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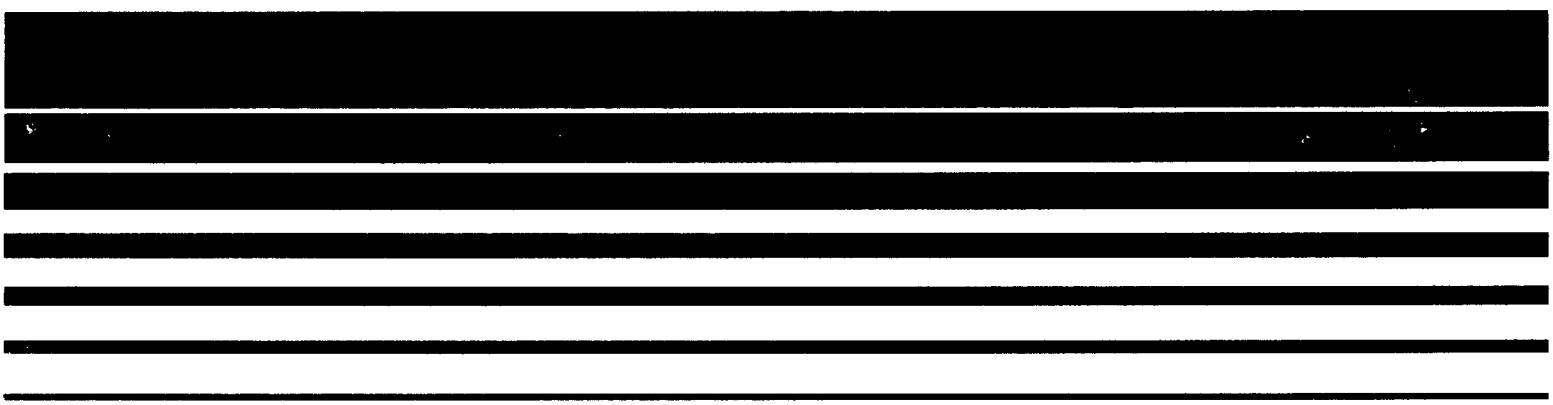
Screening Procedures for Estimating the Air Impacts of Incineration at Superfund Sites



SCREENING PROCEDURES FOR ESTIMATING THE AIR IMPACTS OF INCINERATION AT SUPERFUND SITES

by

International Technology Corporation
South Square Corporate Centre One
3710 University Drive, Suite 201
Durham, North Carolina 27707-6208

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Joseph Padgett, Work Assignment Manager
Aaron Martin, Project Officer

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SECTION 1

INTRODUCTION

1.1 Background/Objectives

The U.S. Environmental Protection Agency (EPA) Regional Air Offices are routinely involved in the analysis and evaluation of air impacts from various remedial alternatives selected for cleanup actions at Superfund sites. The reviews and evaluations are based largely on information supplied by the Regional Superfund Offices in site documents such as the Remedial Investigation/Feasibility Study (RI/FS), Record of Decision (ROD), and other associated documents. A preliminary evaluation of the air impacts of any proposed remedial alternative is required before the ROD is signed, and an in-depth evaluation is necessary during the Remedial Design (RD) and testing phases before the Remedial Action (RA) is implemented. Two threshold criteria for remedy selection, as stated in the National Contingency Plan (NCP), must be shown to be satisfied during the detailed analysis of remedial alternatives. These criteria are 1) compliance with Federal and State applicable or relevant and appropriate requirements (ARARs), and 2) the remedy selected is protective of human health and the environment. A screening analysis is necessary to show that these criteria are satisfied.

This document presents predictive screening procedures for evaluation of the air impacts of onsite high temperature incineration during the detailed analysis of remedial alternatives. Results of the screening procedures are conservative. The screening procedures are generally not appropriate for use in the in-depth evaluation of existing incineration systems. It has been assumed that the users of this document have a general understanding of incineration; therefore, in-depth discussions of various aspects of the incineration process have not been included. Various general

references on the incineration process and on incinerators used at Superfund sites are available in the literature.[1,2,3,4,5]

This document focuses on rotary kiln incinerators in determining emissions characteristics; however, many elements of the analysis are common to other types of incinerators. Rotary kiln incinerators are frequently used for high temperature thermal treatment of Superfund wastes and are especially suited for treatment of soils contaminated with volatile and semivolatile organic compounds. Sludges and liquid organic wastes can also be handled by these systems, but treatment of wastes containing high concentrations of metals is not desirable because metals are not destroyed by the incineration process.

Air impacts are dependent on the actual incinerator emissions, meteorological dispersion conditions and topography, and distances to receptors. The emissions are dependent on such factors as the waste chemical components, incinerator feed rates, thermal destruction and removal efficiency, and characteristics of the air pollution control system. This document provides guidance in evaluating these factors, in estimating air emission rates, and in predicting ambient air concentrations at receptors of interest so that health effects and compliance with air ARARs can be evaluated.

If data are available from a detailed incinerator design and/or from waste material treatability tests, the analysis will be improved because fewer assumptions or estimates will be required. Treatability tests for the waste material may be particularly valuable in predicting emissions characteristics. When pilot-scale tests or trial burn data are available for an existing incinerator, emission rates may be directly derived and the screening analysis would begin with the dispersion modeling procedures in Section 4.

This document may be useful to the Regional Air/Superfund Coordinators, On Scene Coordinators (OSCs), Remedial Project Managers (RPMs), and others involved in the review and evaluation of high temperature incineration. These procedures may also be useful to Superfund contractors in preparing their original analyses of the incineration alternative.

1.2 Approach

The overall approach of this screening procedure assumes that incineration has been identified as the preferred treatment alternative and that a preliminary or conceptual design of the incineration system has been developed. The analysis begins with assessment of the waste characteristics, treatment rates, incineration system parameters, and general site data. Emissions estimates of organic compounds, particulate matter (PM), metals, and acid gases are developed based on the waste components, control equipment efficiency, and/or emissions-limiting ARARs. Ambient air concentrations at receptors of interest are then estimated using dispersion modeling procedures. These concentrations are compared to air quality ARARs, and a health effects assessment is performed for inhalation exposure to carcinogenic and noncarcinogenic compounds. The final step is summarization of the screening analysis results including the assumptions made and any recommendations or conclusions. A conceptual flowchart of the screening procedures for incineration is shown in Figure 1.

1.3 Limitations

Determining the applicability of these screening procedures to a specific site and/or incineration system is the responsibility of the individuals performing the analysis or document review. The use of "typical" or assumed data as a substitute for nonspecified parameters should be performed with caution. Major limitations and limiting assumptions for the screening procedures are summarized below:

- The incineration systems discussed are limited to rotary kilns only.
- The screening procedures assume that the destruction and removal efficiencies and control efficiencies required by regulation are achievable for a given incinerator. This can only be verified by a series of trial burns.

INCINERATION SCREENING PROCEDURES

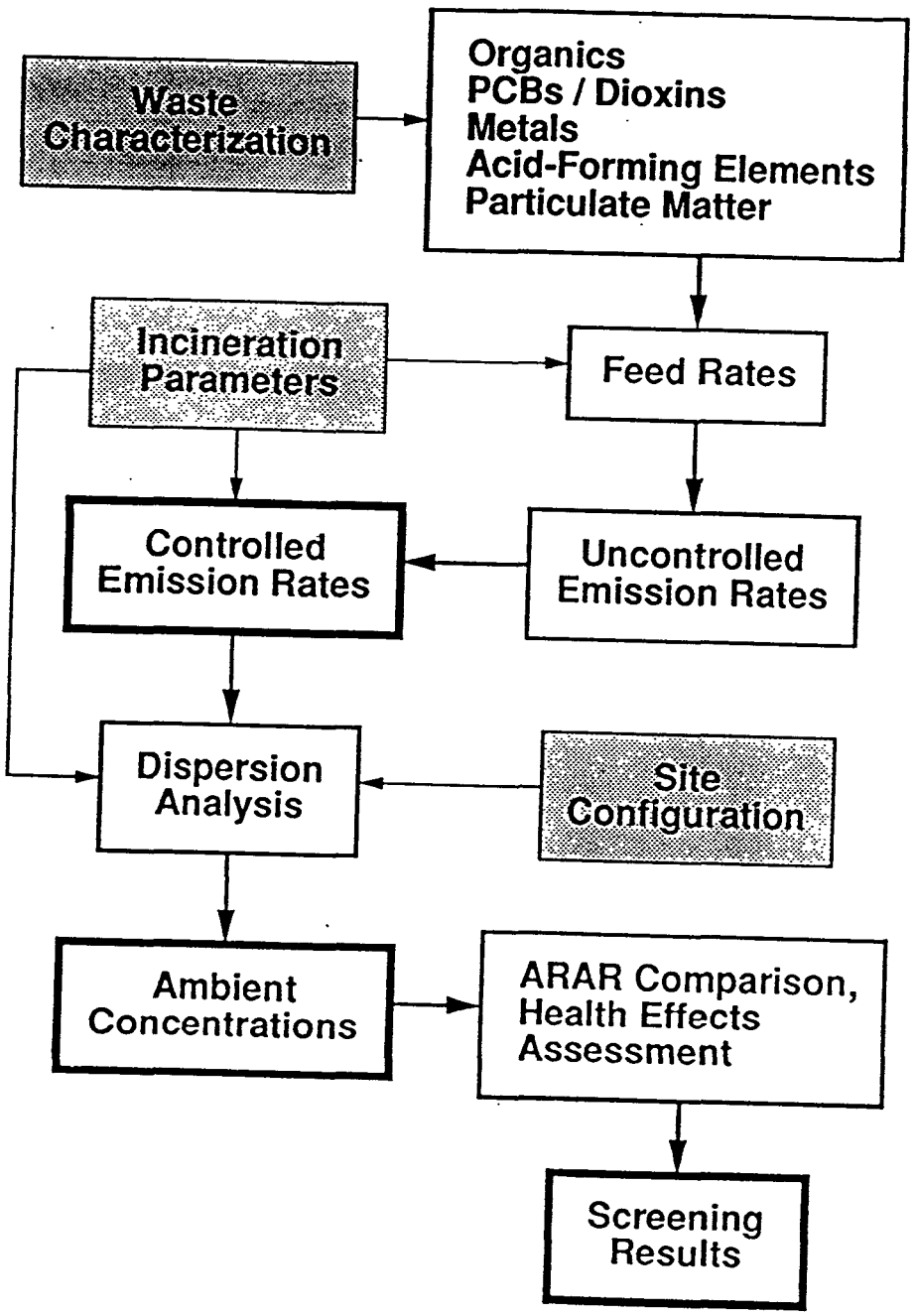

Figure 1. Conceptual flowchart of screening procedures.

