification:_____
Wastewater Stream Description:_____

_____

Process Conditions/Sampling

Date of flow measurement _____
Method of flow measurement _____
Date of concentration measurement _____
Method of concentration measurement _____
Production rate during flow determination (lbs/hr) _____
Production rate during sampling (lbs/hr) _____
Average production rate during base year (lbs/hr) _____

Stream Characteristics

Average flow rate during discharge (lpm) _____ = Q
HAP concentration (mg/l) _____ = C
Annual hours of stream flow (hrs) _____ = H
HAP high-risk weighting factor _____ = F_{HR}

Control

Control device _____
HAP control efficiency (%) _____ = eff

Calculations[a]

Wastewater Emissions Potential (WE_u) = $\frac{0.63\ Q\ C\ H}{1.67E07}$

Wastewater Emissions Potential (WE_u) = $\frac{0.63\ (\quad)(\quad)(\quad)}{1.67E07}$

= [ ] Mg/yr

Source:_____

CALCULATION WORKSHEET FOR ESTABLISHING HAP EMISSIONS FROM WASTEWATER SOURCES (CONCLUDED)

Potential HAP Emissions (E_{HAP}) = WE_u (1 - eff/100)

= (1 - __/100)

= [ ] Mg/yr

Weighted HAP Potential Emissions = E_{HAP} F_{HP}

= ( ) ( )

= [ ] Mg/yr

[a]Calculation worksheet and procedure from "Procedures for Establishing Base Year and Post-reduction HAP Emissions".

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(Please read Instructions on the reverse before completing)

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

Regulations have been proposed governing compliance extensions for Early Reductions of Hazardous Air Pollutants (HAP). The regulations allow a six year MACT standard compliance extension for sources that achieve HAP reductions of 90% (95% for particulates) from a base year of 1987 (or more recent base year). This document includes acceptable emission estimating techniques that can be used when source testing is not feasible. This document includes techniques for synthetic organic chemical manufacturing, ethylene oxide sterlization, and chromium electroplating.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Chromium Electroplating Ethylene Oxide Sterlization Storage Tanks Process Vents Equipment Leaks Wastewater Loading Operation MACT Standard Compliance	Air Pollution Control	

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