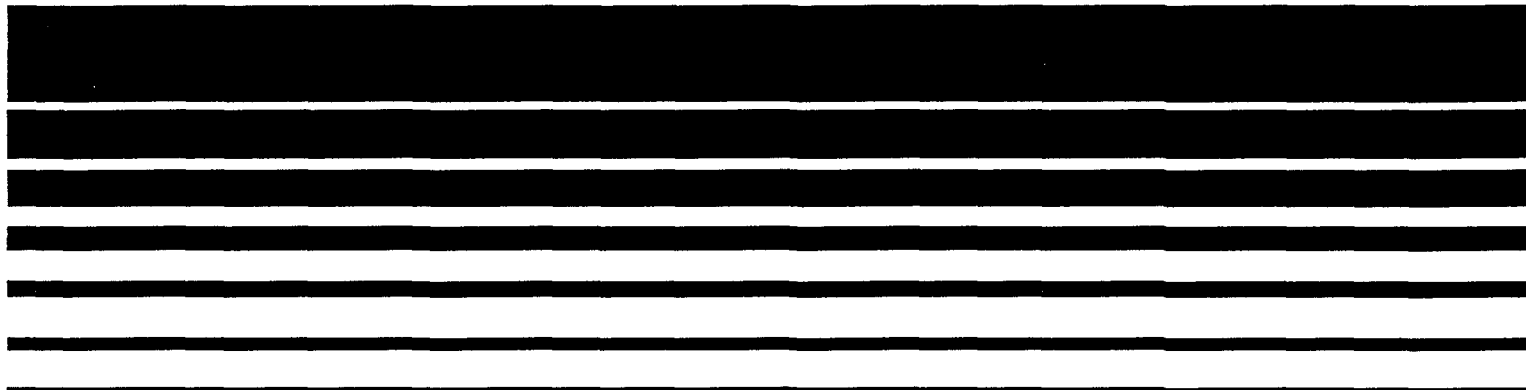




AIR/SUPERFUND NATIONAL TECHNICAL GUIDANCE STUDY SERIES

ESTIMATION OF AIR IMPACTS FOR THERMAL DESORPTION UNITS USED AT SUPERFUND SITES



**ESTIMATION OF AIR IMPACTS
FOR THERMAL DESORPTION
USED AT SUPERFUND SITES**

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TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION	1
PROCESS DESCRIPTION	1
ESTIMATION OF VOC AIR EMISSIONS	5
Average Long-Term Uncontrolled VOC Emission Rate	6
Short-Term Uncontrolled VOC Emission Rate	6
ESTIMATION OF PARTICULATE MATTER AIR EMISSIONS	8
Uncontrolled PM Emission Rate	10
Uncontrolled Emission Rate for Metals	10
ESTIMATION OF AMBIENT AIR CONCENTRATIONS	11
ESTIMATION OF HEALTH EFFECTS	18
Cancer Effects Due to Long-Term Exposure	18
Non-Cancer Effects Due to Long-Term Exposure	30
Short-Term Exposure	32
EXAMPLE	32
CONCLUSIONS	36
REFERENCES	36
 APPENDIX A	 PHYSICAL PROPERTY DATA FOR SELECTED ORGANIC COMPOUNDS
 APPENDIX B	 PHYSICAL PROPERTY DATA FOR SELECTED SEMI-VOLATILE ORGANIC COMPOUNDS

LIST OF TABLES

		<u>Page</u>
1	Default Values for VOC Emissions Model for Thermal Desorption Units	9
2	Default Values for PM Emissions Model for Thermal Desorption Units	12
3	Partition Factors for Metals in Soils	12
4	Example Scenarios for Rotary Dryers and Asphalt Aggregate Dryers	14
5	Example Scenarios for Thermal Screws	14
6	Long-Term and Short-Term Health-Based Action Levels for Organic Compounds in Ambient Air	19
7	Long-Term and Short-Term Health-Based Action Levels for Selected Semi-Volatile Organic Compounds in Air	27
8	Long-Term and Short-Term Health-Based Action Levels for Metals in Ambient Air	29
9	Estimated Emission Rates and Ambient Air Concentrations	35
10	Action Level Concentrations	35

LIST OF FIGURES

1	Generalized Process Diagram for Thermal Screw-Based Thermal Desorption	3
2	Generalized Process Diagram for Rotary Dryer-Based Thermal Desorption	4
3	One-Hour Average Downwind Dispersion Factor Versus Distance for Rotary Dryers and Asphalt Aggregate Dryers with Thermal Oxidizer Control Unit :	15
4	One-Hour Average Downwind Dispersion Factor Versus Distance for Rotary Dryers and Asphalt Aggregate Dryers with Off-Gas Cooling Control Unit	16
5	One-Hour Average Downwind Dispersion Factor Versus Distance for Thermal Screws with Condenser Control Unit	17

INTRODUCTION

The U.S. Environmental Protection Agency's Office of Air Quality Planning and Standards and the Regional Air Offices have been given the responsibility to evaluate air impacts from Superfund sites. An important part of this program is the assessment of air impacts from various alternatives for cleaning up Superfund sites. Since these assessments are frequently required for planning purposes prior to actual cleanup, they depend on estimated emissions and ambient concentrations rather than on field measurements.

This report provides screening procedures for estimating the ambient air concentrations associated with thermal desorption. These procedures are analogous to procedures for air strippers, soil vapor extraction systems, and excavation that have previously been published^{1,2,3}. Thermal desorption is a treatment process where heat is used to physically remove organic compounds from soils and sludges. Procedures are given to evaluate the effect of treatment rate and contaminant concentration on the emission rates and on the ambient air concentrations at selected distances from the treatment area.

Health-based ambient air action levels are also provided for comparison to the estimated ambient concentrations. Many of the health levels have not been verified by EPA, or are based on extrapolations of oral exposures or occupational exposures. Their use could either under or over estimate the potential health effects. The use of action levels that are neither EPA-verified nor EPA-approved should be considered on a case-by-case basis. The statements and conclusions presented in this report are those of the authors and do not reflect U.S. EPA policy.

PROCESS DESCRIPTION

The following discussion and emissions models are adapted from a recent compilation of emission models⁴. A summary of air emissions from thermal desorption units is presented in Eklund, et al⁵. Additional general information about thermal desorption is contained in a guidance document that is currently in press⁶.

In the thermal desorption process, volatile and semi-volatile contaminants are removed from soils, sediments, slurries, and filter cakes. This process typically operates at temperatures of 200°-1000°F but is often referred to as low temperature thermal desorption to differentiate it from incineration. At these lower temperatures, the process promotes physical separation of the components rather than combustion. At operating temperatures near or above 1000°F, some pyrolysis and oxidation may occur in addition to the vaporization of water and organic compounds. Volatile organic compound (VOC) removal is enhanced if the soil contains 10-15 percent moisture prior to treatment since the vaporized water will force out some VOCs.

The contaminated soil is first removed from the ground and then transferred to treatment units, making thermal desorption an *ex situ* process. After it is excavated, the waste material is screened to remove objects greater than 1.5" in diameter before being introduced to the desorber. In general, three desorber designs are used: a directly fired rotary dryer, an asphalt aggregate dryer, or an internally heated screw auger (i.e., thermal screw). Generalized process diagrams for rotary dryers and thermal screws are given in Figures 1 and 2, respectively. The treatment systems include mobile process units designed specifically for treating soil and asphalt kilns adapted to treat soils. Direct or indirect heat exchange vaporizes the volatile compounds producing an off-gas that is treated before being vented to the atmosphere.

Collection and control equipment such as afterburners, fabric filters, activated carbon, or condensers are used to prevent the release of the contaminants to the atmosphere. Most rotary dryers have thermal oxidizers (afterburners) to control emissions of organic compounds, while thermal screws typically have condensers for off-gas treatment. Most systems have a baghouse (fabric filter) or a cyclone to remove particulate matter.

While thermal desorbers are designed to remove volatile and semi-volatile organic compounds, some substances with higher boiling points such as polychlorinated biphenyls (PCBs) and dioxins may also be removed. The higher boiling point compounds usually are associated with particulate matter (PM) and removed in the PM control device.