- The screening procedures only consider incinerator stack emissions. Fugitive emissions (from waste feed storage, blending, auxiliary equipment, and ash handling) may have a greater impact than stack emissions unless they are adequately controlled. The preferred method of control is to enclose all waste storage and feed areas and to vent emissions to the incinerator as make-up air.

- The effects of atmospheric deposition and secondary pathways are not included in the dispersion or health effects analyses.

SECTION 2

ASSESSMENT OF INCINERATION PARAMETERS

2.1 Information/Data Requirements

Information required to perform the screening procedures is presented in this section. This information includes the waste characterization data, incineration system parameters, and site configuration data. Where information is missing in the remedial planning documents, the missing parameters may be estimated based on "typical" data and/or conservative engineering judgement. Some of the required data must be calculated from other parameters or converted to different formats for use in the screening procedures. Table 1 lists the site-specific data required to estimate emission rates and assess air impacts using these procedures. The significance of each parameter and the use of default data are discussed in the remainder of this section.

Supplemental information used in the analysis that is not site-specific includes physical and chemical properties of the contaminants, health effects data for specific contaminants, and ARARs for incineration and air quality. These items are discussed in later sections of this document.

2.2 Waste Characterization Data

Waste characterization data are generally obtained from the RI and any treatability studies conducted. The type of waste and the moisture content will affect the feed rate capacity of a given incinerator. Rotary kiln incinerators can accommodate a larger mass throughput of solid wastes such as contaminated soils than liquid wastes. As the moisture content of the waste increases, the feed rate capacity of the incinerator generally decreases because a larger portion of the heat input is required to evaporate water.

TABLE 1. INPUT DATA REQUIREMENTS

Category	Data item or parameter	Remarks
Waste characterization	• Waste media	Solid, sludge, or liquid
	• Waste quantity	Tons or kg
	• Moisture content (%)	
	• List of chemical compounds	From sampling data
	• "Average" concentrations in waste feed	For analysis of chronic exposures/long-term ARARs
	• Maximum expected concentrations in waste feed	For analysis of subchronic/acute exposures/short-term ARARs
	• Chlorine content (%) - Average and maximum	Calculate from waste concentrations or obtain from ultimate analysis
Incineration parameters	• Description of incinerator	Flow diagrams are helpful
	• Description of air pollution control system	Flow diagrams are helpful
	• Thermal capacity of system	10^6 Btu/h
	• Feed rates or throughput capacity by waste media	Tons/h or kg/h
	• Operating intervals and cumulative operating time of incinerator	For exposure assessment
	• Stack height	For dispersion analysis
	• Stack inner diameter	For dispersion analysis
	• Exhaust temperature/ambient air temperature	For dispersion analysis
	• Exit gas velocity	For dispersion analysis
	• Exit gas flow rate	For emission rates if stack concentrations are known
Site configuration	• Distance to fenceline	For dispersion analysis and exposure assessment
	• Distance to MEI	For dispersion analysis and exposure assessment
	• Surrounding land use	For urban or rural classification (dispersion analysis)
	• Area topography	For complex or noncomplex terrain (dispersion analysis)
	• Special features or special meteorological conditions	To determine if site-specific dispersion modeling is required

The quantity of waste to be treated is important because this will determine what size incineration system will be used and how long it must operate at a given feed rate. The total mass, in kg or tons, is required for contaminated soils or other solid wastes. If volume is given, the density or unit weight of the solid waste media is required to convert from volume to mass.

The list of chemical compounds and their concentrations in the waste media are obtained from the sampling data. Both "average" concentrations and maximum concentrations are necessary to determine contaminant feed rates to be used in long-term and short-term health effects assessment, and assessment of regulatory limits. Soils/solids from different site areas, however, may be blended before entering the incinerator feed system, so that maximum concentrations found in core samples from a site with varying degrees of contamination may represent much higher concentrations than would actually be found in the feed. An accounting of all components of the waste is necessary to properly assess incineration. The role of these components with respect to air emissions is presented in Section 3. If an ultimate analysis of the waste has been performed, information on moisture content, chlorine content, heating value of the waste, etc. can be used in the screening analysis. An ultimate analysis will be required for the Remedial Design and is recommended any time incineration is considered as a likely remedial alternative. Treatability studies will provide even more valuable information for the screening analysis and incinerator design.

2.3 Incineration Parameters

Review of the incineration alternative for a given Superfund site requires some basic information on the size, type, and operating characteristics of the incineration system to be used. Much of this information may be generated in the preliminary or conceptual design required to produce a cost estimate for the remedial alternative in the FS. If preliminary design data are not available, some important assumptions and estimates must be made by the reviewer in order to perform the screening analysis. These assumptions, such as the use of an assumed feed rate, stack height, exit gas

velocity, etc., can become limiting factors and must be clearly stated in the conclusions of the screening analysis.

High temperature thermal treatment technologies that have proven to be effective at Superfund sites include rotary kiln incineration, infrared incineration, and circulating bed combustion. Other technologies that may be applicable to Superfund sites include oxygen-enriched incineration, electric pyrolysis or plasma incineration, and high temperature thermal desorption.[6] Each of these systems may have different equipment configurations, operating characteristics, and air pollution control systems depending on the manufacturer and site-specific application. The emissions characteristics of each technology will be different and will require different estimation procedures. The examples and "typical" data used to estimate emission rates in this document are applicable to rotary kiln incineration systems.

Figure 2 shows an example of a proposed rotary kiln incineration system. In this example soil and liquids contaminated with volatile and semivolatile organics are both processed in the rotary kiln. Organics are volatilized in the kiln and exit with the hot gases into the secondary combustion chamber (SCC) where destruction is completed. Cyclones ahead of the SCC provide removal of large particulate matter. A water quench reduces gas temperature, and a packed tower scrubber provides primary removal of acid gases. An ejector scrubber removes fine particulate matter and additional acid gases before release to the atmosphere from the stack.

In the above example, the conceptual design of the incinerator and air pollution control system is adequately described for screening purposes. The thermal capacity of the system and the feed rates of soils and liquids are also shown in the diagram. Stack parameters shown include the physical stack height and approximate exhaust gas temperature. The exit gas velocity and gas flow rate are not specified, but conservative estimates of these parameters can be made. If adequate waste characterization data are available, good estimates of controlled emission rates can be made for this example. After emission rates are established, site configuration parameters are necessary to complete the dispersion analysis. The final incineration parameters that are necessary are the operating intervals (i.e., hours per day, days

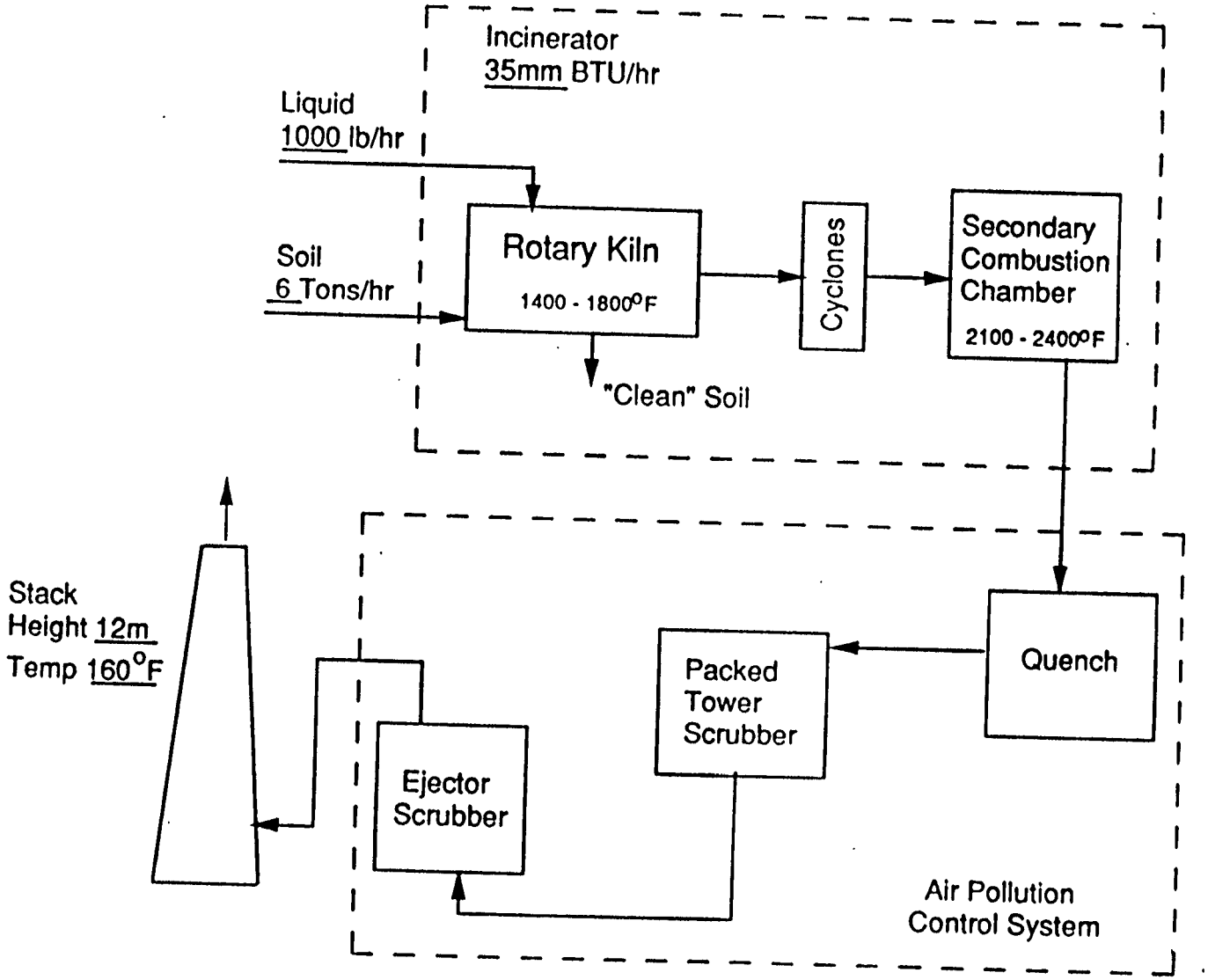

Figure 2. Example of a rotary kiln incineration system.

per week, etc.) and the cumulative operating time (i.e., total weeks, months, or years). These parameters are used to determine the exposure duration for the health effects assessment. A good estimate of these parameters can be made based on the total waste quantity and feed rates.

Table 2 shows ranges of typical parameters for rotary kiln incineration systems by size category. This table can be used as a guide for estimating unknown or unspecified parameters when evaluating a proposed incineration system.

Incineration systems are generally identified by their maximum thermal capacities (10^6 Btu/h), and by their feed rate capacities (tons/h). The thermal capacity is a fixed value based on the maximum heat input to the combustion system (kiln and SCC). The feed rate capacity is generally based on the maximum allowable input of solids at a given condition (say, 10% moisture and less than 5,000 Btu/lb heating value). As moisture and heating value of the waste increases, the feed rate capacity of an incinerator is decreased. For example, an incinerator designed to burn 10 tons/h of low-Btu soil with a moisture content of 10 percent is capable of burning only 1 ton/h of tar sludge with heating value of 8,000 Btu/lb. If the same incinerator is burning soil with a moisture content of 30 percent, the feed rate must be reduced to less than 6 tons/h. Heating value is related to the concentration of organics in the waste, and therefore liquid wastes with high organic concentrations require much smaller feed rates than soils.[7]

The typical quantities of soil given in Table 2 represent ranges in which each size incineration system may be operated economically.[8] Therefore, if the quantity of soil to be treated is known, the size of a "typical" incineration system can be estimated for screening purposes. The corresponding gas volumes shown in Table 2 are estimates based on the given thermal capacities without regard to free moisture in the waste, and operation at 50 percent excess air.[9] These estimates may be used to calculate maximum emission rates of particulate matter based on the maximum allowable stack gas concentration as shown in Section 3.5.

TABLE 2. TYPICAL PARAMETERS FOR ROTARY KILN INCINERATION SYSTEMS[7,8,9,10]

Parameter	Units	Size designation		
		Small	Medium	Large
Thermal capacity	10^6 Btu/h	7-20	20-40	40-100
Typical feed rates for soils[a]	tons/h	1-2	4-9	10-30
	kg/h	900-1800	3600-8200	9100-24,000
Typical feed rates for liquids/sludges[b]	tons/h	0.1-0.6	0.5-3.5	1-15
	kg/h	90-550	450-3200	900-13,600
Typical site quantity of soil	short tons	<5000	5000-30,000	>20,000
	metric tons	<4500	4500-27,000	>18,000
Gas volume	dscfm @ 7% O_2	1800-5000	5000-10,000	10,000-25,000
	dscm/min @ 7% O_2	50-150	150-280	280-710

[a]Assumes 0-15 percent moisture and minimal heating value.
[b]Assumes 10-50 percent moisture and 1000-8000 Btu/lb heating value.

Table 3 gives typical stack parameters for rotary kiln incineration systems. The gas exit velocity and temperature are independent of system size, but physical stack height generally increases with system size. Stack heights of 12 meters or less are most common.[11] Gas exit velocity depends on the actual gas volume and inner diameter of the stack. The exit gas temperature is dependent on the combustion temperature, quench conditions, and characteristics of the air pollution control system. Rotary kiln systems used at Superfund sites generally use a quench to reduce the gas temperature and a wet absorber/scrubber to remove acid gases. Particulate matter is removed by various types of high-efficiency wet scrubbers, although one system uses cyclones and fabric filters before the acid gas absorber.[12] The default values in Table 3 are conservative estimates to be used when the actual parameters are not available.

TABLE 3. STACK PARAMETERS FOR ROTARY KILN INCINERATORS[9,11]

Parameter	Range	Default value
Physical stack height	6 - 20 m	8 m
Stack diameter	0.3 - 1.0 m	0.5 m
Exit velocity	1400 - 4000 ft/min 7 - 20 m/s	2000 ft/min 10 m/s
Exit temperature[a]	150° - 180°F 338° - 355°K	160°F 344°K

[a]Assumes a quench and wet scrubbing system at adiabatic saturation of the stack gas.

2.4 Site Configuration

Stack parameters, controlled emission rates, and site configuration data are the inputs to the dispersion analysis. The first consideration in collecting site configuration data is the physical location of the incinerator stack. Distance to the fenceline and/or MEI is required to determine ambient air levels for the human health evaluation and other regulatory requirements. The significance of surrounding land use, topography, and meteorology are discussed in Section 4.

SECTION 3

ESTIMATION OF EMISSION RATES

3.1 General Procedures

This section presents procedures for estimating emission rates from rotary kiln incinerators burning hazardous waste. The general procedures followed are to 1) establish feed rates of the individual compounds or groups of compounds in the waste, 2) calculate uncontrolled emission rates (except for organic compounds), and 3) calculate controlled emission rate estimates using the equations provided in this section. The input data required to estimate emission rates are the waste characterization data and incineration parameters previously discussed in Sections 2.2 and 2.3. Other data required as variables in the emission rate equations are available from tables included in this section. The convention used in these equations is that all feed rates are given in lb/h and all emission rates are given in g/s.

The remainder of this section is organized by type of emissions, i.e., organic compounds, metals, acid gases, and particulate matter. The assumptions or basis for the emissions estimates are given prior to the equations. In the cases where regulatory limits are used to define the emission rates, citations for these ARARs are given in the tables in Section 5.1.

A worksheet for emissions calculations is given at the end of this section. The worksheet is used to summarize the input data and the results of the emissions calculations. The applicable equations and tables are cited for use with the worksheet.

3.2 Organic Compounds

For purposes of this screen, organic compounds will be divided into three groups by waste classification. The three groups are total hydrocarbons (THCs), polychlorinated biphenyls (PCBs), and dioxins. THC compounds are considered to be all volatile and semivolatile organic compounds that are not PCBs or dioxin wastes.

3.2.1 Feed Rates for Organics

In order to determine the feed rate of each group of organic compounds, the total concentration of organics in the waste from each group must be determined. PCBs and dioxin compounds should be separated from the sampling data first. All remaining organic compounds will then form the THC group. The concentration of each group of organic compounds in the waste is given by the following equation:

$$C_o = \sum_{i=1}^{n} C_{o_i} \qquad (1)$$

where C_o = Concentration of the group of organic compounds of interest (THC, PCB, or dioxin), ppm

C_{o_i} = Concentration of organic species i of the same group, ppm.

The feed rate of each group of organic compounds can be calculated using the following equation:

$$FR_o = (FR)(C_o)(1\times10^{-6}) \qquad (2)$$

where FR_o = Feed rate of organic compounds of interest, lb/h

FR = Mass feed rate of waste to the incinerator, lb/h

C_o = Concentration of the group of organic compounds of interest, ppm

1×10^{-6} = Conversion factor for ppm.

3.2.2 Emission Rates of Organics

Emissions of organic compounds depend on the destruction and removal efficiency (DRE) of the incinerator for those compounds. The DRE is affected by the gas residence times and temperatures in the incinerator combustion chambers. A key assumption in the screening procedures is that the incinerator will be capable of meeting the DREs required by the ARARs (Section 5.1). This can only be verified by a trial burn or treatability tests of wastes from the site. Table 4 contains typical temperatures, residence times, and DREs achieved for incinerators by waste type, and may be used for comparison purposes in evaluating a preliminary incinerator design.

The emission rate estimates for organics are determined by assuming that the DREs required by regulation and achieved through design and proper operation of the incinerator are met exactly for each group of organics. RCRA standards require a DRE of 99.99 percent for each principal organic hazardous constituent (POHC) in the waste feed. POHCs are organic compounds chosen as indicators for the trial burn, and are a subset of the THC compounds. It is assumed that a DRE of exactly 99.99 percent will be achieved for THCs, except when the incinerator is designed and operated to burn PCBs or dioxin wastes. RCRA standards require a DRE of 99.9999 percent for all dioxin wastes, and Toxic Substances Control Act (TSCA) standards also require a DRE of 99.9999 percent for PCBs. It is assumed that a DRE of exactly 99.9999 percent will be achieved for all PCBs, dioxins, and THC when PCBs or dioxins are incinerated.

Small quantities of products of incomplete combustion (PIC) are formed by the reaction and reformation of organic compounds during the combustion process. PIC may include dioxins, furans, formaldehyde, benzo(a)pyrene, and other polynuclear aromatic hydrocarbons (PAH). Emissions of PIC cannot be determined by predictive methods. PIC may be monitored during a trial burn, although levels may be below detection limits of the monitoring equipment. In the screening risk assessment

TABLE 4. TYPICAL TEMPERATURES AND RESIDENCE TIMES FOR HAZARDOUS WASTE DESTRUCTION[14]

Waste type	Temperature, °C	Temperature, °F	Residence time, s	DRE, %
Lean gases containing hydrocarbons of sulfur, fume streams	650-750	1200-1400	0.5 - 0.75	99
Liquid streams containing hydrocarbons, vapor streams containing CO or ammonia	900-1000	1600-1800	1.0 - 2.0	99.99
Halogenated hydrocarbons liquids and vapors, long chain hydrocarbons, waste liquids	1000-1100	1800-2000	1.5 - 2.0	99.99
Combustible solids	1100-1300	2000-2400	1.5 - 2.0	99.99
NO_x or compounds with bound nitrogen (reducing atmosphere, i.e., excess fuel)	1300-1400	2400-2600	1.0 - 2.0	99.99
PCBs, dioxins	1200-1300	2200-2400	1.0 - 2.0	99.9999

procedure discussed in Section 5.2, PIC are considered to be present in the THC emissions, and an aggregate unit cancer risk value for THC may be used to assess these emissions.[13]

There are no uncontrolled emission rate calculations for organic compounds because the destruction and removal occurs in the incinerator combustion chambers. Controlled emission rates are calculated using the equation:

$$ER_o = (FR_o)\left(1 - \frac{DRE_o}{100}\right)(0.126) \qquad (3)$$

where ER_o = Emission rate of organic compounds, g/s

FR_o = Feed rate of organic compounds, lb/h (Equation 2)

DRE_o = 99.99 for THCs alone

= 99.9999 for PCBs or dioxins, and THCs

0.126 = Conversion factor, lb/h to g/s.

3.3 Metals

Metals may be present with organics in soils or other solid wastes and in liquid waste fuels. EPA has identified 10 toxic metals that may pose a hazard to human health and the environment when released in incinerator emissions: antimony, arsenic, barium, beryllium, cadmium, hexavalent chromium, lead, mercury, silver, and thallium. Four of these metals (or their compounds) are known or suspected carcinogens: arsenic, beryllium, cadmium, and hexavalent chromium. A conservative assumption used in the screen is that emissions of chromium are all in the hexavalent state.

3.3.1 Feed Rates for Metals

The feed rates of each individual metal must be determined from the concentration of each metal in the waste feed and the total or mass feed rate of the

waste to the incinerator. The following equation may be used to calculate feed rates for each metal:

$$FR_m = (FR)(C_m)(1\times10^{-6}) \quad (4)$$

where FR_m = Feed rate of metal specie, lb/h

FR = Mass feed rate of waste to the incinerator, lb/h

C_m = Concentration of metal species in the waste, ppm

1×10^{-6} = Conversion factor, dimensionless.