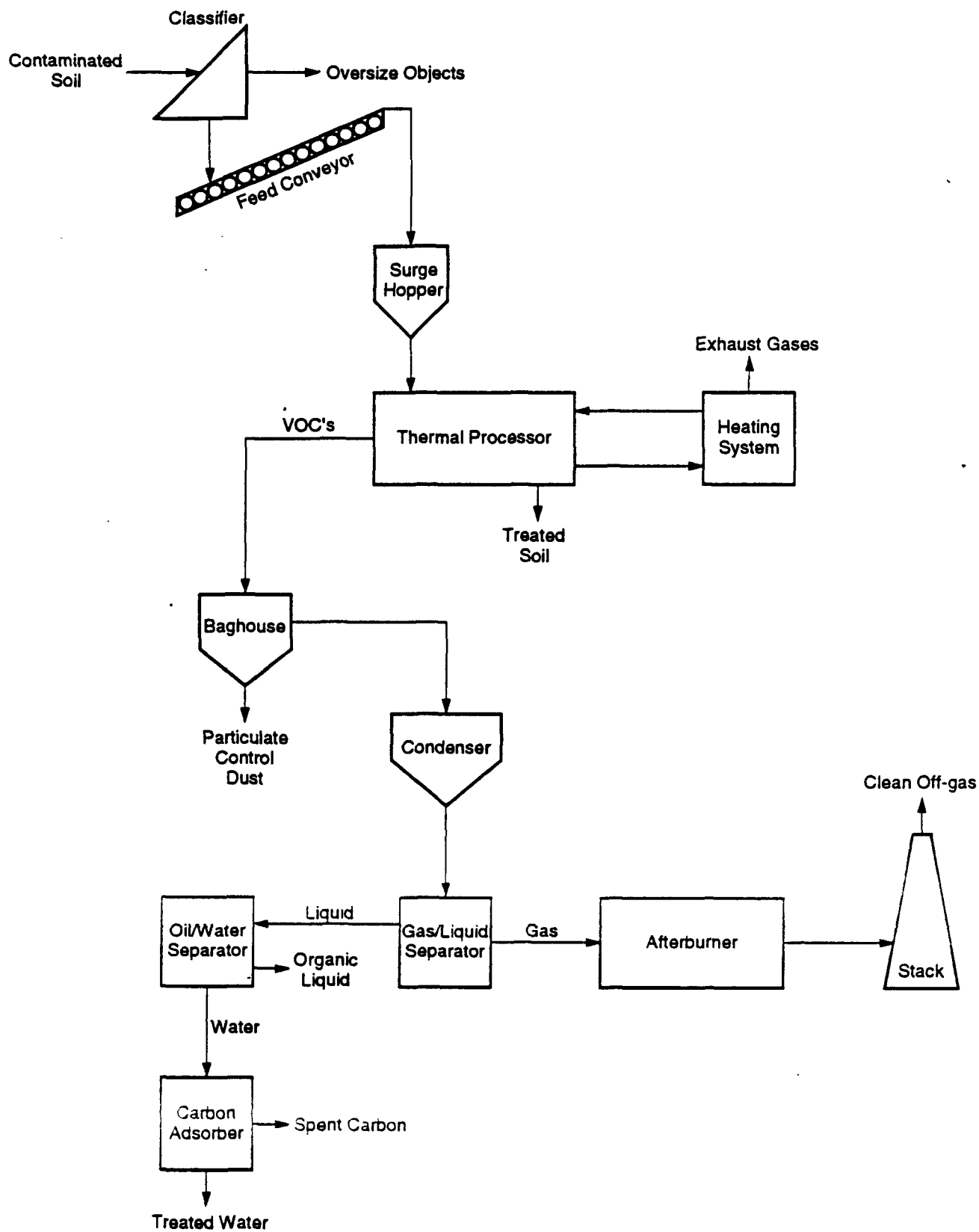


Figure 1. Generalized Process Diagram for Thermal Screw-Based Thermal Desorption

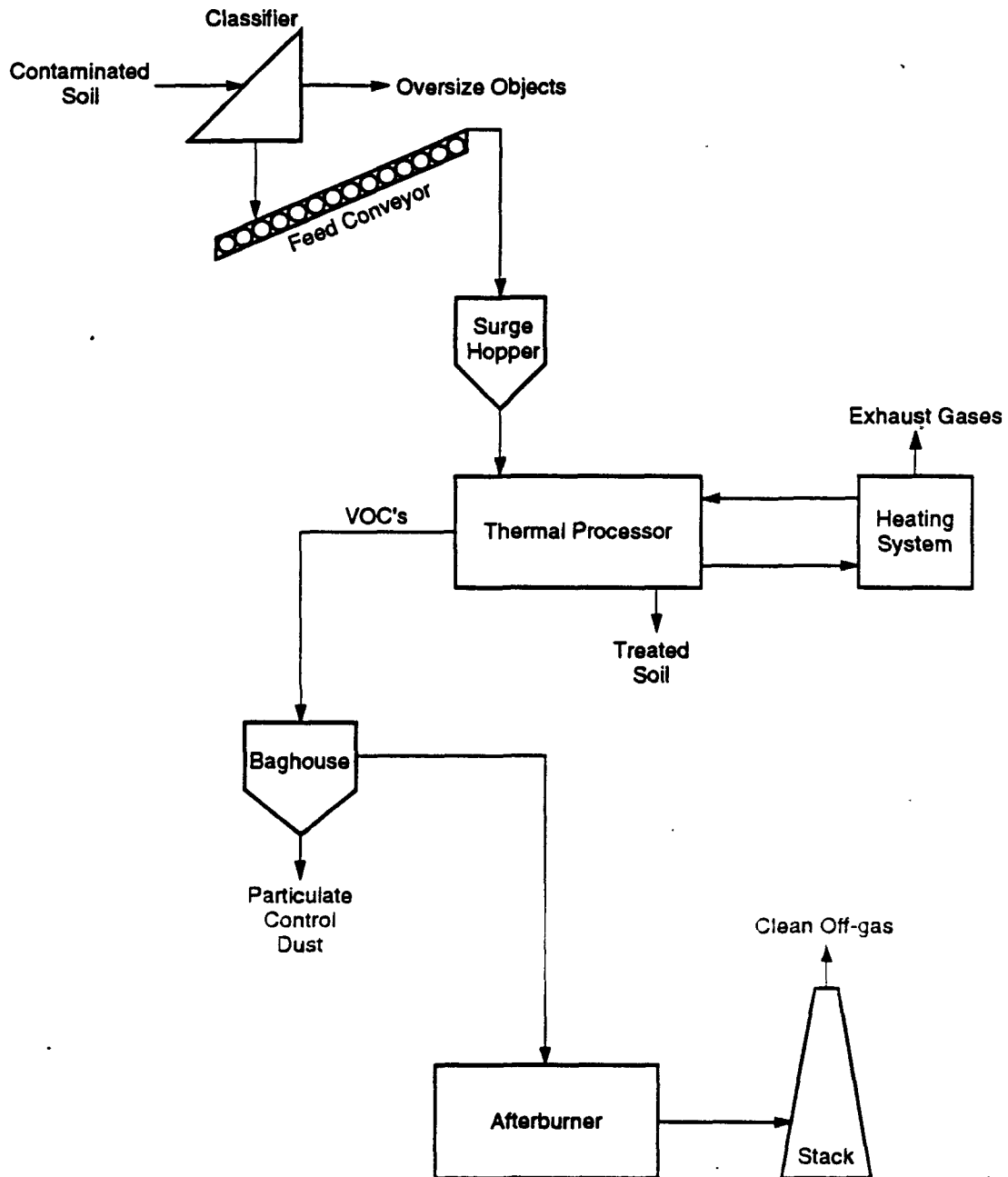


Figure 2. Generalized Process Diagram for Rotary Dryer-Based Thermal Desorption

The specific point sources of air emissions from thermal desorption units vary widely with each process design. The stack of an afterburner vents combustion products, as does a fuel-fired heating system if the combustion gases are not fed into the desorber. The fuel-fired heating system typically operates with propane, natural gas or fuel oil. If control devices are present and working properly, the stack will vent small concentrations of the original VOC contaminants, as well as products of any chemical reactions that might occur from the control devices, such as a baghouse or a scrubber. Relative to incineration, the off-gas volume from the thermal desorption unit may be smaller, there is less likelihood of creating dioxins and other oxidation products, and metals are less likely to partition to the gas-phase. As with incineration, air emission control devices are always part of the system design; the estimates of uncontrolled emissions obtained from this manual can be used to help estimate the required removal efficiency of an emission control system or the size and cost of a given control system.

Fugitive emissions from area sources may contribute significantly to the total air emissions from a remediation site. Probably the largest source is excavation of the contaminated soil. Other sources of fugitive emissions may include the classifier, feed conveyor, and the feed hopper. Fugitive emissions from the components of the thermal desorption system and control devices are possible as well. Emissions may also emanate from the waste streams such as exhaust gases from the heating system, treated soil, dust collected with the particulate control system, untreated oil from the oil/water separator, spent carbon from a liquid- or vapor-phase carbon adsorber, treated water, and scrubber sludge.

ESTIMATION OF VOC AIR EMISSIONS

There are several alternative approaches for estimating the emissions from thermal desorption processes. The best method is to directly measure the emissions during full-scale or pilot-scale operations. The next best method is to estimate the emissions using predictive equations with site-specific inputs. If site-specific information is not available, a conservative estimate can be made using default values for the input parameters. Equations are given below for estimating an average long-term emission rate (Equation 1) and a short-

term emission rate (Equation 2). Equation 2 is the recommended equation for estimating VOC emissions; Equation 1 can be used as a gross check of total emissions.

Average Long-Term Uncontrolled VOC Emission Rate (Worst Case)

A simple check of the total emissions potential for the site should be made by dividing the total mass of a given contaminant to be removed by the expected duration of the clean-up:

$$ER_{avg} = \frac{(S_v)(C)(\beta)(1)}{t_R} \quad (\text{Eq. 1})$$

where ER_{avg} = Average worst case emission rate (g/sec);
 S_v = Volume of contaminated soil to be treated (m^3);
 C = Average contaminant concentration ($\mu g/g$);
 β = Bulk density of soil (g/cm^3);
 1 = Constant ($g/10^6 \mu g * 10^6 cm^3/m^3$); and
 t_R = Duration of remediation (sec).

The volume of contaminated soil and the total mass of each contaminant of concern present typically are determined during the remedial investigation (RI) of the site, while the fraction of contaminated soil that must be treated typically is determined during the feasibility study (FS) for the site. Final clean-up criteria also should be considered when calculating the volume of soil to be treated. The duration of the clean-up will usually be limited by the operational rate of the treatment process. For Equation 1, a typical default value for bulk density of uncompacted soil is $1.5 g/cm^3$.

Short-Term Uncontrolled VOC Emission Rate

The primary factors affecting the emission rate of a given compound from a thermal desorption unit are the concentration of the contaminant in the soil, the mass rate of soil being treated, and the volatility of the contaminant. Uncontrolled VOC emissions from a thermal desorption unit can be estimated by using the following mass balance approach:

(Eq. 2)

$$ER = \left(\frac{C}{1,000} \right) \left(\frac{F_T}{3,600} \right) \left(\frac{V}{100} \right)$$

where ER = Emission rate for contaminant of interest (g/sec);
C = Concentration of the contaminant in the soil ($\mu\text{g/g}$);
1000 = Conversion factor ($\mu\text{g/g}$ / g/kg);
 F_T = Total feed rate of waste into process unit (kg/hr);
3600 = Conversion factor (sec/hr); and
V = Amount of contaminant volatilized (%).

Equation 2 does not take into account emissions from excavation or materials handling, but these emissions should be considered when determining the total air impacts for a thermal desorption unit. Fugitive emissions from the desorber system must be calculated on an ad hoc basis. It is assumed in Equation 2 that no control device is present, so any combustion gases or PICs from fume incinerators would require further modeling.

Site-specific field data must be collected (e.g., during the RI/FS) to provide the input data necessary to generate reasonably accurate estimates of air emissions. The minimum field data required are knowledge of the specific contaminants present in the soil to be treated and the average contaminant concentration.

The preferred source of input data for Equation 2 is field measurements for the thermal desorption system of interest. Some of this information may be obtained from the thermal desorption vendor or from design specification documents. The removal efficiency (i.e., percent volatilized) of the thermal desorption unit for various compounds will vary. The operating temperature and residence time of the process unit will obviously affect the amount of volatilization. In addition, the moisture content of the waste material and the concentration range will also influence the fraction of a given organic contaminant that is volatilized. Field test data should be obtained to estimate this parameter. Once the thermal desorption unit is in operation, stack sampling of emissions from the system can be performed to confirm the emission estimates.

If the feed rate or the amount of volatilization is not available from other sources, then the default values listed in Table 1 can be used. As shown in Table 1, the percentage of a given compound that is volatilized is somewhat dependent on its vapor pressure. Organic compounds can be divided into VOCs and semi-volatile organic compounds (SVOCs) based on their vapor pressure at 25°C:

$$\begin{aligned}\text{VOCs} &= \text{Vapor pressure} \geq 1 \text{ mm Hg} \\ \text{SVOCs} &= \text{Vapor pressure} < 1 \text{ mm Hg}.\end{aligned}$$

Vapor pressure data for organic compounds can be found in Appendices A and B.

The VOC control devices generally will reduce the emissions by one to two orders of magnitude. Equation 2 can be modified to account for the effectiveness of any control device by adding the following term:

$$(1 - \text{CE}/100)$$

where CE = Control efficiency (%).

ESTIMATION OF PARTICULATE MATTER AIR EMISSIONS

The equations presented in this section were developed by Eklund, et al.⁴ and modified slightly by IT Corporation to estimate the uncontrolled PM emission from thermal desorbers⁸. In actual practice, however, control devices for particulate matter are almost always used. Most of the available thermal desorption systems utilize baghouses or cyclones for PM control. Baghouses are especially efficient in removing particulate matter from off-gas streams.

The procedures for estimating emissions outlined below may be useful for estimating the required removal efficiency of a proposed control device or for estimating the size and cost of a control device capable of achieving a given removal efficiency. Information on the effectiveness of various control devices is available from various sources^{5,8,9,10}.

Table 1

Default Values for VOC Emissions Model for Thermal Desorption Units

Parameter	Symbol	Units	Default Value	Expected Range	Reference
Feed rate	F _T	kg/hr	27,200	2700 - 90,800	5
% Volatilized	V	%	Desorber Temperature of 200-600°F	—	7
			VOCs/BTEX 99		
			SVOCs/PNAs 90		
			THC 95		
			PCBs 50		
			Desorber Temperature of 600-1000°F	—	7
			VOCs/BTEX 99.99		
			SVOCs/PNAs 99		
			THC 99.9		
			PCBs 99		
Other Parameters of Possible Interest*					
Mass of soil to be treated	M	kg	—	4.5x10 ⁵ - 2.3x10 ⁷	5
Residence Time	RT	min	—	3 - 70	5

*These parameters may be used to find the treatment rate, F_T , using:

$$F_T = M * 60 / RT$$

Uncontrolled PM Emission Rate

The particulate matter emissions from thermal desorption units can be estimated from a simple mass-balance formula which gives a conservative estimate:

$$ER = (0.18)(Q) \quad (\text{Eq. 3})$$

where ER = PM Emission rate (g/sec);
0.18 = PM loading in stack emissions (g/dscm); and
Q = Exit gas flow rate (dscm).

The maximum allowable PM emissions under RCRA regulations is 0.18 g/dscm. This limit is not always achieved in actual operation, however⁵. Typical levels of controlled emissions can be estimated by replacing the PM loading value of 0.18 g/dscm in Equation 3 with a PM loading concentration term, C_{PM} . Default values for this term are given later in this section (see Table 2).

Uncontrolled Emission Rate for Metals

If the dust is contaminated, the PM emissions from Equation 3 may be translated to emissions rates of the contaminant using Equation 4. In general, the particulate matter at a site will contain a higher fraction of metal species than the bulk soil at the site; in other words, the particulate matter is enriched with the metals.¹⁰

$$ER = 0.278 F_m \left(\frac{PF}{100} \right) \quad (\text{Eq. 4})$$

where ER = Emission rate (g/sec);
0.278 = Conversion factor (g/sec / kg/hr);
 F_m = Feed rate of metal (kg/hr); and
PF = Partitioning factor of metal (%).

The feed rate of elements in the waste stream can be calculated from the total feed rate and the concentration of metal species in the soil using Equation 5.

$$F_m = (F_T)(C_m)(10^{-6}) \quad (\text{Eq. 5})$$

where F_T = Total feed rate (kg/hr);
 C_m = Concentration of metal in the bulk soil ($\mu\text{g/g}$); and
 10^{-6} = Conversion factor ($\text{g}/\mu\text{g}$).

The minimum field data required to estimate emissions from thermal desorption systems are the specific contaminants present in the material and their average and maximum concentrations in the soil. Values for the flow rate of material to the thermal desorption unit, exhaust gas flow rate, and the efficiency of any control devices may be obtained from design specification documents or from field measurements. If this information is not available from other sources, default values for use with Equations 3 and 5 are presented in Table 2. Table 3 contains default values for metal partitioning factors for soils for use in Equation 4.