3.3.2 Uncontrolled Emission Rates

The uncontrolled emission rate of a metal is affected by the feed rate of the metal and the "partitioning" of the metal within the incinerator system. Partitioning refers to the fact that a portion of the metals in the waste feed will remain in the solids in the rotary kiln and be discharged with the bottom ash, and a portion of the metals will be carried out of the rotary kiln and SCC with the combustion gases.

Conservative estimates of the partitioning of metals in incinerators have been developed by EPA[5] and are shown in Table 5. The partitioning factor represents the percent metal that leaves the incinerator combustion chambers and travels into the air pollution control device (APCD). Table 5 represents worst case conditions for various types of incinerators. Other partitioning factors based on test results from specific types of rotary kiln incinerators may be substituted where available. The partitioning factors are used, along with the feed rates of each metal calculated in Section 3.3.1, to determine uncontrolled emission rate estimates for the appropriate metals. The uncontrolled emission rate of each metal may be calculated using the equation:

$$ER_{m_u} = (FR_m)\left(\frac{PF}{100}\right)(0.126) \quad (5)$$

TABLE 5. CONSERVATIVE ESTIMATES OF METALS PARTITIONING (%) TO APCD[a,11]

Metal[c]	Solids[b]		Liquids
	1600°F	2000°F	All temperatures
Antimony	100	100	100
Arsenic	100	100	100
Barium	50	100	100
Beryllium	5	5	100
Cadmium	100	100	100
Chromium	5	5	100
Lead	100	100	100
Mercury	100	100	100
Silver	100	100	100
Thallium	100	100	100

[a]The remaining percentage is contained in the bottom ash of the incinerator.
[b]The combustion gas temperature is estimated to be 100° - 400°F higher than the solids temperature.
[c]Assumptions:
- Chlorine content $\leq$ 1% of waste feed
- Excess air = 50%
- Entrainment = 5%
- Waste metals content $\leq$ 100 ppm for each metal. For a given set of combustion chamber conditions, the maximum amount of metal which will be vaporized will become constant as the metal concentration in the solids increase. As a result, higher concentrations of metals are expected to have lower partitioning factors.

where FR_m = Feed rate of metal specie, lb/h

ER_{m_u} = Uncontrolled emission rate of metal specie, g/s

PF = Partitioning factor for metal specie, % (from Table 5)

0.126 = Conversion factor, lb/h to g/s.

3.3.3 Controlled Emission Rates of Metals

The controlled emission rates of metals are dependent on the efficiency of the incinerator's APCD in the removal of metals from the combustion gases. EPA has developed efficiency estimates for the removal of particulate matter and metals for various APCDs[15] as shown in Table 6. The APCD efficiencies are used with the uncontrolled emission rates of metals determined in Section 3.3.2 to calculate controlled emission rates using the equation:

$$ER_{m_c} = (ER_{m_u})\left(1 - \frac{CE_m}{100}\right) \quad (6)$$

where ER_{m_c} = Controlled emission rate for metal specie, g/s

EM_{m_u} = Uncontrolled emission rate for metal specie, g/s

CE_m = Control efficiency for APCD, % (from Table 6).

3.4 Acid Gases

The presence of halogenated organics and/or sulfur in the waste feed can cause the formation of acid gases during incineration. The acid gases of primary interest are hydrogen chloride (HCl), hydrogen fluoride (HF), hydrogen bromide (HBr), and sulfur dioxide (SO_2). These gases are formed from the chlorine-, fluorine-, bromine-, and sulfur-bearing compounds in the waste feed.

3.4.1 Feed Rates of Acid-Forming Elements

By knowing the concentration and molecular weights of the compounds containing acid-forming elements in the waste, the aggregate concentration of each

TABLE 6. ESTIMATED APCD EFFICIENCIES FOR CONTROLLING TOXIC METALS[15]

APCD	Pollutant				
	Ba, Be	Ag	Cr	As, Sb, Cd, Pb, Tl	Hg[a]
WS[a]	50	50	50	40	30
VS-20[a]	90	90	90	20	20
VS-60[a]	98	98	98	40	40
ESP-1	95	95	95	80	0
ESP-2	97	97	97	85	0
ESP-4	99	99	99	90	0
WESP[a]	97	97	96	95	60
FF[a]; FF/WS[a]	95	95	95	90	50
PS[a]	95	95	95	95	80
SD/FF; SD/C/FF	99	99	99	95	90
DS/FF	98	98	98	98	50
ESP-1/WS; ESP-1/PS	96	96	96	90	80
ESP-4/WS; ESP-4/PS	99	99	99	95	85
VS-20/WS[a]	97	97	97	96	80
WS/IWS[a]	95	95	95	95	85
WESP/VS-20/IWS[a]	99	99	98	97	90
C/DS/ESP/FF; C/DS/C/ESP/FF	99	99	99	99	98
SD/C/ESP-1	99	99	98	95	85

[a]It is assumed that flue gases have been precooled (usually in a quench). If gases are not cooled adequately, mercury recoveries will diminish, as will cadmium and arsenic to a lesser extent.

APCD Codes

C = Cyclone
WS = Wet Scrubber including: Sieve Tray Tower
Packed Tower
Bubble Cap Tower
PS = Proprietary Wet Scrubber Design (high efficiency PM and gas collection)
VS-20 = Venturi Scrubber, ca. 20-30 in W. G. Δp
VS-60 = Venturi Scrubber, ca. > 60 in W. G. Δp
ESP-1 = Electrostatic Precipitator; 1 stage
ESP-2 = Electrostatic Precipitator; 2 stages
ESP-4 = Electrostatic Precipitator; 4 stages
WESP = Wet Electrostatic Precipitator
IWS = Ionizing Wet Scrubber
DS = Dry Scrubber
FF = Fabric Filter (Baghouse)
SD = Spray Dryer (Wet/Dry Scrubber)

element can be determined using the equation:

$$C_A = \sum_{i=1}^{n} \left[(C_{A_i}) \left(\frac{MW_A}{MW_{A_i}} \right) \right] \quad (7)$$

where C_A = Concentration of acid-forming element (Cl, F, Br, or S) in the waste, ppm

C_{A_i} = Concentration of compound i containing the same element, ppm

MW_A = Molecular weight of acid-forming element

MW_{A_i} = Molecular weight of compound i containing the same element.

If an ultimate analysis of waste samples has been performed, the concentration of each element will be available from this data, and the use of Equation 7 will not be necessary. Ultimate analysis data for each element is reported in percent (1 percent = 10,000 ppm).

The feed rate of each acid-forming element is calculated using the equation:

$$FR_A = (FR)(C_A)(1 \times 10^{-6}) \quad (8)$$

where FR_A = Feed rate of acid-forming element, lb/h

FR = Mass feed rate of waste to the incinerator, lb/h

C_A = Concentration of acid-forming element, ppm

1×10^{-6} = Conversion factor for ppm.

If sulfur is present in the auxiliary fuel, the feed rate of sulfur from the fuel must be added to the feed rate of sulfur from the waste to obtain the total sulfur feed rate.

3.4.2 Uncontrolled Emission Rates of Acid Gases

Uncontrolled emission rates for acid gases formed from halogenated compounds in the waste are calculated by assuming that the total mass of each acid-forming element combines with hydrogen in stoichiometric proportion to form the acid gases. Likewise, it is assumed that all sulfur combines with oxygen to form SO_2. The

stoichiometric ratios of acid gas-to-element are given in Table 7. Uncontrolled emission rates of acid gases are calculated using the equation:

$$ER_{A_U} = (FR_A)(R_A)(0.126) \quad (9)$$

where ER_{A_U} = Uncontrolled emission rate of acid gas, g/s

FR_A = Feed rate of element, lb/h

R_A = Stoichiometric ratio of acid gas-to-element, g/g (From Table 7)

0.126 = Conversion factor, lb/h to g/s.

TABLE 7. STOICHIOMETRIC RATIOS OF ACID GAS TO ELEMENT

Element	Acid gas	Stoichiometric ratio, (g/g)
Bromine (Br)	Hydrogen bromide (HBr)	1.013
Chlorine (Cl)	Hydrogen chloride (HCl)	1.028
Fluorine (F)	Hydrogen fluoride (HF)	1.053
Sulfur (S)	Sulfur dioxide (SO_2)	1.998

3.4.3 Controlled Emission Rates of Acid Gases

Hazardous waste incinerators are equipped with acid gas scrubbers in order to control HCl emissions to a maximum of 1.8 kg/h (0.5 g/s) or 1 percent of the uncontrolled HCl emissions as presently required by RCRA (Section 5.1). Therefore, 99 percent of the HCl must be removed by the APCD unless the HCl emissions are less than or equal to 0.5 g/s. Wet scrubbers are typically used for acid gas control by rotary kiln incinerators at Superfund sites.

Typical control efficiencies for wet scrubbers used for acid gas control are reported as:[14]

HCl	99%
HF	99%
SO_2	90%+

Typical efficiencies for removal of HBr by wet scrubbers have not been reported.

Controlled emission rates of acid gases are calculated using the following equation:

$$ER_{A_C} = (ER_{A_U})\left(1 - \frac{CE_s}{100}\right) \quad (10)$$

where ER_{A_C} = Controlled emission rate of acid gas, g/s

ER_{A_U} = Uncontrolled emission rate of acid gas, g/s

CE_s = Scrubber control efficiency for the acid gas, % (use values given previously for wet scrubbers).

3.5 Particulate Matter

Under the existing RCRA standards (Section 5.1), incinerator particulate matter (PM) emissions must not exceed a stack concentration of 0.08 grains per dry standard cubic foot (gr/dscf)(or 180 mg/dscm) corrected to 7 percent oxygen in the stack gas (50% excess air). Some of the factors affecting PM emissions are waste composition, particle size distribution, feed rate, and incinerator design. Because PM emissions cannot be predicted accurately without detailed data, the maximum allowable emission rate, based on RCRA standards, will be used as a conservative estimate. The allowable emission rate of PM is calculated by the equation:

$$ER_{PM} = (0.08\ gr/dscf)(Q_G)(0.00108) \quad (11)$$

where ER_{PM} = Emission rate of PM, g/s

Q_G = Gas flow rate, dscfm at 7 percent oxygen in the stack gas

0.00108 = Conversion factor, gr/min to g/s.

3.6 Emissions of Other Contaminants

3.6.1 Oxides of Nitrogen

Formation of oxides of nitrogen (NO_x) is a potential concern with any combustion source including incinerators. The rate of NO_x formation is a function of fuel firing rate, excess oxygen, flame temperature, and burner design. NO_x emissions can be effectively controlled by proper design of the combustion equipment. Evaluation of NO_x emissions is beyond the scope of these screening procedures.

3.6.2 Carbon Monoxide

Carbon monoxide (CO) emissions are also a concern with combustion sources. CO emissions, however, are directly related to the combustion efficiency and THC emissions of incinerators. CO monitoring of stack gases is a regulatory requirement for incinerators under RCRA. If the required DREs for organics are met, CO emissions will generally be within acceptable levels.

3.6.3 Chlorine

EPA has raised the concern that free chlorine (Cl_2) emissions from incinerators may be a potential problem when there is insufficient hydrogen available (from hydrocarbon compounds or water vapor) to react with all of the chlorine in the waste.[16] Cl_2 can be controlled by emissions testing and by providing more hydrogen in the waste or auxiliary fuel or the addition of superheated steam to the stack gas. Emissions of Cl_2 can be calculated for a worst case scenario using procedures similar to those for acid gas emissions in Section 3.4. This is generally not necessary for screening purposes unless there are very high levels of chlorine in the waste feed.

3.7 Worksheet for Emissions Calculations

Table 8 is included in the screen as a summary worksheet for emissions calculations. In this table, the double underlines represent input data, and the single underlines represent calculated values. References to the applicable text sections,

TABLE 8. WORKSHEET FOR EMISSIONS CALCULATIONS

Waste element	Concentration, ppm	Feed rate, lb/h	Compound emitted	PF or R_A[a]	Uncontrolled emissions, g/s	DRE/control efficiency, %	Controlled emissions, g/s
		Section 2.3					
Total mass	N/A		N/A	N/A	N/A	N/A	N/A
ORGANICS:	Equation 1	Equation 2					Equation 3
THC			THC	N/A	N/A	99.99[b]	
PCBs			PCB	N/A	N/A	99.9999[c]	
Dioxins			Dioxin	N/A	N/A	99.9999[b]	
METALS:	Sampling data	Equation 4		Table 5	Equation 5	Table 6	Equation 6
Antimony			Sb				
Arsenic			As				
Barium			Ba				
Beryllium			Be				
Cadmium			Cd				
Chromium			Cr(+6)				
Lead			Pb				
Mercury			Hg				
Silver			Au				

(continued)

TABLE 8 (Continued)

Waste element	Concentration, ppm	Feed rate, lb/h	Compound emitted	PF or R_A[a]	Uncontrolled emissions, g/s	DRE/control efficiency, %	Controlled emissions, g/s
Thallium			Tl				
GASES:	Equation 7	Equation 8			Equation 9	Section 3.4.3	Equation 10
Chlorine			HCl	1.028		99[b]	
Sulfur			SO_2	1.998			
Fluorine			HF	1.053			
Bromine			HBr	1.013			
PM:					Gas flow, dscfm	Stack concentration gr/dscf	
					Table 2		Equation 11
Particulate	N/A	N/A	PM	N/A		0.08[b]	

[a]Partitioning factor, % (metals) or Stoichiometric ratio, g/g (gases).
[b]RCRA requirement (Section 5.1).
Note: If the incinerator is designed to burn PCBs or Dioxins, a DRE of 99.9999 should be achieved for all organics.
[c]TSCA requirement (Section 5.1).

look up tables, and needed equations are included in the worksheet. This table is used as an aid in the calculation and summarization of feed rates, uncontrolled emission rates, and controlled emission rates for incineration. The worksheet can be assembled in this format using a spreadsheet program on a personal computer.

SECTION 4

ESTIMATION OF AMBIENT AIR CONCENTRATIONS

4.1 Dispersion Models

If emission rates and release parameters for the incinerator stack are known, dispersion modeling techniques are used to estimate ambient air concentrations at offsite receptors or at the fenceline, as appropriate. The computer dispersion models can use either site-specific meteorology (preferred) or generic worst-case conditions to produce ambient air concentration estimates. Because this document is concerned with screening procedures only, the range of available dispersion models is not discussed here. The recommended dispersion models to be used in these screening procedures, as discussed in Sections 4.3 and 4.4, are EPA's SCREEN model[17] and/or Industrial Source Complex (ISCLT) model.[18] The TSCREEN model also incorporates the SCREEN algorithm and may be used in conjunction with its associated workbook.[19] These dispersion models are available from EPA's Support Center for Regulatory Air Models Bulletin Board System (SCRAM-BBS), accessed through the OAQPS Technology Transfer Network, at (919) 541-5742 or FTS 629-5742. The appropriate user's manuals should be consulted for data input procedures and interpretation of outputs. The EPA Regional Air/Superfund Coordinator, Meteorologist or Modeling Contact may be consulted if assistance is needed.

4.2 Data Input Requirements

An incinerator stack is treated as a point source for purposes of dispersion analysis. The required inputs to the analysis are emission rate, stack height, exit velocity, stack diameter, gas temperature, and ambient air temperature. Site

configuration data include location of the stack, fenceline, and MEI, which are required to determine appropriate downwind distances for concentration estimates. The surrounding land use should be examined to determine rural or urban classification. Examination of the topography is necessary to determine complex or noncomplex terrain classification and any unusual features. The presence of buildings should be noted for possible downwash situations. If site-specific meteorological data are available, they should be used in the dispersion analysis. Use of generic worst-case conditions, however, will generally produce more conservative estimates.

4.3 Short-Term Concentration Estimates

Use the SCREEN dispersion model to predict short-term downwind ambient air concentrations in $\mu g/m^3$. The SCREEN model produces a maximum one-hour average concentration estimate at specified downwind distances.

When running SCREEN, use an emission rate of 1 g/s and run all wind stability classes. The result will be a one-hour ambient concentration estimate, in $\mu g/m^3$, for a 1 g/s emission rate. This value may be used as a dispersion factor ($\mu g/m^3$ per g/s) in computing ambient concentration estimates for multiple pollutants. To obtain concentration estimates for each pollutant use the following equation:

$$C_{mi} = (ER_i)(F) \qquad (12)$$

where C_{mi} = Maximum hourly ambient air concentration of pollutant i, $\mu g/m^3$

ER_i = Emission rate of pollutant i, g/s

F = Dispersion factor from SCREEN model run, $\mu g/m^3$ per g/s.

If estimates for other short-term averaging times are needed (i.e., to determine ARAR compliance), multiply the one-hour estimate by the appropriate factor below:

Averaging time	Multiplying factor[19]
3 hours	0.9 (± 0.1)
8 hours	0.7 (± 0.2)
24 hours	0.4 (± 0.2)

4.4 Long-term Concentration Estimates

If site-specific meteorological data are available, use the ISCLT model to predict long-term downwind ambient air concentrations in $\mu g/m^3$. As an alternative, long-term estimates may be made by multiplying the short-term estimate obtained from SCREEN by a conversion factor to obtain annual average estimates. This approach generally results in a higher estimate of the annual average concentration than if the ISCLT model, with site-specific data, is used. The conservative conversion factor, 0.025, can be used when the terrain is relatively flat and no unusual meteorological conditions exist. Use the following equation to obtain concentration estimates for each pollutant:

$$C_{ai} = (ER_i)(F)(0.025) \qquad (13)$$

where C_{ai} = Annual average ambient air concentration of pollutant i, $\mu g/m^3$

ER_i = Emission rate of pollutant i, g/s

F = Dispersion factor from SCREEN model run, $\mu g/m^3$ per g/s.

Use of the SCREEN model in predicting ambient air concentrations is illustrated in the Case Example in Section 6.

SECTION 5

EVALUATION OF ARARS AND HEALTH EFFECTS

5.1 ARARS

The 1990 revisions to the NCP require compliance with ARARs during remedial action, and compel attainment of ARARs during removal actions whenever practicable. Guidance on compliance with federal ARARs for incineration at Superfund sites can be found in the EPA documents, CERCLA Compliance With Other Laws Manual: Parts I and II (OSWER Directives 9234.1-01 and 9234.1-02).[20,21] Information taken from these documents is summarized in Tables 9 and 10. Table 9 presents selected action-specific ARARs for incineration, and Table 10 presents selected chemical-specific ARARs for incinerator stack emissions. All potential ARARs should be identified and addressed in the FS stage of the remedial process.

Regulatory standards that may apply to incineration include RCRA, the Toxic Substances Control Act (TSCA), Clean Air Act (CAA), State Air Toxic Program requirements, and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). New regulatory standards for hazardous waste incinerators (proposed amendments to RCRA Subpart O) have not been released at the time this document was prepared. While the regulations on burning of hazardous waste in Boilers and Industrial Furnaces (BIF rule)[22] are not directly applicable to Superfund incinerators, substantive requirements of the BIF rule may be applied to certain incinerators at the discretion of regulatory authorities.

The chemical-specific ARARs evaluation is performed by simply comparing the ARAR limits for pollutants of interest (i.e., lead, PM, SO_2, etc.) to the estimated ambient air concentrations (Sections 4.3 - 4.4). Action-specific ARARs may be evaluated by examining the proposed incinerator design, if available.

TABLE 9. SELECTED ACTION-SPECIFIC POTENTIAL ARARS FOR INCINERATION

Actions	Requirements	Prerequisites for applicability	Citation
RCRA			
Incineration	Analyze the waste feed	RCRA hazardous waste	40 CFR 264.341
	Dispose of all hazardous waste and residues, including ash, scrubber water, and scrubber sludge.		40 CFR 264.351
	No further requirements apply to incinerators that only burn wastes that are listed as hazardous solely by virtue of combination with other wastes, and if the waste analysis demonstrates that no Appendix VII constituent is present that might reasonably be expected to be present		40 CFR 264.340
	Performance standards for incinerators:	RCRA hazardous waste	
	• Achieve a destruction and removal efficiency of 99.99 percent for each principal organic hazardous constituent in the waste feed and 99.9999 percent for dioxins		40 CFR 264.343
	• Reduce hydrogen chloride emissions to 1.8 kg/h or 1 percent of the HCl in the stack gases before entering any pollution control devices		40 CFR 264.342
	• Not release particulate in excess of 180 mg/dscm corrected for amount of oxygen in stack gas		40 CFR 264.343
	Monitoring of various parameters during operation of the incinerator is required. These parameters include:		40 CFR 264.343

(continued)

TABLE 9 (Continued)

Actions	Requirements	Prerequisites for applicability	Citation
	• Combustion temperature • Waste feed rate • An indicator of combustion gas velocity • Carbon monoxide		
	Control fugitive emissions either by: • Keeping combustion zone sealed or • Maintaining combustion-zone pressure lower than atmospheric pressure		40 CFR 264.345
	Utilize automatic cutoff system to stop waste feed when operating conditions deviate		
TSCA			
Incineration of liquid PCBs	Combustion requirements • Either: 2-second dwell time at 1200° C(± 100°C) and 3 percent excess oxygen in stack gas or 1.5 second dwell time at 1600°C and 2 percent excess oxygen in stack gas	Incineration of liquid PCBs at concentrations of 50 ppm or greater unless specified in 40 CFR section 761.70[a]	40 CFR 761.70 (TSCA)

(continued)

TABLE 9 (Continued)