These equations are meant to predict the behavior of thermal desorption systems used at "typical" Superfund sites. If a particular site has soil with a high silt content, or other unusual condition, the accuracy of these models may be affected. It is prudent to always monitor actual field emissions to verify the model predictions. The PM control devices generally will reduce the emissions by one to two orders of magnitude. Equations 3 and 4 can be modified to account for the effectiveness of any control device by adding the following term:

$$(1 - \text{CE}/100)$$

where CE = Control efficiency (%).

ESTIMATION OF AMBIENT AIR CONCENTRATIONS

Estimates of short-term, worst-case ambient concentrations should be obtained by using site specific release parameters in the EPA's TSCREEN model¹¹. Estimates of long-term concentrations should be obtained by using EPA's Industrial Source Complex (ISCLT) model. Here, for simplicity, the annual average estimates are derived by multiplying the short-term estimate obtained from the TSCREEN model, by a conversion factor to account for variations of wind direction over time. This approach results in a higher estimate of the annual average concentration than if the ISCLT model, with site specific data, is used.

Table 2.
Default Values for PM Emissions Model for Thermal Desorption Units

Parameter	Symbol	Units	Default Value	Expected Range	Reference
Feed Rate	F_T	kg/hr	27,200	2,700 - 90,800	5
Exit Gas Flow Rate ^a	Q	m ³ /sec	8.8	1.8 - 16.2	-
PM Loading in Stack Emissions	C_{PM}	g/dscm	0.46 ^b	--	5
		g/dscm	0.08 ^c	0.01 - 0.17	5

^aAssumes dry standard m³/sec (20°C, 1 atm)

^bAsphalt plant with controls

^cRotary dryer with controls

Table 3.
Partition Factors for Metals in Soils

Parameter	Symbol	Units	Default Value	Metal	Reference
Metal Partitioning Factor	PF	%	100	Mercury	7
			20	Lead	
			10	Beryllium Chromium Copper Iron Zinc	

Typical remediation scenarios for rotary dryers and asphalt aggregate dryers are given in Table 4, and typical scenarios for thermal screws are given in Table 5. The scenarios were based on information obtained from a review of the existing literature and conversations with manufacturers of thermal desorption units. The worst-case, short-term downwind dispersion of emitted gases from each of these scenarios for an emission rate of 1 gram per second, is illustrated in Figures 3, 4, and 5. Of the variables listed in Tables 4 and 5, the stack height and the exhaust gas velocity and temperature are used to estimate the downwind dispersion.

Figures 3 and 4 illustrate the downwind dispersion for rotary dryer and asphalt aggregate dryer thermal desorption units. The results are presented for two exhaust gas temperatures. The higher temperature shown in Figure 3 is typical for thermal oxidation as an off-gas treatment process and the lower temperature shown in Figure 4 represents off gas that has been cooled by a heat exchanger, a quench chamber, or a scrubber. Generally, baghouses require gas temperatures of less than 150°F. Figure 5 illustrates the downwind dispersion of emitted gases for thermal screws. The exit gas from thermal screw thermal desorption units is generally around 21°C because condensation is the most common off-gas treatment process for these units.

The curves in all figures were calculated according to the following assumptions: 1) the combined emission rate is 1 gram per second; 2) a flat terrain without any structures near the desorption unit; 3) the emission plume is of low, positive buoyancy; 4) the stack is the only downwash structure; and 5) the receptors are at ground level. The third-order inflection points in the curves are an artifact of the model. Ideally, the curves should follow a smooth decay from peak values.

Figures 3, 4, and 5 can be used to estimate the maximum hourly ambient air concentration for an emission rate of 1 gram per second at selected distances downwind from a thermal desorption unit. The dispersion factor, in micrograms/m³ per g/sec, obtained from

Table 4.
Example Scenarios for Rotary Dryers and Asphalt Aggregate Dryers

Parameter	Units	System		
		Small	Medium	Large
Feed rate (soils)	kg/hr	7,300	27,200	59,000
Gas Volume ^a	m ³ /min	110	530	7,400
	cfm	4,000	18,700	26,000
Stack Height	m	9.1	7.6	6.1
Stack Diameter	m	0.4	1.3	1.3
Exit Gas Velocity ^a	m/sec	15	6.7	9.3
Exit Gas Temperature ^b	°C	--	--	--

^aGas volume and exit velocity assume dry standard conditions at 7% O₂ (20 °C, 1 atm).

^bExhaust gas temperature is highly dependent on the types of control devices used. For thermal oxidation with no off-gas cooling assume 815 °C (1500 °F). For any configuration with off-gas cooling by a heat exchanger, quench chamber, or scrubber, assume 120 °C (250 °F).

Table 5.
Example Scenarios for Thermal Screws

Parameter	Units	System	
		Small	Large
Feed Rate (Soils)	kg/hr	3200	8200
Gas Volume ^a	m ³ /min	3.7	24.8
	scfm	130	875
Stack Height	m	6.7	4.6
Stack Diameter	m	0.2	0.2
Exhaust Gas Velocity	m/sec	2.0	13.2
Exhaust Gas Temperature ^b	°C	21	21

^aGas volume and exit velocity assume dry standard conditions at 7% O₂ (20 °C, 1 atm).

^bAssumes off-gas treatment is condensation, which is typical for thermal screws.

Exhaust Gas Temperature is 815°C

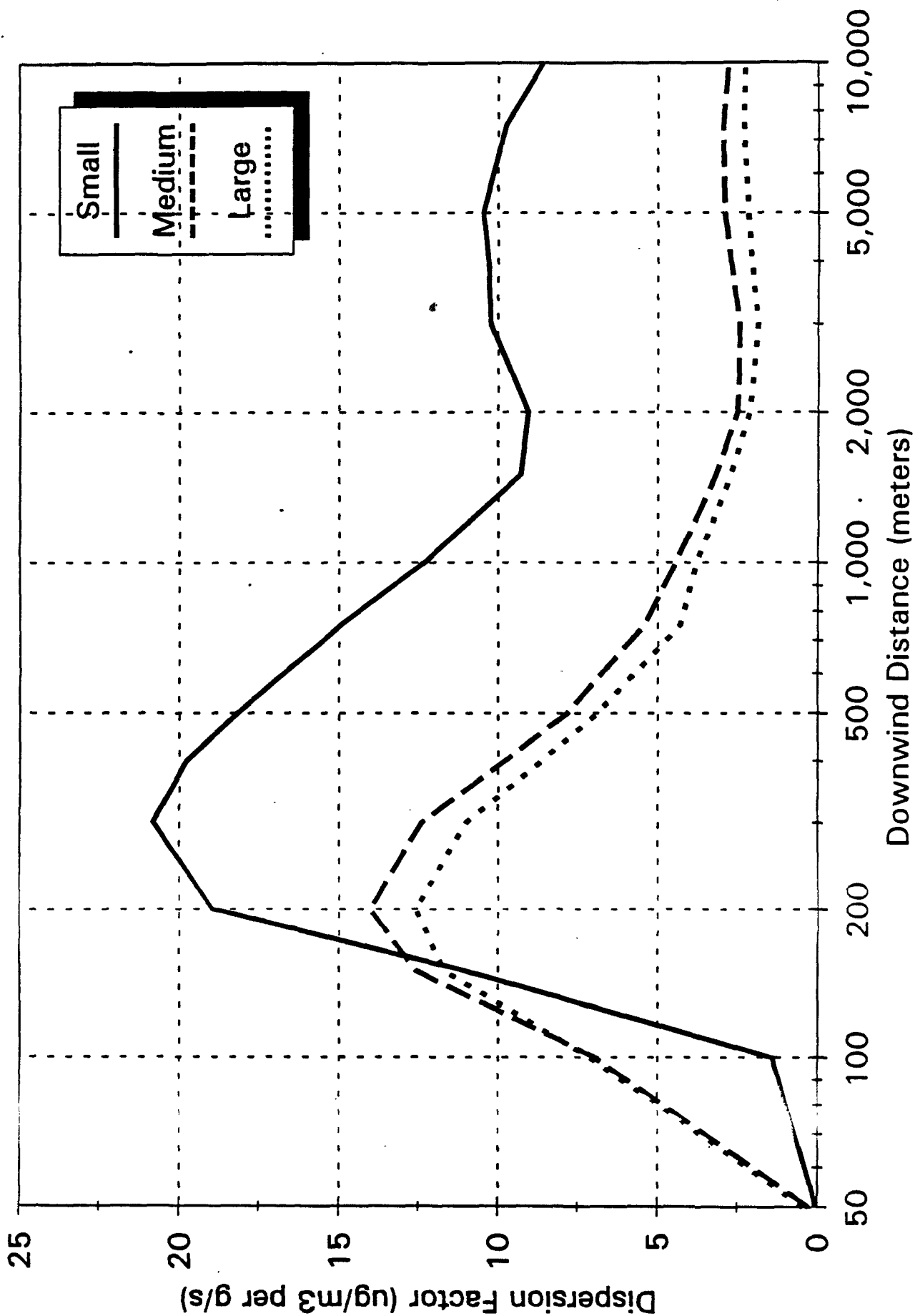


Figure 3. One-Hour Average Downwind Dispersion Factor Versus Distance for Rotary Dryers and Asphalt Aggregate Dryers With Thermal Oxidizer Control Unit

Exhaust Gas Temperature is 120°C

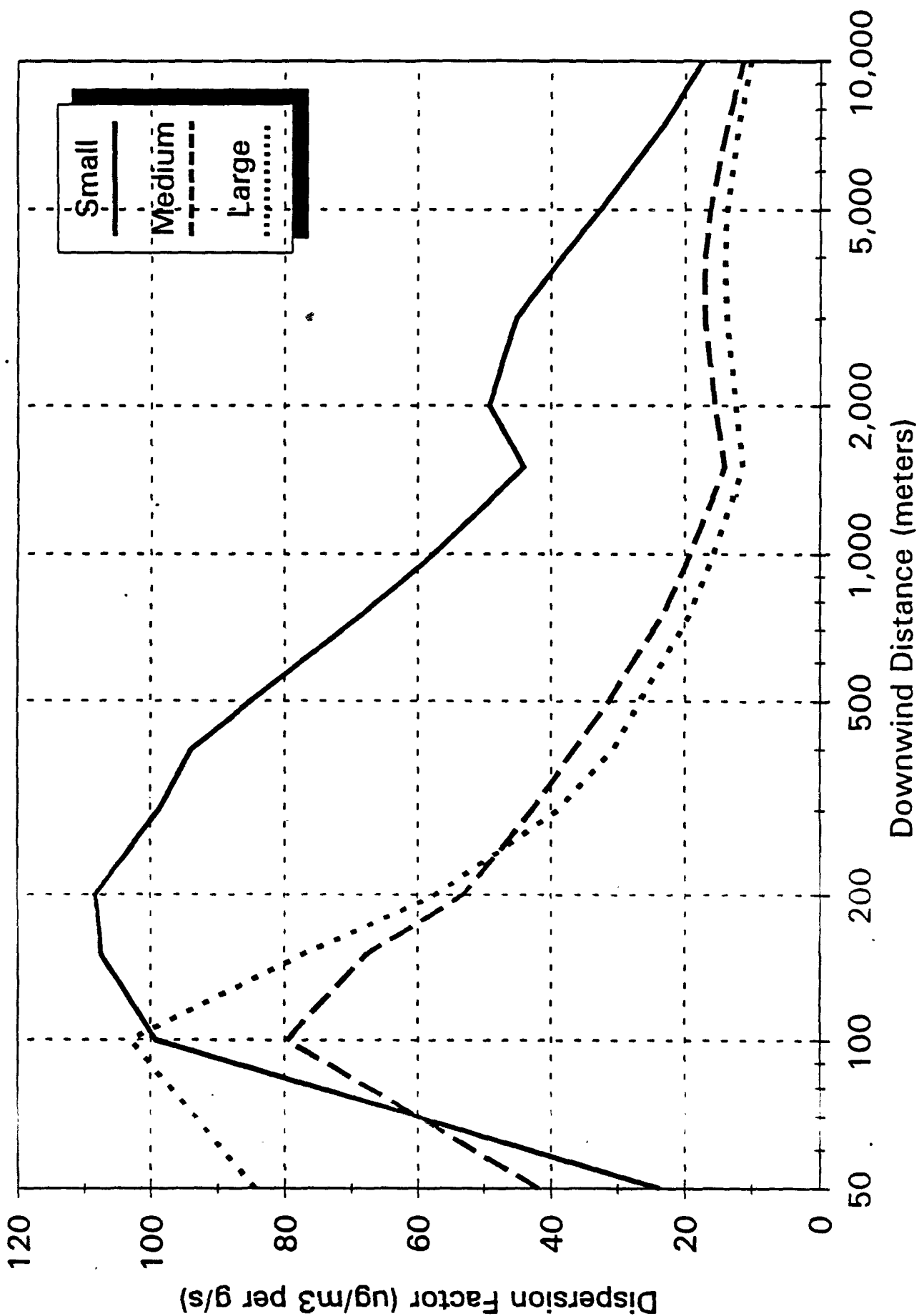


Figure 4. One-Hour Average Downwind Dispersion Factor Versus Distance for Rotary Dryers and Asphalt Aggregate Dryers With Off-Gas Cooling Control Unit