Actions	Requirements	Prerequisites for applicability	Citation
	• Combustion efficiency of at least 99.9999 percent		
	• Rate and quantity of PCBs fed to the combustion system shall be measured and recorded at regular intervals no longer than 15 minutes		
	• Temperature of incineration shall be continuously measured and recorded		
	• Flow of PCBs to incinerator must stop automatically whenever the combustion temperature drops below specified temperature		
	Monitoring must occur:		
	• When the incinerator is first used or modified; monitoring must measure for O_2, CO, CO_2, Oxides of Nitrogen, HCl, RCl, PCBs, Total Particulate Matter		40 CFR 761.70 (TSCA)
	• Whenever the incinerator is incinerating PCBs, the O_2 and CO levels must be continuously checked. CO_2 must be periodically checked.		40 CFR 761.70 (TSCA)
	Water scrubbers must be used for HCl control		

(continued)

TABLE 9 (Continued)

Actions	Requirements	Prerequisites for applicability	Citation
	Treatment standards under RCRA land disposal restrictions (LDRs): • Incineration or • Burning in high efficiency boilers	Incineration of liquid PCBs under the California List Waste land disposal restrictions, assuming that HOC wastes are mixed with a RCRA-listed or -characteristic waste and total HOC concentration is equal to or greater than 1,000 mg/kg or PCB concentration alone is 50 ppm	40 CFR 268.42 (RCRA)
Incineration of Nonliquid PCBs, PCB Articles, PCB Equipment, and PCB Containers	Same as for liquid PCBs	Incineration of non-liquid PCBs, PCB articles, PCB equipment, and PCB containers at concentrations of 50 ppm or greater unless specified in 40 CFR section 761.70	40 CFR 761.70 (TSCA)
	Mass air emissions from the incinerator shall be no greater than 0.001 g PCB per kg of the PCBs entering the incinerator		40 CFR 761.70 (TSCA)
	Monitoring is required		40 CFR 761.70 and 761.180 (TSCA)

(continued)

TABLE 9 (Continued)

Actions	Requirements	Prerequisites for applicability	Citation
	Same as for liquid PCBs	Incineration of non-liquid PCBs regulated as HOCs under the California List Wastes land disposal restrictions, provided that HOC wastes are mixed with a RCRA-listed or RCRA-characteristic waste and total HOC concentrations equal to or greater than 1,000 mg/kg	40 CFR 268.42 (RCRA)
FIFRA			
Incineration of Organic Pesticides	Performance standards: 2-second residence time at 1000°C (or equivalent that will assure complete destruction)	Incineration of organic pesticides, except organic mercury, lead, cadmium, and arsenic (recommended).	40 CFR 165.8 40 CFR 165.1
	Meet requirements of CAA relating to gaseous emissions		40 CFR 165.8
	Dispose of liquids, sludges, or solid residues in accordance with applicable Federal, State, and local pollution control requirements.		40 CFR 165.8

(continued)

TABLE 9 (Continued)

Actions	Requirements	Prerequisites for applicability	Citation
Incineration of Metallo-organic Pesticides	Chemically or physically treat pesticides to recover heavy metals; incinerate in same manner as organic pesticides.	Incineration of metallo-organic pesticides, except mercury, lead, cadmium, or arsenic compounds (recommended).	40 CFR 165.8
Incineration of Combustible containers	Incinerate in same manner as organic pesticides.	Incineration of combustible containers that formerly held organic or metallo-organic pesticides, except organic mercury, lead, arsenic, and cadmium (recommended).	40 CFR 165.9

[a]An approved incinerator (under section 761.70) can be used to destroy any concentration of PCBs; a high-efficiency boiler approved under section 761.60(a)(2)(iii) can be used for mineral oil dielectric fluid from PCB-contaminated electrical equipment containing PCBs in concentrations greater than or equal to 50 ppm but less than 500 ppm; and a RCRA-approved incinerator [under RCRA κ3005(a)] can be used for PCBs that are not subject to the incineration requirements of TSCA (i.e., at concentrations less than 50 ppm). Except as provided in section 761.75(b)(ii), liquid PCBs shall not be processed into nonliquid forms to circumvent the high-temperature incineration requirements of section 761.60(a).

[b]Incineration of nonliquid PCBs can only be carried out in TSCA-approved incinerators (under section 761.60), which may be used to destroy any concentration of PCBs.

TABLE 10. SELECTED CHEMICAL-SPECIFIC POTENTIAL ARARS FOR INCINERATOR STACK EMISSIONS

Chemical name	Requirements	Prerequisites for applicability	Citation
CLEAN AIR ACT			
NESHAPS			
Beryllium	Not more than 10 μg/day or 0.01 g/m^3 ambient concentrations (with 3 years of monitoring data)	Extraction plants, ceramic plants, foundries, incinerators, rocket propellant plants, machine shops	40 CFR Part 61 (CAA)
NAAQS			
Carbon monoxide	Not to exceed 9 ppm over 8-hour period and not to exceed 35 ppm over a 1-hour period (primary); no secondary standards	Major stationary and mobile sources	40 CFR Part 50 (CAA)
Lead	Not to exceed 1.5 $\mu g/m^3$ based on a quarterly average	Major stationary sources	40 CFR Part 50 (CAA)
Nitrogen dioxide	Not to exceed 0.053 ppm annually	Major stationary and mobile sources	40 CFR Part 50 (CAA)
Particulate matter (PM_{10})	Not to exceed 50 $\mu g/m^3$ annually Not to exceed 150$\mu g/m^3$/24-hour period	Major stationary sources	40 CFR Part 50 (CAA)
Ozone	Not to exceed 0.12 ppm/h	Major stationary and mobile sources	40 CFR Part 50 (CAA)
Sulfur oxides	Not to exceed 0.03 ppm annually Not to exceed 0.14 ppm/24-hour period. Not to exceed 0.5 ppm/3-hour period	Major stationary sources	40 CFR Part 50 (CAA)

5.2 Health Effects

The evaluation of health effects from incinerator emissions should conform to EPA's Risk Assessment Guidance for Superfund (RAGS) Part C[23], once this document is released. Part C presents general guidance on risk assessment procedures for evaluation of remedial alternatives during and after the Feasibility Study. If ambient air concentrations have been estimated, RAGS Part A[24] may be consulted for detailed procedures for assessing inhalation exposure. The remainder of this section presents a simplified procedure for health effects screening for inhalation exposure. Exposures from secondary pathways due to deposition of particulate emissions from Superfund site incinerators are generally thought to be insignificant when compared to the inhalation pathway.

5.2.1 Chemical Compounds

As discussed in Section 3.2.2, THC emissions are considered to be all unburned hydrocarbons and PIC produced from organic compounds in the feed, exclusive of any PCBs or dioxins in the feed. For predictive screening purposes only, an aggregate inhalation unit risk of $1x10^{-5}$ $m^3/\mu g$ is to be used for THC emissions. This approach is consistent with the proposed RCRA Tier II CO and THC Limits presented in the Guidance on PIC Controls for Hazardous Waste Incinerators.[13]

Emissions of PCBs are to be treated separately from other organic compounds. For emissions of dioxins, all forms of dioxin are to be aggregated in the waste feed and the inhalation unit risk value of the most toxic specie present (usually 2,3,7,8-TCDD) is to be used for assessment of the undestroyed dioxin emissions. Emissions of each metal and HCl are evaluated individually for health effects.

5.2.2 Action Levels

Potential carcinogenic health effects from long-term exposure to emissions of carcinogenic substances are evaluated using inhalation unit risk factors. Potential health effects from long-term exposure to substances with noncarcinogenic effects are evaluated using chronic inhalation reference concentrations (RfCs). These factors are

obtained from EPA's Integrated Risk Information System (IRIS). User support for IRIS is available at (513) 569-7254. If health effects data are not found in IRIS, consult the latest EPA Health Effects Assessment Summary Tables (HEAST).[25] For assessment of health effects due to exposure to lead emissions, contact the EPA Regional Toxicologist for guidance.

For convenience, the unit risk and/or RfC factors for chemicals of interest have been listed, and converted to ambient air concentrations in $\mu g/m^3$, in Table 11. Where inhalation data were not available, the oral slope factor or RfD was converted to an inhalation concentration using a body weight of 70 kg and breathing rate of 20 m^3/day (average adult values). The risk-specific concentration for carcinogens are based on a $1x10^{-6}$ risk and lifetime (70-year) exposure. For nonpermanent incinerators, the risk-specific concentration for carcinogens may be adjusted using the following equation:

$$C_c = \frac{(C_{70})(70\ years)}{y} \qquad (14)$$

where C_c = Risk-specific ambient concentration adjusted for exposure period, $\mu g/m^3$

C_{70} = Risk-specific ambient concentration for 70-year exposure, $\mu g/m^3$

y = Incinerator operating life or exposure period, years.

The adjusted risk-specific concentrations and RfC concentrations are compared to the predicted ambient air concentrations. If any of the long-term action levels are exceeded, a potential air emissions problem is indicated.

5.2.3 Risk Calculation and Combined Exposures

The potential health effects due to combined exposure to multiple substances must be evaluated. For screening purposes, the individual risks for all carcinogens are summed, and the hazard index is computed for noncarcinogenic effects of substances.

TABLE 11. LONG-TERM ACTION LEVELS FOR AMBIENT AIR

Chemical	Carcinogenic group	Carcinogenicity inhalation unit risk $(\mu g/m^3)^{-1}$	Chronic toxicity inhalation RfC mg/m^3	Risk-specific conc. (Carc.) 10^{-6} 70 yr, $\mu g/m^3$	RfC conc. (noncarc.), $\mu g/m^3$	Regulatory limit annual average, $\mu g/m^3$
THC		1E-5		0.1		
PCBs	B2	(7.7E+0)[a]		0.00046		
Dioxin (2,3,7,8-TCDD)	B2	3.3E-2		0.00003		
Antimony			(4E-4)[b]		1.4	
Arsenic	A	4.3E-03	ND	0.00023		
Barium			5E-3		5	
Beryllium	B2	2.4E-03	ND	0.00042		0.01 $\mu g/m^3$ (NESHAPS)
Cadmium	B1	1.8E-03	ND	0.00055		
Chromium (VI)	A	1.2E-02	2E-6	0.000083	0.002	
Lead	B2	NA	ND	NA	ND	0.9 $\mu g/m^3$ (NAAQS)
Mercury			3E-4		0.3	
Silver			(3E-3)[b]		10.5	
Thallium			(7E-5)[b]		0.24	
HCl			7E-3		7	

[a]Oral Slope Factor $(mg/kg/day)^{-1}$
[b]Oral RfD, mg/kg/day.

The individual risk for exposure to each carcinogen is calculated using the following equation:

$$R_i = \frac{(C_{ai})(IUR)(y)}{70\ years} \tag{15}$$

where R_i = Cancer risk for inhalation exposure to compound i, dimensionless

C_{ai} = Ambient air concentration of compound i, $\mu g/m^3$

IUR = Inhalation unit risk, $(\mu g/m^3)^{-1}$

y = Incinerator operating life of exposure period, years.

The combined risk is obtained by summing the individual risks for each carcinogen:

$$\textit{Aggregate Inhalation Cancer Risk} = \sum_{i=1}^{n} R_i \tag{16}$$

The combined risk should not exceed the target level of $1x10^{-6}$.

For substances with noncarcinogenic effects, calculate the hazard quotient and sum these values to produce the hazard index:

$$HQ_i = \frac{C_{ai}}{RfC_i} \tag{17}$$

and

$$HI = \sum_{i=1}^{n} HQ_i \tag{18}$$

where HQ_i = Hazard quotient for compound i, dimensionless

C_{ai} = Ambient air concentration of compound i, $\mu g/m^3$

RfC_i = RfC concentration of compound i, $\mu g/m^3$

HI = Hazard index for combined exposure, dimensionless.

Neither the individual hazard quotients nor the hazard index should exceed a value of 1.0.

SECTION 6

CASE EXAMPLE

The following is a hypothetical case example used to illustrate the use of the screening procedures. The incineration system to be evaluated is similar to the system shown in Figure 2. Average emission rates and long-term exposures are calculated in the example.

The Udumpit site is a 10-acre abandoned waste site previously used to bury, dump, and store industrial wastes such as paint sludges, solvents, and other wastes containing PCBs, oils and greases, phenols, and heavy metals. The site is located in a relatively flat rural area. The site area to be remediated by incineration contains 66,600 tons of soil contaminated primarily with PCBs and lead. Table 12 contains sampling data for the average concentrations of compounds found in the soil waste. Table 13 contains relevant data taken from the ultimate analysis of composite soil samples. Emission rates based on average concentration (average feed conditions) will be calculated assuming that soils will be blended before incineration.

The proposed incineration system is a 35 x 10^6 Btu/h with a feed rate capacity of 6 tons/h for soils with a moisture content of 10 percent or less. No free liquids are to be incinerated. The air pollution control system and general configuration are shown in Figure 2. The ejector scrubber is considered equivalent to a venturi scrubber with a pressure drop of 25 inches of water. The kiln is to be operated at a temperature of 1600° F and the SCC at 2200° F. The system will be operated 24 hours per day, 6 days per week. The incinerator stack is to be located 300 meters from the fenceline and will be 8 meters tall. An adult apartment complex borders the fence. Calculations begin below.

TABLE 12. SOIL SAMPLE DATA

Compound	Average concentration, ppm
Organics	
PCBs	272
Tetrachlorodibenzo-p-dioxin (TCDD)	0.06
Tetrachlorodibenzofuran (TCDF)	0.005
Methyl ethyl ketone	47
Trichloroethene	50
Tetrachloroethane	50
Benzene	5
Toluene	11
Methylene chloride	160
Carbon disulfide	3
Acetone	37
Bis(2-ethylhexyl) phthalate	50
Phenol	28
Total xylenes	3
Inorganics	
Barium	591
Chromium	85
Lead	778
Zinc	301
Arsenic	2
Cadmium	20

TABLE 13. DATA TAKEN FROM ULTIMATE ANALYSIS

Moisture content	9.0%
Ash content	81%
Chlorine content	0.08%
Sulfur content	0.02%
Higher heating value	<1000 Btu/lb

The time required to incinerate all soil is:

$$(66{,}600\ tons)\left(\frac{1\ h}{6\ tons}\right) = 11{,}100\ h$$

Elapsed days:

$$(11{,}100\ h)\left(\frac{1\ day}{24\ h}\right)\left(\frac{7\ day\ week}{6\ days\ operation}\right) = 540\ days,\ or\ 1.5\ years$$

Convert the sampling data to the proper format to be used in the worksheet to calculate emission rates. For organics, separate and total each of the PCBs, dioxin wastes, and all other organic waste concentrations from Table 12:

PCBs = 272 ppm

Dioxins (total of TCDD and TCDF):

Dioxin = 0.065 ppm

THC (total hydrocarbons - all other organics):

THC = 444 ppm

Metals - use concentration data directly from Table 12

Elements forming acid gases - use values for chlorine and sulfur from Table 13:

Cl	=	0.08%	=	800 ppm
S	=	0.02%	=	200 ppm

The only other input data necessary to estimate emission rates is the exhaust gas volume for particulates. This is estimated from Table 3 to be 8,750 dscfm. At this point, the worksheet (Table 8) is used to calculate the emission rates.

Table 14 shows the summaries of emissions calculations for the case example. Sample detailed calculations for selected components are shown below:

PCBs

Feed rate (Equation 2),

$$FR_{PCB} = (1200\ lb/h)\ (272\ ppm)\ (1\times10^{-6}) = 3.264\ lb/h$$

Emission rate (Equation 3),

$$ER_{PCB} = (3.264\ lb/h)\left(1 - \frac{99.9999}{100}\right)(0.126) = 4.113\times10^{-7}\ g/s$$

Lead

Feed rate (Equation 4),

$$FR_{Pb} = (12{,}000\ lb/h)\ (778\ ppm)\ (1\times10^{-6}) = 9.336\ lb/h$$

Uncontrolled emission rate (Equation 5),

$$ER_{Pb_U} = (9.336\ lb/h)\left(\frac{100}{100}\right)(0.126) = 1.176\ g/s$$

Controlled emission rate (Equation 6),

$$ER_{Pb_C} = (1.176\ g/s)\left(1 - \frac{96}{100}\right) = 0.047\ g/s$$

TABLE 14. EMISSIONS CALCULATIONS FOR CASE EXAMPLE

Waste element	Concentration, ppm	Feed rate, lb/h	Compound emitted	PF or R_A[a]	Uncontrolled emissions, g/s	DRE/control efficiency, %	Controlled emissions, g/s
		Section 2.3					
Total mass	N/A	12,000	N/A	N/A	N/A	N/A	N/A
ORGANICS:	Equation 1	Equation 2					Equation 3
THC	444	5.3280	THC	N/A	N/A	99.9999	6.713E-07
PCBs	272	3.2640	PCB	N/A	N/A	99.9999	4.113E-07
Dioxins	0.065	0.00078	Dioxin	N/A	N/A	99.9999	9.828E-11
METALS:	Sampling data	Equation 4			Table 5	Equation 5	Table 6	Equation 6
Antimony		0	Sb					
Arsenic	2	0.024	As		100	0.0030	96	1.21E-04
Barium	591	7.092	Ba		50	0.4468	97	1.34E-02
Beryllium		0	Be					
Cadmium	20	0.24	Cd		100	0.302	96	1.210E-03
Chromium	85	1.02	Cr(+6)		5	0.0064	97	1.928E-03
Lead	778	9.336	Pb		100	1.1763	96	4.705E-02
Mercury		0	Hg					
Silver		0	Au					

(continued)

TABLE 14 (Continued)

Waste element	Concentration, ppm	Feed rate, lb/h	Compound emitted	PF or R_A[a]	Uncontrolled emissions, g/s	DRE/control efficiency, %	Controlled emissions, g/s
Thallium		0	Tl				
GASES:	Equation 7	Equation 8			Equation 9	Section 3.4.3	Equation 10
Chlorine	800	9.6	HCl	1.028	1.2435	99	1.243E-02
Sulfur	200	2.4	SO_2	1.998	0.6042	90	6.042E-02
Fluorine		0	HF	1.053			
Bromine		0	HBr	1.013			
PM:					Gas flow, dscfm	Stack concentration gr/dscf	
					Table 2		Equation 11
Particulate	N/A	N/A	PM	N/A	8750	0.08	0.756

[a]Partitioning factor, % (metals) or Stoichiometric ratio, g/g (gases).

HCl

Feed rate of chlorine (Equation 8),

$$FR_{Cl} = (12{,}000\ lb/h)\ (800)\ (1\times10^{-6}) = 9.6\ lb/h$$

Uncontrolled emission rate (Equation 9),

$$ER_{HCl_U} = (9.6\ lb/h)\ (1.028)\ (0.126) = 1.244\ g/s$$

Controlled emission rate (Equation 10),

$$ER_{HCl_C} = (1.244\ g/s)\left(1 - \frac{99}{100}\right) = 0.0124\ g/s$$

Using the procedure outlined in Section 4, the SCREEN model was run to produce a one-hour ambient air concentration estimate for a 1 g/s emission rate (Figure 3). The resulting dispersion factor at a downwind distance of 300 m is:

$$F = 197.5\ \mu g/m^3/g/s$$

This factor was multiplied by the controlled emission rates to produce the one-hour ambient air concentration estimates. The one-hour estimates were multiplied by a factor of 0.025 to obtain annual ambient concentration estimates. The results of these operations are shown in Table 15.

In order to assess ARARs and health effects, the chemical-specific ARARs and health effects data were assembled with the predicted annual ambient air concentrations in Table 16. The risk-specific concentrations for carcinogens were adjusted by a factor of 70/1.5 to account for the incinerator operating life (Equation 14). None of the action levels were exceeded when compared to the predictive concentrations.

04-18-91
15:57:13

*** SCREEN-1.1 MODEL RUN ***
*** VERSION DATED 88300 ***

UDUMPIT SITE INCINERATOR

SIMPLE TERRAIN INPUTS:

SOURCE TYPE	=	POINT
EMISSION RATE (G/S)	=	1.000
STACK HEIGHT (M)	=	8.00
STK INSIDE DIAM (M)	=	.50
STK EXIT VELOCITY (M/S)	=	10.00
STK GAS EXIT TEMP (K)	=	344.00
AMBIENT AIR TEMP (K)	=	293.00
RECEPTOR HEIGHT (M)	=	.00
IOPT (1=URB,2=RUR)	=	2
BUILDING HEIGHT (M)	=	.00
MIN HORIZ BLDG DIM (M)	=	.00
MAX HORIZ BLDG DIM (M)	=	.00

BUOY. FLUX = .91 M**4/S**3; MOM. FLUX = 5.32 M**4/S**2.