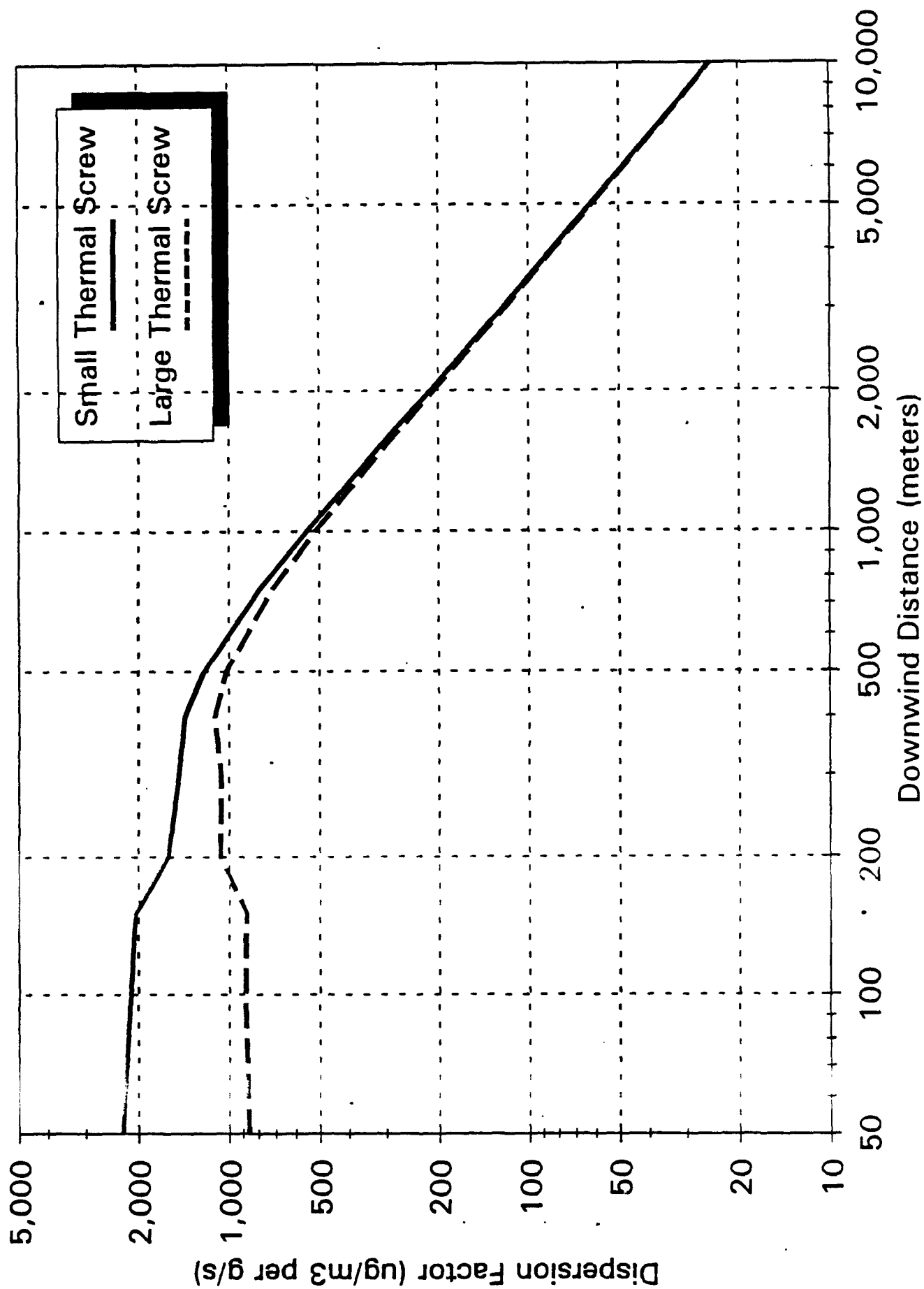


Figure 5. One-Hour Average Downwind Dispersion Factor Versus Distance for Thermal Screws With Condenser Control Unit

Figure 3, 4, or 5 can be substituted into Equation 6 to estimate the maximum hourly ambient concentration and into Equation 7 to estimate the annual average ambient air concentration for a given downwind distance. Since TSCREEN provides maximum short-term estimates, the factor of 0.08 in Equation 7 is used to convert the short-term estimate to an annual average estimate. This assumption has been recently revised by the U.S. EPA; it is still under review by EPA, however, and may be subject to further change.

$$C_m = (ER)(F) \quad (\text{Eq. 6})$$

$$C_a = (ER)(F)(0.08) \quad (\text{Eq. 7})$$

where C_m = Maximum hourly ambient air concentration ($\mu\text{g}/\text{m}^3$);
 C_a = Annual average ambient air concentration ($\mu\text{g}/\text{m}^3$);
 ER = Emission rate (g/sec); and
 F = Dispersion factor from Figure 3, 4, or 5 ($\mu\text{g}/\text{m}^3$ / g/sec).

ESTIMATION OF HEALTH EFFECTS

Cancer Effects Due to Long-Term Exposure

Potential cancer effects resulting from long-term exposure to substances emitted to the air can be evaluated using inhalation unit risk factors. Inhalation unit risk factors are a measure of the cancer risk for each $\mu\text{g}/\text{m}^3$ of concentration in the ambient air. They are available on EPA's Integrated Risk Information System (IRIS), the U.S. EPA's preferred source of toxicity information. User Support can be contacted at (513) 569-7254. The next best source of inhalation unit risk factors is EPA's Health Effects Assessment Summary Tables (HEAST) which are updated annually¹². Inhalation unit risk factors listed in IRIS as of January 1993 or in HEAST (FY 1992) are given in Table 6 for 168 volatile and semi-volatile organic compounds. This is an updated version of the same table contained in References 2 and 3. Similar information is given in Tables 7 and 8 for selected semi-volatile organic compounds and metals, respectively. Emission data for thermal desorption units was reviewed to develop the list of SVOCs given in Table 7.

Table 6.

Long-Term and Short-Term Health-Based Action Levels for Organic Compounds in Ambient Air

No.	Chemical	CAS Number	Carcinogenicity ^a	Chronic Toxicity ^a	Long-Term Action Levels				Short-Term Action Levels ^d
					Risk-Specific Concentrations for Carcinogenicity	RfC-Based Concentrations for Non-Carcinogenic Effects (µg/m ³)	Concentrations Based on Occupational Exposure ^d		
							10 ⁻⁶ 70-year Risk (µg/m ³)	Lowest OEL/1000 (µg/m ³)	
1	Acetaldehyde	75-07-0	2.2e-06 ^c	9e-03 ^c	0.45	9	180	1,800	
2	Acetic Acid	64-19-7	—	—	—	—	25	250	
3	Acetic anhydride	108-24-7	—	—	—	—	20	200	
4	Acetone	67-64-1	— ^{a*}	(4e-01) ^b	—	400	1,780	17,800	
5	Acetonitrile	75-05-8	— ^c	5e-02 ^f	—	50	67	670	
6	Acrolein	107-02-8	— ^{a*}	2e-05 ^e	—	0.02	0.23	2.30	
7	Acrylic acid	79-10-7	— ^c	3e-04 ^c	—	0.3	5.90	59	
8	Acrylonitrile	107-13-1	6.8e-05 ^c	2e-03 ^c	0.015 ^c	2	4.30	43	
9	Allyl alcohol	107-18-6	— ^c	(2e-02) ^b	—	20	4.80	48	
10	Allyl chloride	107-05-1	— ^{a*}	1e-03 ^c	—	1	3.00	30	
11	Aniline	62-53-3	1.6e-6 ^b	1e-03 ^c	0.63	1	7.60	76	
12	Anthracene	120-12-7	— ^{a*}	(1e+00) ^b	—	1,000	0.20	2.00	
13	Benzaldehyde	100-52-7	— ^c	(4e-01) ^b	—	400	—	—	
14	Benzene	71-43-2	8.3e-06 ^c	— ^c	0.12	—	32	320	
15	Benzoic acid	65-85-0	— ^{a*}	(1.4e+01) ^b	—	14,000	—	—	
16	Benzyl alcohol	100-51-6	— ^c	(1e+00) ^b	—	1,000	—	—	
17	Benzyl chloride	100-44-7	5e-05 ^b	— ^c	0.02	—	5	50	
18	Bromoform	75-25-2	1.1e-06 ^c	(7e-02) ^b	0.91	70	5	50	
19	1,3-Butadiene	106-99-0	2.8e-04 ^c	— ^c	3.6e-03	—	22	220	
20	n-Butane	106-97-8	—	—	—	—	1,900	19,000	
21	2-Butanol	15892-23-6	—	—	—	—	303	3,030	
22	n-Butanol	71-36-3	— ^{a*}	(4e-01) ^b	—	400	152	1,520	

Table 6. (Continued)

No.	Chemical	CAS Number	Carcinogenicity ^a Inhalation Unit Risk 1/(μg/m ³)	Chronic Toxicity ^a Inhalation RfC (mg/m ³)	Long-Term Action Levels				Short-Term Action Levels ^d Lowest OEL/100 (μg/m ³)
					Risk-Specific Concentrations for Carcinogenicity 10 ⁻⁶ 70-year Risk (μg/m ³)	RfC-Based Concentrations for Non-Carcinogenic Effects (μg/m ³)	Concentrations Based on Occupational Exposure ^d Lowest OEL/1000 (μg/m ³)		
23	n-Butyl-Acetate	123-86-4	-	-	-	-	710	7,100	
24	Tert-Butyl-Alcohol	75-65-0	-	-	-	-	300	3,000	
25	Carbon disulfide	75-15-0	- ^e	1e-02 ^f	-	10	12	120	
26	Carbon Tetrachloride	56-23-5	1.5e-05 ^e	(2.5e-03) ^g	0.0067	2.5	12.6	126	
27	Carbonyl Sulfide	463-58-1	- ^e	- ^e	-	-	-	-	
28	Catechol	120-80-9	- ^e	- ^e	-	-	20	200	
29	Chlorine	7782-50-5	- ^e	- ^e	-	-	1.5	15	
30	Chlorobenzene	108-90-7	- ^{ee}	2e-02 ^f	-	20	46	460	
31	Chlorodifluoromethane	75-45-6	- ^e	- ^e	-	-	3,540	35,400	
32	Chloroform	67-66-3	2.3e-05 ^e	(4e-02) ^g	0.043	40	9.78	98	
33	Chloromethyl methyl ether	107-30-2	- ^e	- ^e	-	-	-	-	
34	Chloropentafluoroethane	76-15-3	-	-	-	-	6,320	63,200	
35	Chloroprene	126-94-8	- ^e	7e-03 ^f	-	7	35	350	
36	m-Cresol	108-39-4	- ^{ee}	(2e-01) ^g	-	200	22	220	
37	o-Cresol	95-48-7	- ^{ee}	(2e-01) ^g	-	200	22	220	
38	p-Cresol	106-44-5	- ^{ee}	(2e-01) ^g	-	200	22	220	
39	Cyanogen	460-19-5	- ^e	(1.4e-01) ^g	-	140	20	200	
40	Cyclohexane	110-82-7	-	-	-	-	1,030	10,300	
41	Cyclohexanol	108-93-0	-	-	-	-	200	2,000	
42	Cyclohexanone	108-94-1	- ^e	(18) ^g	-	18,000	100	1,000	
43	Cyclohexene	110-83-8	-	-	-	-	1,010	10,100	
44	Cyclopentane	287-92-3	-	-	-	-	1,720	17,200	
45	Diazomethane	334-88-3	- ^e	- ^e	-	-	0.34	3.4	

Table 6. (Continued)

No.	Chemical	CAS Number	Carcinogenicity ^a Inhalation Unit Risk 1/($\mu\text{g}/\text{m}^3$)	Chronic Toxicity ^a Inhalation RfC (mg/m ³)	Long-Term Action Levels				Short-Term Action Levels ^d Lowest OEL/100 ($\mu\text{g}/\text{m}^3$)
					Risk-Specific Concentrations for Carcinogenicity 10 ⁻⁶ 70-year Risk ($\mu\text{g}/\text{m}^3$)	RfC-Based Concentrations for Non-Carcinogenic Effects ($\mu\text{g}/\text{m}^3$)	Concentrations Based on Occupational Exposure ^d Lowest OEL/1000 ($\mu\text{g}/\text{m}^3$)		
46	Dibutyl-O-Phthalate	84-74-2	— ^{aa}	(4e-01) ^b	—	400	5.00	50	
47	o-Dichlorobenzene	95-50-1	— ^{aa}	2e-01 ^f	—	200	150	1,500	
48	p-Dichlorobenzene	106-46-7	6.6e-6 ^b	8e-01 ^f	0.15	800	450	4,500	
49	Dichloroethylether	111-44-4	3.3e-04 ^c	—	3.0e-03	—	29	290	
50	Dichlorodifluoromethane	75-71-8	— ^a	(0.7) ^b	—	200	4,950	49,500	
51	1,1-Dichloroethane	75-34-3	— ^{aa}	5e-01 ^f	—	500	400	4,000	
52	1,2-Dichloroethane	107-06-2	2.6e-05 ^c	—	0.038 ^c	—	4.00	40	
53	1,1-Dichloroethylene	75-35-4	5e-05 ^c	(3e-02) ^b	0.020	30	4.00	40	
54	cis-1,2-dichloroethylene	156-59-2	— ^{aa}	(4e-02) ^b	—	40	790	7,900	
55	trans-1,2-dichloroethylene	156-60-5	— ^a	(7e-02) ^b	—	70	790	7,900	
56	Dichloromethane	75-09-2	4.7e-07 ^c	3e+00 ^f	2.1	3,000	174	1,740	
57	Dichloromonofluoromethane	75-43-4	—	—	—	—	40	400	
58	1,2-Dichloropropane	78-87-5	2e-05 ^b	4e-3 ^c	0.050	4	347	3,470	
59	1,3-Dichloropropene	542-75-6	3.7e-05 ^f	2e-02 ^c	0.027	20	4.5	45	
60	1,2-Dichloro-1,1,2,2-Tetrafluoroethane	76-14-2	—	—	—	—	6,990	69,900	
61	Diethanolamine	111-42-2	—	—	—	—	13	130	
62	Diethyl amine	109-89-7	—	—	—	—	30	300	
63	N,N-Dimethylaniline	121-69-7	— ^a	(7e-03) ^b	—	7	25	250	
64	Diethyl ether	60-29-7	—	(7e-01) ^b	—	700	1,200	12,000	
65	Dimethylamine	124-40-3	— ^a	— ^c	—	—	9.2	92	
66	Dimethyl formamide	68-12-2	— ^a	3e-02 ^c	—	30	30	300	
67	1,1-Dimethyl hydrazine	57-14-7	1e-03 ^f	— ^a	1e-03	—	1	10	
68	2,4-Dinitrophenol	51-28-5	— ^a	(7e-03) ^b	—	7	—	—	

Table 6. (Continued)

No.	Chemical	CAS Number	Carcinogenicity ^a	Chronic Toxicity ^a	Long-Term Action Levels				Short-Term Action Levels ^d
					Inhalation Unit Risk 1/($\mu\text{g}/\text{m}^3$)	Risk-Specific Concentrations for Carcinogenicity 10 ⁻⁶ 70-year Risk ($\mu\text{g}/\text{m}^3$)	RfC-Based Concentrations for Non-Carcinogenic Effects ($\mu\text{g}/\text{m}^3$)	Concentrations Based on Occupational Exposure ^d	
69	1,4-Dioxane	123-91-1	3.1e-03 ^b	— ^c	3.2e-04	—	90	900	
70	Diphenyl	92-52-4	— ^c	(1.8e-01) ^b	—	180	1.00	10	
71	Epichlorohydrin	106-89-8	1.2e-06 ^c	1e-3 ^c	0.83	1.0	7.6	76	
72	1,2-Epoxybutane	106-88-7	— ^c	2e-02 ^c	—	20	—	—	
73	Ethanol	64-17-5	—	—	—	—	1,880	18,800	
74	Ethyl acetate	141-78-6	— ^c	(3.2e+00) ^b	—	3,200	1,400	14,000	
75	Ethyl acrylate	140-88-5	1.4e-05 ^b	— ^c	0.071	—	20	200	
76	Ethyl amine	75-04-7	—	—	—	—	18	180	
77	Ethylbenzene	100-41-4	— ^c	1e-00 ^c	—	1,000	434	4,340	
78	Ethyl bromide	74-96-4	— ^c	— ^c	—	—	22	220	
79	Ethyl carbamate	51-79-6	— ^c	— ^c	—	—	—	—	
80	Ethyl chloride	75-00-3	— ^c	1e+01 ^c	—	10,000	2,600	26,000	
81	Ethylenediamine	107-15-3	— ^c	0.07	—	70	25	250	
82	Ethylene dibromide	106-93-4	2.2e-04 ^c	— ^c	4.5e-03	—	—	—	
83	Ethylene glycol	107-21-1	— ^c	(7.0e+00) ^b	—	7,000	127	1,270	
84	Ethylene imine	151-56-4	— ^c	—	—	—	0.88	8.80	
85	Ethylene oxide	75-21-8	1.0e-04 ^c	(3.6e+00) ^b	0.010	3,600	1.80	18	
86	Formaldehyde	50-00-0	1.3e-05 ^c	(7e-01) ^b	0.077	700	1.2	12	
87	Formic Acid	64-18-6	— ^c	(7e+00) ^b	—	7,000	9.00	90	
88	Furan	110-00-9	— ^c	(4.0e-03) ^b	—	4	—	—	
89	Glycerol	56-81-5	—	—	—	—	5.00	50	
90	n-Heptane	142-82-5	— ^c	— ^c	—	—	1,600	16,000	
91	n-Hexane	110-54-3	— ^c	2e-01 ^c	—	200	176	1,760	

Table 6. (Continued)

No.	Chemical	CAS Number	Carcinogenicity ^a Inhalation Unit Risk 1/($\mu\text{g}/\text{m}^3$)	Chronic Toxicity ^a Inhalation RfC (mg/m ³)	Long-Term Action Levels				Short-Term Action Levels ^d Lowest OEL/100 ($\mu\text{g}/\text{m}^3$)
					Risk-Specific Concentrations for Carcinogenicity 10 ⁻⁶ 70-year Risk ($\mu\text{g}/\text{m}^3$)	RfC-Based Concentrations for Non-Carcinogenic Effects ($\mu\text{g}/\text{m}^3$)	Concentrations Based on Occupational Exposure ^d		
							Lowest OEL/1000 ($\mu\text{g}/\text{m}^3$)		
							Lowest OEL/1000 ($\mu\text{g}/\text{m}^3$)		
92	Hydrazine	302-01-2	4.9e-03 ^e	— ^e	2.0e-04	—	0.1	1	
93	Hydrochloric acid	7647-01-0	— ^e	7e-03 ^e	—	7	7.5	75	
94	Hydrogen cyanide	74-90-8	— ^e	(0.07) ^b	—	70	11	110	
95	Hydrogen Sulfide	7783-06-4	— ^e	9e-04 ^e	—	0.9	14	140	
96	Isobutanol	78-83-1	—	(1.1e+00) ^b	—	1,100	150	1,500	
97	Isobutyl acetate	110-19-0	—	—	—	—	700	7,000	
98	Isopropyl alcohol	67-63-0	— ^e	— ^e	—	—	983	9,830	
99	Isopropyl amine	75-31-0	—	—	—	—	12	120	
100	Isopropylbenzene	98-82-8	— ^e	(1.4e-01) ^b	—	140	245	2,450	
101	Methanol	67-56-1	— ^e	(2e+00) ^b	—	2,000	260	2,600	
102	Methyl acetate	79-20-9	— ^e	(4e+00) ^b	—	4,000	606	6,060	
103	Methyl acrylate	96-33-3	— ^{ee}	(1.1e-01) ^b	—	110	35	350	
104	Methyl amine	74-89-5	—	—	—	—	6.4	64	
105	Methyl bromide	74-83-9	— ^{ee}	5e-3 ^e	—	5	19	190	
106	Methyl-tert-butyl-ether	1634-04-4	— ^e	5e-01 ^e	—	500	—	—	
107	Methyl chloride	74-87-3	1.8e-06 ^e	— ^e	0.55	—	103	1,030	
108	Methyleyclohexane	108-87-2	—	3e+00 ^e	—	3,000	1,600	16,000	
109	Methyl-ethyl-ketone	78-93-3	— ^{ee}	1e-00 ^e	—	1,000	590	5,900	
110	Methyl formate	107-31-3	—	—	—	—	246	2,460	
111	Methyl hydrazine	60-34-4	3e-04 ^b	— ^e	3.3e-03	—	0.38	3.8	
112	Methyl iodide	74-88-4	— ^e	— ^e	—	—	10	100	
113	Methyl-Isobutyl-Ketone	108-10-1	— ^e	8e-02 ^f	—	80	205	2,050	
114	Methyl isocyanate	624-83-9	— ^e	— ^e	—	—	0.047	0.47	

Table 6. (Continued)

No.	Chemical	CAS Number	Carcinogenicity ^a Inhalation Unit Risk 1/(μg/m ³)	Chronic Toxicity ^c Inhalation RfC (mg/m ³)	Long-Term Action Levels				Short-Term Action Levels ^d Lowest OEL/100 (μg/m ³)
					Risk-Specific Concentrations for Carcinogenicity 10 ⁻⁴ 70-year Risk (μg/m ³)	RfC-Based Concentrations for Non-Carcinogenic Effects (μg/m ³)	Concentrations Based on Occupational Exposure ^d Lowest OEL/1000 (μg/m ³)		
115	Methyl-Isopropyl-Ketone	563-80-4	-	-	-	-	705	7,050	
116	Methyl mercaptan	74-93-1	- ^e	- ^e	-	-	0.98	98	
117	Methyl methacrylate	80-62-6	- ^e	(3e-01) ^b	-	300	410	4,100	
118	Methyl-n-Propyl-ketone	107-87-9	-	-	-	-	700	7,000	
119	Alpha-methyl-styrene	98-83-9	- ^e	(2.5e-01) ^b	-	250	240	2,400	
120	Monoethanolamine	141-43-5	-	-	-	-	7.50	75	
121	Morpholine	110-91-8	-	-	-	-	70	700	
122	Naphthalene	91-20-3	- ^{e,e}	-	-	-	50	500	
123	2-Nitropropane	79-46-9	2.7e-03 ^e	2e-02 ^e	3.7e-04	20	35	350	
124	N-Nitrosodimethylamine	62-75-9	1.4e-02 ^e	- ^e	7.1e-05	-	-	-	
125	N-Nitrosomorpholine	59-89-2	-	-	-	-	-	-	
126	n-Nonane	111-84-2	-	-	-	-	1,050	10,500	
127	n-Octane	111-65-9	-	-	-	-	1,400	14,000	
128	n-Pentane	109-66-0	-	-	-	-	1,770	17,700	
129	Phenanthrene	85-01-9	- ^{e,e}	- ^e	-	-	0.20	2	
130	Phenol	108-95-2	- ^{e,e}	(2.1e+00) ^b	-	2,000	19	190	
131	Phosgene	75-44-5	- ^e	- ^e	-	-	0.4	4	
132	Phosphine	7803-51-2	- ^e	3e-05 ^f	-	0.03	0.4	4	
133	Phthalic anhydride	85-44-9	- ^e	1.2e-01 ^f	-	120	6.00	60	
134	Propane	74-98-6	-	-	-	-	1,800	18,000	
135	1,2-Propanediol	57-55-6	- ^e	- ^e	-	-	-	-	
136	1-Propanol	71-23-8	- ^e	- ^e	-	-	492	4,920	
137	beta-Propiolactone	57-57-8	- ^e	- ^e	-	-	1.5	15	

Table 6. (Continued)