*** FULL METEOROLOGY ***

****
*** SCREEN AUTOMATED DISTANCES ***
****

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (UG/M**3)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	SIGMA Y (M)	SIGMA Z (M)	DWASH
50.	144.3	1	3.0	3.0	960.0	14.6	14.5	7.5	NO
100.	201.9	2	3.0	3.0	960.0	14.6	19.4	10.8	NO
200.	212.5	3	2.0	2.0	640.0	18.0	23.8	14.3	NO
300.	197.5	4	2.0	2.0	640.0	18.0	22.8	12.4	NO
400.	177.3	4	2.0	2.0	640.0	18.0	29.6	15.5	NO
500.	156.8	4	1.0	1.0	320.0	27.9	36.6	19.2	NO
600.	149.7	4	1.0	1.0	320.0	27.9	43.1	22.0	NO
700.	137.3	4	1.0	1.0	320.0	27.9	49.5	24.7	NO
800.	123.6	4	1.0	1.0	320.0	27.9	55.9	27.4	NO
900.	110.7	4	1.0	1.0	320.0	27.9	62.1	30.0	NO
1000.	98.93	4	1.0	1.0	320.0	27.9	68.4	32.6	NO
1100.	89.10	4	1.0	1.0	320.0	27.9	74.5	34.6	NO
1200.	80.65	4	1.0	1.0	320.0	27.9	80.6	36.5	NO
1300.	82.75	6	1.0	1.0	5000.0	31.9	43.6	17.8	NO
1400.	84.21	6	1.0	1.0	5000.0	31.9	46.5	18.6	NO
1500.	84.92	6	1.0	1.0	5000.0	31.9	49.5	19.3	NO
1600.	85.02	6	1.0	1.0	5000.0	31.9	52.4	20.0	NO
1700.	84.64	6	1.0	1.0	5000.0	31.9	55.4	20.7	NO
1800.	83.88	6	1.0	1.0	5000.0	31.9	58.3	21.4	NO
1900.	82.83	6	1.0	1.0	5000.0	31.9	61.2	22.0	NO
2000.	81.55	6	1.0	1.0	5000.0	31.9	64.0	22.7	NO
MAXIMUM 1-HR CONCENTRATION AT OR BEYOND 50. M:									
140.	219.1	3	3.0	3.0	960.0	14.6	17.2	10.4	NO

DWASH= MEANS NO CALC MADE (CONC = 0.0)
DWASH=NO MEANS NO BUILDING DOWNWASH USED
DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED
DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED
DWASH=NA MEANS DOWNWASH NOT APPLICABLE, X<3*LB

****
*** SUMMARY OF SCREEN MODEL RESULTS ***
****

CALCULATION PROCEDURE	MAX CONC (UG/M**3)	DIST TO MAX (M)	TERRAIN HT (M)
SIMPLE TERRAIN	219.1	140.	0.

****
** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **
****

Figure 3. SCREEN Model Run.

TABLE 15. CASE EXAMPLE - AMBIENT AIR CONCENTRATIONS

Compound emitted	Controlled emissions, g/s	Dispersion factor, $\mu g/m^3$-g/s	1-hour ambient concentration, $\mu g/m^3$	Annual ambient concentration, $\mu g/m^3$
THC	6.71E-07	197.5	1.33E-04	3.31E-06
PCB	4.11E-07	197.5	8.12E-05	2.03E-06
Dioxin	9.83E-11	197.5	1.94E-08	4.85E-10
Arsenic	1.21E-04	197.5	2.39E-02	5.97E-04
Barium	1.34E-02	197.5	2.65E+00	6.62E-02
Cadmium	1.21E-03	197.5	2.39E-01	5.97E-03
Chromium	1.93E-04	197.5	3.81E-02	9.52E-04
Lead	4.71E-02	197.5	9.29E+00	2.32E-01
HCl	1.24E-02	197.5	2.46E+00	6.14E-02
SO_2	6.04E-02	197.5	1.19E+01	2.98E-01
PM	7.56E-01	197.5	1.49E+02	3.73E+00

TABLE 16. CASE EXAMPLE - ACTION LEVEL COMPARISON ($\mu g/m^3$)

Compound	RfC conc.	Risk-specific conc. 10^{-6} 70 yr	Adjusted risk-specific conc. 1.5 yr	ARAR annual basis	Predicted annual avg. conc.	Status
THC		0.1	4.67		3.3E-6	OK
PCBs		0.00046	0.021		2.0E-6	OK
Dioxin		0.00003	0.0014		4.9E-10	OK
Arsenic		0.00023	0.011		0.0006	OK
Barium	5				0.066	OK
Cadmium		0.00055	0.026		0.006	OK
Chromium (VI)	0.002	0.000083	0.0039		0.001	OK
Lead				0.9	0.23	OK
HCl	7				0.061	OK
SO_2				80	0.30	OK
PM				50	3.7	OK

The risks for exposure to carcinogenic compounds were calculated using Equation 15, with unit risks taken from Table 11. These calculations are shown below:

$$R_{THC} = \frac{(3.3E\text{-}6)(1.0E\text{-}5)(1.5)}{70} = 7.1E\text{-}13$$

$$R_{PCB} = \frac{(2.0E\text{-}6)(2.2E\text{-}3)(1.5)}{70} = 9.4E\text{-}11$$

$$R_{Dioxin} = \frac{(4.9E\text{-}10)(3.3E\text{-}2)(1.5)}{70} = 3.5E\text{-}13$$

$$R_{AS} = \frac{(0.0006)(4.3E\text{-}3)(1.5)}{70} = 5.5E\text{-}8$$

$$R_{Cd} = \frac{(0.006)(1.8E\text{-}3)(1.5)}{70} = 2.3E\text{-}7$$

$$R_{Cr} = \frac{(0.001)(1.2E\text{-}2)(1.5)}{70} = 2.6E\text{-}7$$

$$\sum R\ (TOTAL) = 5.5E\text{-}7$$

The total estimated carcinogenic risk is 6×10^{-7}, which is below the target level of 1×10^{-6}.

For noncarcinogenic effects of compounds, the hazard indices and hazard quotient were calculated using Equations 17 and 18 as shown below.

$$HQ_{Ba} = \frac{0.066}{5} = 0.01$$

$$HQ_{Cr} = \frac{0.001}{0.002} = 0.5$$

$$HQ_{HCl} = \frac{0.061}{7} = 0.01$$

$$HI\ (TOTAL) = 0.52$$

Since the hazard index is below 1.0, no potential problem is indicated for noncarcinogenic effects of the incinerator emissions.

Considering the conservative nature of the screening analysis, and if all of the design assumptions held true, the incinerator stack emissions (excluding consideration of lead) should not pose an adverse air impact. Exposure to the lead emissions should be investigated further using guidance from an EPA Toxicologist.

REFERENCES

1. American Society of Mechanical Engineers. Hazardous Waste Incineration - A Resource Document. ASME, New York, NY. 1988.

2. Donnelly, J. R. Air Pollution Control for Hazardous Waste Incinerators. Proceedings of the 12th National Conference: Hazardous Materials Control/Superfund '91. Hazardous Materials Control Research Institute. December 1991.

3. U.S. Environmental Protection Agency. Superfund Engineering Issue: Issues Affecting the Applicability and Success of Remedial/Removal Incineration Projects. EPA/540/2-91/004. February 1991.

4. U.S. Environmental Protection Agency. Engineering Bulletin: Mobile/Transportable Incineration Treatment. EPA/540/2-90/014. September 1990.

5. U.S. Environmental Protection Agency. Experience in Incineration Applicable to Superfund Site Remediation. EPA/625/9-88/008. December 1988.

6. Johnson, N. P. and Cosmos, M. G. Thermal Treatment Technologies for Hazardous Waste Remediation. Pollution Engineering. October 1989.

7. McCormick, R. J. and Duke, M. L. Onsite Incineration as a Remedial Action Alternative. Pollution Engineering. August 1989.

8. Cudahy, J. J. and Eicher, A. R. Thermal Remediation Industry: Markets, Technologies, Companies. Pollution Engineering. November 1989.

9. U.S. Environmental Protection Agency. Engineering Handbook for Hazardous Waste Incineration. September 1981.

10. Cudahy, J. J. and Troxler, W. L. 1990 Thermal Remediation Contractor Survey. Journal of the Air and Waste Management Association. Volume 40, No. 8. August 1990.

11. U.S. Environmental Protection Agency. Technical Background Document. Control of Metals and HCl Emissions From Hazardous Waste Incinerators. Versar, Inc. August 1989.

12. DiAntonio, K. K. and Tillman, D. A. Incineration of Contaminated Soil at a Superfund Site: From Pilot Test to Remediation. Proceedings of 11th National Conference: Superfund '90. Hazardous Materials Control Research Institute. November 1990.

13. U.S. Environmental Protection Agency. Guidance on PIC Controls for Hazardous Waste Incinerators. Volume V of the Hazardous Waste Incineration Series. EPA/530-SW-90-040. April 1990.

14. Radian Corporation. Air/Superfund National Technical Guidance Study Series. Volume III - Estimation of Air Emissions From Cleanup Activities at Superfund Sites. EPA/450/1-89-003. January 1989.

15. U.S. Environmental Protection Agency. Guidance on Metals and Hydrogen Chloride Controls for Hazardous Waste Incinerators. Volume IV of the Hazardous Waste Incineration Guidance Series. August 1989.

16. Federal Register. Environmental Protection Agency. Standards for Owners and Operators of Hazardous Waste Incinerators and Burning of Hazardous Wastes in Boilers and Industrial Furnaces. Vol. 55, No. 82, page 17862. April 27, 1990.

17. U.S. Environmental Protection Agency. Screening Procedures for Estimating the Air Quality Impacts of Stationary Sources. EPA-450/4-88-010. August 1988.

18. U.S. Environmental Protection Agency. Industrial Source Complex (ISC) Dispersion Model User's Guide - Second Edition (Revised). Volume I and II. EPA-450/4-88-002a and 002b. December 1987.

19. U.S. Environmental Protection Agency. A Workbook of Screening Techniques for Assessing Impacts of Toxic Air Pollutants. EPA-450/4-88-009. September 1989.

20. U.S. Environmental Protection Agency. CERCLA Compliance with Other Laws Manual: Interim Final. EPA/540/6-89/006. August 1988.

21. U.S. Environmental Protection Agency. CERCLA Compliance with Other Laws manual: Part II Clean Air Act and Other Environmental Statutes and State Requirements. EPA/540/6-89/009. August 1989.

22. U.S. Environmental Protection Agency. Methods Manual for Compliance with the BIF Regulations. EPA/530-SW-91-010. December 1990.

23. U.S. Environmental Protection Agency. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part C, Risk Evaluation of Remedial Alternatives). Publication 9285.7-01C. October 1991.

24. U.S. Environmental Protection Agency. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part A). EPA/540/1-89/002. December 1989.

25. U.S. Environmental Protection Agency. Health Effects Assessment Summary Tables, Annual FY-91. OERR 9200.6-303(91-1). January 1991.

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16. ABSTRACT

The purpose of the project was to develop screening procedures for estimating the air impacts of incineration at Superfund sites. The document outlines procedures for estimating uncontrolled and controlled emission rates of hydrocarbons, particulate matter, metals, acid gases and other contaminants as well as screening procedures for estimating ambient air concentrations of these contaminants. The document also provides screening evaluation procedures for compliance with applicable or relevant and appropriate requirements (ARARs) and for health effects.

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