No.	Chemical	CAS Number	Carcinogenicity ^a	Chronic Toxicity ^a	Long-Term Action Levels				Short-Term Action Levels ^d
					Risk-Specific Concentrations for Carcinogenicity 10 ⁻⁶ 70-year Risk (μg/m ³)	RfC-Based Concentrations for Non-Carcinogenic Effects (μg/m ³)	Concentrations Based on Occupational Exposure ^d Lowest OEL/1000 (μg/m ³)	Lowest OEL/100 (μg/m ³)	
138	Propionaldehyde	123-38-7	—	—	—	—	—	—	—
139	Propionic acid	79-09-4	— ^a	— ^a	—	—	30	30	300
140	n-Propyl-Acetate	109-60-4	—	—	—	—	835	835	8,350
141	Propylene oxide	75-56-9	3.7e-06 ^a	3e-02 ^a	0.27	30	48	48	480
142	1,2-Propylenimine	75-55-8	— ^a	— ^a	—	—	4.7	4.7	47
143	Pyridine	110-86-1	— ^a	(4e-03) ^b	—	4	15	15	150
144	Quinone	106-51-4	— ^a	— ^a	—	—	0.4	0.4	4
145	Styrene	100-42-5	— ^a	1.0e+00 ^d	—	1000	213	213	2,130
146	1,1,1,2-Tetrachloro-2,2-Difluoroethane	76-11-9	—	—	—	—	4,170	4,170	41,700
147	1,1,2,2-Tetrachloroethane	79-34-5	5.8e-05 ^{cc}	— ^a	0.017	—	6.90	6.90	69
148	Tetrachloroethylene	127-18-4	5.8e-07 ^e	(3.5e-2) ^b	1.7	35	170	170	1,700
149	Tetrahydrofuran	109-99-9	— ^a	— ^a	—	—	590	590	5,900
150	Toluene	108-88-3	— ^{cc}	4e-01 ^e	—	400	375	375	3,750
151	p-Toluidine	106-49-0	5.4e-05 ^b	— ^a	0.019	—	8.80	8.80	88
152	1,1,1-Trichloroethane	71-55-6	— ^{cc}	1.0e+00 ^d	—	1,000	1,900	1,900	19,000
153	1,1,2-Trichloroethane	79-00-5	1.6e-05 ^{cc}	1.4e-02 ^e	0.063	14	45	45	450
154	Trichloroethylene	79-01-6	— ^a	— ^a	—	—	269	269	2,690
155	Trichlorofluoromethane	75-69-4	— ^a	7.0e-01 ^f	—	700	5,620	5,620	56,200
156	1,2,3-Trichloropropane	96-18-4	— ^a	2.0e-02 ^e	—	20	60	60	600
157	1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1	— ^a	(2.7e+01) ^b	—	27,000	7,600	7,600	76,000
158	Triethylamine	121-44-8	— ^a	7e-3 ^e	—	7	40	40	400
159	Trifluorobromomethane	75-63-8	—	—	—	—	6,090	6,090	60,900
160	1,2,3-Trimethylbenzene	526-73-8	—	—	—	—	123	123	1,230

Table 6. (Continued)

No.	Chemical	CAS Number	Carcinogenicity ^a	Chronic Toxicity ^b	Long-Term Action Levels				Short-Term Action Levels ^d
					Risk-Specific Concentrations for Carcinogenicity	RC-Based Concentrations for Non-Carcinogenic Effects	Concentrations Based on Occupational Exposure ^e	Lowest OEL/1000 ($\mu\text{g}/\text{m}^3$)	
161	1,2,4-Trimethylbenzene	95-63-6	—	—	—	—	123	123	1,230
162	1,3,5-Trimethylbenzene	108-67-8	—	—	—	—	123	123	1,230
163	Vinyl acetate	108-05-4	— ^c	2e-01 ^c	—	200	30	30	300
164	Vinyl bromide	593-60-2	3.2e-05 ^f	—	0.031	—	20	20	200
165	Vinyl-chloride	75-01-4	8.4e-05 ^c	—	0.012	—	2.60	2.60	26
166	m-Xylene	108-38-3	— ^c	(7) ^b	—	7000	434	434	4,340
167	o-Xylene	95-47-6	— ^c	(7) ^b	—	7000	434	434	4,340
168	p-Xylene	106-42-3	— ^c	— ^c	—	—	434	434	4,340

INSTRUCTIONS ON USE:

Read short-term action level directly from last column. For the three columns of long-term action levels, use the 10-6 risk data, if available, then the RfC data; use the OEL/1000 if no other data exists.

^a EPA does not necessarily endorse the use of oral slope factors or oral RfDs to derive inhalation values. These are intended to serve as screening levels only and do not represent EPA guidance.

^b Derived based on oral slope factor (or oral RfD).

^c Verified, available on IRIS (1/93) or Workgroup concurrence on final database file, and IRIS input pending.

^d EPA does not necessarily endorse the use of occupational exposure limits to derive short- and long-term action levels for ambient air. These are intended to serve as screening levels only and do not represent EPA guidance. Intended changes for OEL values are included, where applicable.

^e EPA Class C or D carcinogen.

^f Available in the Health Effects Assessment Summary Tables (HEAST, FY1992).

Table 7.

Long-Term and Short-Term Health-Based Action Levels for Selected Semi-Volatile Organic Compounds in Air

No.	Chemical	CAS Number	Carcinogenicity ^a Inhalation Unit Risk 1/(μg/m ³)	Chronic Toxicity ^a Inhalation RfC (mg/m ³)	Long-Term Action Levels				Short-Term Action Levels ^d Lowest OEL/100 (μg/m ³)
					Risk-Specific Concentrations for Carcinogenicity 10 ⁻⁶ 70-year Risk (μg/m ³)	RfC-Based Concentrations for Non-Carcinogenic Effects (μg/m ³)	Concentrations Based on Occupational Exposure ^d Lowest OEL/1000 (μg/m ³)		
1	Acenaphthene	83-32-9	-- ^c	(2.1e-01) ^b	--	210	--	--	
2	2-Acetoaminofluorene	53-96-3	--	--	--	--	--	--	
3	2-Acetylfuran	1192-62-7	--	--	--	--	--	--	
4	Benzidine	92-87-5	6.7e-02 ^c	(1.1e-02) ^b	1.5e-05	10.5	--	--	
5	Benzo(a)anthracene	56-55-3	-- ^c	-- ^c	--	--	--	--	
6	Benzo(a)pyrene	50-32-8	1.7e-03 ^b	--	5.9e-04	--	0.2 ^a	2.0	
7	Benzo(a)fluoranthene	205-99-2	-- ^c	-- ^c	--	--	--	--	
8	Benzo(g,h,i)perylene	191-24-2	-- ^c	-- ^c	--	--	--	--	
9	Benzo(k)fluoranthene	207-08-9	-- ^c	-- ^c	--	--	--	--	
10	Bis(2-ethylhexyl)phthalate	117-81-7	4e-06 ^b	(7e-02) ^b	0.25	70	5	50	
11	Chlordane	57-74-9	3.7e-04 ^c	(2.1e-04) ^b	2.7e-03	0.21	0.5	5	
12	Chrysene	218-01-9	--	--	--	--	0.2 ^a	2.0 ^a	
13	Cresol	1319-77-3	-- ^{c,c}	(2e-01) ^b	--	200	22	220	
14	Dioxin (2,3,7,8-TCDD)	1746-01-6	--	--	--	--	--	--	
15	Dibenzofuran	132-64-9	-- ^{c,c}	-- ^c	--	--	--	--	
16	Dibenzo(a,h)anthracene	53-70-3	-- ^c	-- ^c	--	--	--	--	
17	Di-n-butylphthalate	84-74-2	-- ^{c,c}	(3.5e-01) ^b	--	350	5	50	
18	Ethylenamine	593-67-9	--	--	--	--	--	--	
19	Fluoranthene	206-44-0	-- ^{c,c}	(1.4e-01) ^b	--	140	--	--	
20	Fluorene	86-73-7	-- ^{c,c}	(1.4e-01) ^b	--	140	--	--	
21	Heptachlor	76-44-8	1.3e-03 ^c	(1.8e-03) ^b	7.7e-04	1.8	0.5	5	

Table 7. (Continued)

No.	Chemical	CAS Number	Carcinogenicity ^a Inhalation Unit Risk 1/(μg/m ³)	Chronic Toxicity ^a Inhalation RfC (mg/m ³)	Long-Term Action Levels			
					Risk-Specific Concentrations for Carcinogenicity 10 ⁻⁶ 70-year Risk (μg/m ³)	RfC-Based Concentrations for Non-Carcinogenic Effects (μg/m ³)	Concentrations Based on Occupational Exposure ^d Lowest OEL/1000 (μg/m ³)	Short-Term Action Levels ^d Lowest OEL/100 (μg/m ³)
22	Hexachlorocyclopentadiene	77-47-4	-- ^a	7e-5 ^f	--	0.07	0.1	1.0
23	Indeno(1,2,3-CD)pyrene	193-39-5	--	--	--	--	--	--
24	Lindane	58-89-9						
25	Maleic Anhydride	108-31-6	-- ^a	(3.5e-01) ^b	--	350	1	10
26	2-Methylnaphthalene	91-57-6	--	--	--	--	--	--
27	p-Nitrosodiphenylamine	156-10-5	--	--	--	--	--	--
28	Nitrobenzene	98-95-3	-- ^a	2e-3	--	2.0	5	50
29	PCBs	1336-36-3	2.2e-03 ^b	-- ^c	4.5e-04	--	--	--
30	PAHs	--	--	--	--	--	0.2 ^g	2.0 ^h
31	Parathion	56-38-2	-- ^a	(2.1e-02) ^b	--	21	0.1	1.0
32	Pyrene	129-00-0	-- ^a	(1.1e-01) ^b	--	105	--	--
33	Tridecane	629-50-5	--	--	--	--	--	--
34	Undecane	1120-21-4	--	--	--	--	--	--

INSTRUCTIONS ON USE: Read short-term action level directly from last column. For the three columns of long-term action levels, use the 10-6 risk data, if available, then the RfC data; use the OEL/1000 if no other data exists.

- ^a EPA does not necessarily endorse the use of oral slope factors or oral RfDs to derive inhalation values. These are intended to serve as screening levels only and do not represent EPA guidance.
- ^b Derived based on oral slope factor (or oral RfD).
- ^c Verified, available on IRIS or Workgroup concurrence on final database file, and IRIS input pending.
- ^d EPA does not necessarily endorse the use of occupational exposure limits to derive short- and long-term action levels for ambient air. These are intended to serve as screening levels only and do not represent EPA guidance. Intended changes for OEL values are included, where applicable.
- ^e EPA Class C or D carcinogen.
- ^f Available in the Health Effects Assessment Summary Tables (HEAST, FY 1992).
- ^g As coal tar pitch volatiles.

Table 8.

Long-Term and Short-Term Health-Based Action Levels for Metals in Ambient Air

No.	Chemical	CAS Number	Carcinogenicity ^a Inhalation Unit Risk 1/($\mu\text{g}/\text{m}^3$)	Chronic Toxicity ^a Inhalation RfC (mg/m ³)	Long-Term Action Levels				Short-Term Action Levels ^d Lowest OEL/100 ($\mu\text{g}/\text{m}^3$)
					Risk-Specific Concentrations for Carcinogenicity 10 ⁻⁶ 70-year Risk ($\mu\text{g}/\text{m}^3$)	RfC-Based Concentrations for Non-Carcinogenic Effects ($\mu\text{g}/\text{m}^3$)	Concentrations Based on Occupational Exposure ^c		
							Lowest OEL/1000 ($\mu\text{g}/\text{m}^3$)		
1	Antimony	7440-36-0	ND	(1.4+00) ^b	--	1,400	0.50	5.00	
2	Arsenic	7740-38-2	4.3e-03 ^c	(1.0e+00) ^b	2.3e-04	1,050	0.20	2.00	
3	Beryllium	7440-41-7	2.4e-03 ^c	(1.7e+01) ^b	4.2e-04	17,500	0.002	0.02	
4	Cadmium	7440-43-9	1.8e-03 ^c	(3.5e+00) ^b	5.6e-04	3,500	0.05	0.50	
5	Chromium III	7440-47-3	ND	(3.5+03) ^b	--	3,500,000	0.50	5.00	
6 [*]	Chromium IV	7440-47-3	1.2e-02 ^c	(1.7e+01) ^b	8.3e-05	17,500	0.05	0.50	
7	Cobalt [†]	7440-48-4	ND	ND	--	--	0.05	0.50	
8	Lead	7439-92-1	ND	ND	--	--	0.15	1.50	
9	Manganese	7439-96-5	ND ^{**}	4e-04 ^c	ND	0.40	0.50	5.00	
10	Mercury (vapor)	7439-97-6	ND ^{**}	3e-04 ^c	ND	0.30	0.05	0.50	
11	Nickel	7440-02-0	2e-04 ^c	(7.0e+01) ^b	5.0e-03	70,000	1.00	10.00	
12	Selenium	7782-49-2	ND ^c	(1.7e+01) ^b	--	17,500	0.20	2.00	

INSTRUCTIONS ON USE:

Read short-term action level directly from last column. For the three columns of long-term action levels, use the 10-6 risk data, if available, then the RfC data; use the OEL/1000 if no other data exists.

- ^a EPA does not necessarily endorse the use of oral slope factors or oral RfDs to derive inhalation values. These are intended to serve as screening levels only and do not represent EPA guidance.
- ^b Derived based on oral slope factor (or oral RfD).
- ^c Verified, available on IRIS or Workgroup concurrence on final database file, and IRIS input pending.
- ^d EPA does not necessarily endorse the use of occupational exposure limits to derive short- and long-term action levels for ambient air. These are intended to serve as screening levels only and do not represent EPA guidance. Intended changes for OEL values are included, where applicable.
- ^e EPA Class C or D Carcinogen.

Equation 8 can be used to estimate the cancer risk at a specified distance downwind of the thermal desorption unit. Cancer risk is a measure of the increased probability of developing cancer in a lifetime as a result of the exposure in question. Equation 8 assumes continuous exposure (24 hours/day, 365 days/year for 70 years) to the estimated annual average concentration in air.

$$R = (C_a)(IUR) \quad (\text{Eq. 8})$$

where R = Cancer risk from long-term exposure to a specific compound in air (dimensionless);

C_a = Annual average ambient concentration, from Equation 7 ($\mu\text{g}/\text{m}^3$); and

IUR = Inhalation unit risk factor, from Table 6, 7, or 8 ($\mu\text{g}/\text{m}^3$)⁻¹.

If the source operates for less than 70 years, multiply C_a by $x/70$, where x is the expected operating time of the source in years before using Equation 8. If more than one contaminant is present, the cancer risks for each contaminant can be summed to derive the total cancer risk at a specified distance downwind of the source.

Non-Cancer Effects Due to Long-Term Exposure

Non-cancer effects can be evaluated by using chronic inhalation reference concentrations (RfCs). An inhalation RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of continuous exposure of the human population to contaminants in the air that is likely to be without appreciable risk of deleterious effects during a lifetime. During the past three years, the EPA has become increasingly active in the development of chemical specific RfCs.

If inhalation RfCs were not available from either IRIS or HEAST, then chronic oral reference dose (RfD) data (in $\text{mg}/\text{kg}/\text{day}$) were multiplied by 70 kg (average body weight of an adult), then divided by 20 m^3/day (average adult inhalation rate), and finally multiplied by 1000 $\mu\text{g}/\text{mg}$ to derive a value in $\mu\text{g}/\text{m}^3$. This methodology was selected as the best available

approach for this screening document. The EPA, however, does not condone derivation of RfCs from data for other routes of exposure on a chemical specific basis.

The EPA considers the minimum basis for the derivation of an RfC to be a properly conducted inhalation study that examines portal of entry effects. Portal of entry effects are particularly important with respect to inhalation. There are many known cases where respiratory effects due to inhalation exposure are much more severe than effects resulting from equivalent oral doses. Therefore, ambient air action levels based on extrapolated oral data should be used cautiously since there may be significant differences between the oral and inhalation exposure pathways.

For compounds lacking RfC or RfD values, action levels were based on occupational exposure levels recommended by the Occupational Safety and Health Administration (OSHA)¹³ and the American Conference of Governmental Industrial Hygienists (ACGIH)¹⁴. The action levels were estimated by using the lower of the OSHA Permissible Exposure Limit-Time Weighted Average (PEL-TWA) level (or ceiling value) or the ACGIH Threshold Limit Value-Time Weighted Average (TLV-TWA) level (or ceiling value). The lower value was divided by 1000 to compensate for differences between occupational and residential exposures. It should be noted that occupational exposure levels are not intended for evaluation or control of community air pollution or in estimating the toxic potential of continuous, uninterrupted exposures. Therefore, ambient air action levels based on occupational exposure limits are not precise distinctions between safe and dangerous ambient air concentrations, nor are they necessarily indices of toxicity.

Long-term ambient air action level concentrations for non-carcinogens based on RfCs, extrapolated RfDs and occupational exposure levels are also listed in Tables 6, 7, and 8. The action levels are in units of $\mu\text{g}/\text{m}^3$ to facilitate comparison to the ambient air concentrations estimated from Equation 7.

Short-Term Exposure

The short-term (one hour) action levels, in $\mu\text{g}/\text{m}^3$, are presented in the last column of Tables 6, 7, and 8. The listed values were obtained by dividing the lowest of (1) the OSHA PEL-TWA or (2) the ACGIH TLV-TWA (or ceiling limits if 8-hour averages are not available) by 100. Division by 100 accounts for variations in human sensitivity (occupational levels are designed to protect healthy adult workers) and for uncertainties in using occupational exposure levels to derive ambient air action levels.

The occupational exposure levels on which the short-term action levels are based are subject to change. To check the values in Tables 6, 7, and 8 (or to derive values for compounds not listed in the tables), determine the current OSHA PEL-TWA values by consulting 29 CFR Section 1910 and the most recent edition of the ACGIH publication entitled *Threshold Limit Values and Biological Exposure Indices*.

The short-term action levels listed in Tables 6, 7, and 8 can be compared directly with the estimated maximum hourly ambient air concentrations obtained by using Equation 6 and Figures 3, 4, and 5. Use of the short term action levels should consider that no EPA accepted method exists to determine the short-term concentrations of airborne chemicals acceptable for community exposure.

EXAMPLE

The following steps illustrate the use of the procedures presented in this document. The goal is to estimate the maximum hourly and annual average ambient air concentrations at the nearest receptor to a thermal desorption process and compare these values to the action level concentrations listed in Tables 6, 7, and 8.

- Step 1** First, collect all necessary information. For this example, assume a site that has approximately 10,000 m^3 of soil contaminated with benzene, toluene, and lead at concentrations in the soil at 1.0 $\mu\text{g}/\text{g}$, 24.0 $\mu\text{g}/\text{g}$, and 100 $\mu\text{g}/\text{g}$, respectively. A rotary dryer will be used and the treatment rate is estimated to be 7.5 tons/hr (6800 kg/hr). The

amount of benzene and toluene volatilized in the thermal desorption process is 99.48% and 99.98%, respectively. The exhaust gas flowrate is assumed to be 110 m³/min (1.83 m³/sec). The thermal desorption process is expected to be in continual operation for 90 days (7.776 x 10⁶ seconds). The bulk density of the soil at the site averages about 1.5 g/cm³. The nearest off-site downwind receptor is 400 meters away.

Step 2

Estimate the total emissions potential for the site. Using Equation 1, the average long-term emission rate of benzene would be:

$$ER = \frac{(10,000)(1.0)(1.5)(1)}{(7.776 \times 10^6)} = 1.93 \times 10^{-3} \text{ g/sec}$$

The average long-term emission rate for toluene is 0.046 g/sec, and for lead is 0.19 g/sec. All these rates assume that 100% of the contaminant is lost to the atmosphere. This is obviously an overly conservative assumption for lead, since it will not partition completely to the gas-phase. The estimate for VOCs is based on no controls present, so it too may be overly conservative.

Step 3

Estimate the VOC emission rate of each compound from the thermal desorption operation. The appropriate data are used with Equations 2 and 3. For benzene, the emission rate would be:

$$1/1000 * 6800/3600 * 99.48/100 = 1.88 \times 10^{-3} \text{ g/sec}$$

The emission rate for toluene is 4.51×10^{-2} g/sec.

Step 4

Estimate the PM and metal emissions. The particulate matter emissions are the emissions from the thermal desorption unit. From Equation 3, the emissions are:

$$ER = (0.18)(1.83) = 0.33 \text{ g/sec}$$

The feed rate of lead can be determined using Equation 5:

$$F_{\text{lead}} = (6800)(100)(10^{-6}) = 0.680 \text{ kg/hr}$$

The elemental feed rate can then be used along with a partition factor of 20% from Table 3 to calculate the emission rate of lead using Equation 4:

$$ER_{\text{lead}} = (0.278)(0.680)(20/100) = 3.78 \times 10^{-2} \text{ g/sec}$$

Step 5

Compare the estimated emission rates from Steps 3 and 4 to those from Step 2. The comparison is:

Compound	Equation 1 Emission Rate (g/sec)	Equation 2 Emission Rate (g/sec)
Benzene	1.93×10^{-3}	1.88×10^{-3}
Toluene	4.6×10^{-2}	4.51×10^{-2}
Lead	1.9×10^{-1}	3.78×10^{-2}

The VOC emission rates estimated using Equation 2 are essentially the same as the total emissions potential for the site. This is expected since the default value used for the percent of the contaminant that is volatilized is nearly 100%.

The estimated emissions of lead are below the total amount of lead present, which is as expected since far less than 100% of the lead present would be expected to become airborne. The estimated VOC and PM emission rates are used below to assess ambient air concentrations.

Step 6

Estimate the downwind ambient air concentrations. From Figure 3, the maximum hourly ambient air concentration at a distance of 400 meters for a small unit is approximately 20 ug/m^3 per g/sec emission rate. This corresponds to an annual average dispersion factor of 1.6 ug/m^3 per g/s ($20 \times 0.08 = 1.6$). Using Equation 6, the hourly average ambient air concentration for benzene would be:

$$C_m = (1.88 \times 10^{-3})(20) = 0.038 \text{ ug/m}^3$$

Using Equation 7, the annual average air ambient concentration for benzene would be:

$$C_a = (0.038)(0.08) = 0.0030 \text{ ug/m}^3$$

The ambient air concentrations estimated from Equations 6 and 7 are presented in Table 9.

Step 7

Compare the downwind concentrations to the action level ambient air concentrations. The short-term and long-term action levels from Tables 6 and 8 for the compounds of interest are presented in Table 10. Of the estimated maximum hourly ambient concentrations, only lead is at all close to the action level. The annual average ambient concentrations show also that only lead is approaching the action level.

Table 9.

Estimated Emission Rates and Ambient Air Concentrations

	Soil Concentration For Example Problem ($\mu\text{g/g}$)	Emission Rate (g/s)	Ambient Concentrations ($\mu\text{g/m}^3$)	
			Maximum 1-Hour	Annual Average
Benzene	1.0	1.88×10^{-3}	0.038	0.0030
Toluene	24.0	4.55×10^{-2}	0.91	0.073
Lead	100	3.79×10^{-2}	0.76	0.061
Particulate Matter	--	0.33	--	--

Table 10.

Action Level Concentrations

	Action Levels $\mu\text{g/m}^3$	
	Short-Term	Long-Term
Benzene	320	0.12 ¹
Toluene	3,750	400 ²
Lead	1.5	0.15 ³

¹Based on 10^{-6} , 70-year risk.²Based on reference dose concentrations (RfCs).³Based on occupational exposure limits

- Step 8** Document the results of the air pathway analysis and define a future course of action. Based on these screening level results, a more rigorous analysis of the air impacts is not necessary. The air impacts should be re-examined, however, when the site-specific data become available, if the inputs differ from the default values. Also, it would be advisable to perform an ambient air monitoring program during remediation to document the actual worker and community exposures.

CONCLUSIONS

The procedures presented here are not intended to negate the need for rigorous analyses that consider site specific meteorological conditions and the health effects of the specific compounds involved. Although the procedures are based on what is typical and reasonable for cleaning up Superfund sites, the underlying assumptions need to be kept in mind. For example, emission models assume typical operating conditions, dispersion models assume Gaussian distribution of the plume, and many of the health levels are not endorsed by the Environmental Protection Agency. EPA's Regional Toxicologist should be contacted for general toxicological information and technical guidance on evaluation of chemicals without established toxicity values.

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APPENDIX A

**PHYSICAL PROPERTY DATA
FOR SELECTED ORGANIC COMPOUNDS**
(For compounds in Table 5 of the report)

Source: Reference 4

Appendix A - Physical Property Data

No.	Organic Compound	CAS NO.	Formula	Molecular Weight (g/g-mol)	Vapor Pressure (mm Hg) ^a	Diffusivity in Air (cm ² /sec)	Saturated Vapor Conc. (µg/m ³) ^b	Henry's Law Constant		Maximum Water Solubility (mg/L)	Diffusivity in Water (cm ² /sec)	Log K _{ow}
								H ^b	Log H			
1	Acetaldehyde	75-07-0	C ₂ H ₄ O	44.00	760	0.1240	1.80E+09	9.50e-05	-4.02	inf	1.41e-05	-
2	Acetic acid	64-19-7	C ₂ H ₄ O ₂	60.06	15.41	0.1300	4.97E+07	6.27e-02	-1.20	inf	1.20e-05	-
3	Acetic anhydride	108-24-7	C ₄ H ₆ O ₃	102.09	5.266	0.2350	2.89E+07	5.91e-06	-5.23	-	9.33e-06	-
4	Acetone	67-64-1	C ₃ H ₆ O	58.08	266	0.1240	8.30E+08	2.50e-05	-4.60	inf	1.14e-5	-0.24
5	Acetonitrile	75-05-8	C ₂ H ₃ N	41.06	90	0.1280	1.99E+08	5.80e-06	-5.24	inf	1.66e-5	-0.34
6	Acrolein	107-02-8	C ₃ H ₄ O	56.1	244.2	0.1050	7.36E+08	5.66e-05	-4.25	208,000	1.22e-5	-
7	Acrylic acid	79-10-7	C ₃ H ₄ O ₂	72.1	5.2	0.0908	2.02E+07	1.00e-07	-7.00	inf	1.08e-5	0.13
8	Acrylonitrile	107-13-1	C ₃ H _{3.5} N	53.06	114	0.1220	3.25E+08	8.80e-05	-4.06	73,500	1.34e-5	-0.92
9	Allyl alcohol	107-18-6	C ₃ H ₆ O	58.08	23.3	0.1140	7.27E+07	1.80e-05	-4.74	inf	1.14e-5	-0.22
10	Allyl chloride	107-05-1	C ₃ H ₅ Cl	76.53	368	0.0	1.51E+09	3.71e-01	-0.43	3,600	0.0	-
11	Aniline	62-53-3	C ₆ H ₅ N	93.13	1	0.0700	5.01E+06	2.60e-06	-5.59	35,000	8.3e-6	-
12	Anthracene	120-12-7	C ₁₄ H ₁₀	178.23	1.3E-06	0.0	1.25E+01	6.75e-02	-1.17	1.3	0.0	4.45
13	Benzaldehyde	100-52-7	C ₇ H ₆ O	106.12	1	-	5.70E+06	4.23e-05	-4.37	3,000	-	-
14	Benzene	71-43-2	C ₆ H ₆	78.12	95.2	0.0932	4.00E+08	5.50e-03	-2.26	1,780	9.8e-6	2.12
15	Benzoic acid	65-85-0	C ₇ H ₆ O ₂	122.12	0.00704	0.0	4.62E+04	1.82e-08	-7.74	2,900	7.97e-6	-
16	Benzyl alcohol	100-51-6	C ₇ H ₈ O	108.14	0.15	-	8.72E+05	6.10e-07	-6.21	35,000	-	-
17	Benzyl chloride	100-44-7	C ₇ H ₇ CH ₂ Cl	126.6	1.21	0.0750	8.23E+06	4.33e-04	-3.36	1,619	7.8e-6	2.63
18	Bromoform	75-25-2	CHBr ₃	252.77	5.6	0.0	7.61E+07	5.94e-04	-3.23	3,190	0.0	-
19	1,3-Butadiene	106-99-0	C ₄ H ₆	54.09	2100	0.2490	6.09E+09	1.42e-01	-0.85	735	1.8e-5	1.99
20	N-Butane	106-97-8	C ₄ H ₁₀	58.12	1820	0.2490	5.69E+09	2.91e-01	-0.54	61	-	-
21	2-Butanol	15892-23-6	C ₄ H ₁₀ O	74.12	10	-	3.98E+07	2.20e-06	-5.66	184,000	-	-
22	N-Butanol	71-36-3	C ₄ H ₁₀ O	74.12	6.5	0.0800	2.59E+07	2.20e-06	-5.66	77,000	9.3e-6	-
23	N-Butyl-Acetate	123-86-4	C ₈ H ₁₆ O ₂	116.16	15	0.0	9.37E+07	1.64e-04	-3.79	14,000	0.0	-
24	Tert-Butyl-Alcohol	75-65-0	C ₄ H ₁₀ O	74.12	0.17	-	6.77E+05	2.20e-06	-5.66	inf	-	-
25	Carbon disulfide	75-15-0	CS ₂	76.13	366	0.1040	1.50E+09	1.68e-02	-1.77	2,900	1.0e-5	2.00

Appendix A. (Continued)

No.	Organic Compound	CAS NO.	Formula	Molecular Weight (g/g-mol)	Vapor Pressure (mm Hg) ^a	Diffusivity in Air (cm ² /sec)	Saturated Vapor Conc. (μg/m ³) ^a	Henry's Law Constant		Maximum Water Solubility (mg/L)	Diffusivity in Water (cm ² /sec)	Log Kow
								H ^b	Log H			
26	Carbon tetrachloride	56-23-5	CCl ₄	153.82	113	0.0632	9.34E+08	3.00e-02	-1.52	800	8.8e-6	2.83
27	Carbonyl sulfide	463-58-1	COS	60.1	—	—	—	—	—	—	—	—
28	Catechol	120-80-9	C ₆ H ₄ (OH) ₂	110.1	—	—	—	—	—	—	—	—
29	Chlorine	7782-50-5	Cl ₂	70.9	—	—	—	—	—	—	—	—
30	Chlorobenzene	108-90-7	C ₆ H ₅ Cl	112.56	11.8	0.0730	7.14E+07	3.93e-03	-2.41	488	8.7e-6	2.84*
31	Chlorodifluoromethane	75-45-6	CHClF ₂	86.47	—	—	—	1.00e-01	-1.00	2	—	—
32	Chloroform	67-66-3	CHCl ₃	119.38	208	0.0888	1.33E+09	3.39e-03	-2.47	9,300	1.0e-5	1.97*
33	Chloromethyl methyl ether	107-30-2	C ₂ H ₅ Cl ₂	80.51	—	—	—	9.12x10 ⁻⁴	-5.04	2.5x10 ⁴	—	0.0
34	Chloropentafluoroethane	76-15-3	C ₂ ClF ₅	154.47	—	—	—	2.45e-01	-0.61	—	—	—
35	Chloroprene	126-99-8	C ₄ H ₅ Cl	88.5	273	0.1040	1.12E+09	3.35e-01	-0.475	—	1.0e-5	—
36	M-Cresol	108-39-4	C ₇ H ₈ O	108.14	0.08	0.0740	4.65E+05	4.43e-07	-6.35	25,000	1.0e-5	1.97
37	O-Cresol	95-48-7	C ₇ H ₈ O	108.14	0.24	0.0740	1.40E+06	2.60e-06	-5.59	31,000	8.3e-6	—
38	P-Cresol	106-44-5	C ₇ H ₈ O	108.14	0.11	0.0740	6.39E+05	4.43e-07	-6.35	24,000	1.0e-5	—
39	Cyanogen	460-19-5	C ₂ N ₂	52.04	3980	—	1.11E+10	4.96e-03	-2.30	9,300	—	—
40	Cyclohexane	110-82-7	C ₆ H ₁₂	84.16	100	0.0839	4.52E+08	1.37e-02	-1.86	100	9.1e-6	3.44
41	Cyclohexanol	108-93-0	C ₆ H ₁₂ O	100.16	1.22	0.2140	6.57E+06	4.47e-06	-5.35	38,200	8.31e-6	1.23
42	Cyclohexanone	108-94-1	C ₆ H ₁₀ O	98.14	4.8	0.0784	2.53E+07	4.13e-06	-5.38	23,000	8.62e-6	—
43	Cyclohexene	110-83-8	C ₆ H ₁₀	82.15	—	—	—	1.03e+01	1.01	213	—	2.86
44	Cyclopentane	287-92-3	C ₅ H ₁₀	70.13	317.44	—	1.20E+09	1.00e-02	-2.00	156	—	—
45	Diazomethane	334-88-3	CH ₂ N ₂	42.04	—	—	—	—	—	?	—	—
46	Dibutyl-O-Phthalate	84-74-2	C ₁₆ H ₂₂ O ₄	278.35	1.00E-05	0.0439	—	2.80e-07	-6.55	400	7.8e-6	5.60
47	O-Dichlorobenzene	95-50-1	C ₆ H ₄ Cl ₂	147.00	1	0.0690	7.90E+06	1.94e-03	-2.71	145	7.9e-6	3.60
48	P-Dichlorobenzene	106-46-7	C ₆ H ₄ Cl ₂	147.00	1.2	0.0690	9.48E+06	1.60e-03	-2.80	79	7.9e-6	3.38
49	Dichloroethylether	111-44-4	C ₄ H ₈ Cl ₂ O	143.02	1.4	—	1.08E+07	—	—	?	7.9e-6	3.39
50	Dichlorodifluoromethane	75-71-8	CCl ₂ F ₂	120.91	4870	0.0	3.16E+10	4.01e-01	-0.40	280	0.0	2.16

Appendix A. (Continued)

No.	Organic Compound	CAS NO.	Formula	Molecular Weight (g/g-mol)	Vapor Pressure (mm Hg)*	Diffusivity in Air (cm ² /sec)	Saturated Vapor Conc. (µg/m ³)	Henry's Law Constant		Maximum Water Solubility (mg/L)	Diffusivity in Water (cm ² /sec)	Log Kow
								H ^b	Log H			
51	1,1-Dichloroethane	75-34-3	C ₂ H ₄ Cl ₂	98.96	234	0.0919	1.24E+09	1.54e-02	-1.81	5,500	9.9e-6	1.79
52	1,2-Dichloroethane	107-06-2	C ₂ H ₄ Cl ₂	98.96	80	0.1040	4.26E+08	1.20e-03	-2.92	8,690	9.9e-6	1.48
53	1,1-Dichloroethylene	75-35-4	C ₂ H ₂ Cl ₂	96.94	600	0.1040	3.13E+09	2.59e-02	-1.59	210	—	1.84
54	cis-1,2-Dichloroethylene	156-59-2	C ₂ H ₂ Cl ₂	96.94	208		1.08E+09	4.55e-03	-2.34	800	—	0.70
55	trans-1,2-Dichloroethylene	156-60-5	C ₂ H ₂ Cl ₂	96.94	324		1.69E+09	9.46e-03	-2.02	600	—	0.48
56	Dichloromethane	75-09-2	CH ₂ Cl ₂	84.93	362	0.117	1.65E+09	3.19e-03	-2.50	16,700	1.17 x 10 ⁻⁵	1.30
57	Dichloromonofluoromethane	75-43-4	CHCl ₂ F	102.92	1360	0.0	7.52E+09	9.21e+02	2.96	0.2	0.0	
58	1,2-Dichloropropane	78-87-5	C ₃ H ₆ Cl ₂	112.99	42	0.0782	2.55E+08	2.30e-03	-2.64	2,700	8.73e-6	2.00
59	1,3-Dichloropropane	542-75-6	C ₃ H ₆ Cl ₂	110.98	43	0.0	2.57E+08	2.33e-06	-5.63	2,700	0.0	2.00
60	1,2-Dichloro-1,1,2,2-Tetrafluoroethane	76-14-2	C ₂ Cl ₂ F ₄	170.92	—		—	2.45e-01	-0.61	137	—	2.82
61	Diethanolamine	111-42-2	C ₄ H ₁₁ NO ₂	105.14	—		—			(61)?	—	—
62	Diethyl amine	109-89-7	C ₄ H ₁₁ N	73.14	350@35C	—	1.38E+09	7.31e-03	-2.14	20,000	—	—
63	N,N-Dimethylaniline	121-69-7	C ₉ H ₉ N	121.18	—		—			(63)?	—	—
64	Diethyl ether	60-297	C ₄ H ₁₀ O	74.12	440@20C	0.0782	1.75E+09	2.65e-04	-3.58	60,400	8.61e-6	—
65	Dimethylamine	124-40-3	C ₂ H ₇ N	45.08	563 @ 0C	—	1.36E+09	5.24e-06	-5.28	—	—	-0.38
66	Dimethyl formamide	68-12-2	C ₃ H ₇ NO	73.09	4.0	0.0939	1.57E+07	1.92e-05	-4.72	20,000	1.03e-5	—
67	1,1-Dimethyl hydrazine	57-14-7	C ₃ H ₈ N ₂	60.10	157	0.1060	5.07E+08	1.24e-04	-3.91	100,000	1.09e-5	-1.32
68	2,4-Dinitrophenol	51-28-5	C ₆ H ₄ N ₂ O ₃	184.11	53.8	0.0	5.32E+08	1.53e-07	-6.82	19,500	0.0	1.50
69	1,4-Dioxane	123-91-1	C ₄ H ₈ O ₂	88.11	37	0.2290	1.75E+08	2.31e-05	-4.64	inf	1.02e-5	0.01
70	Diphenyl	92-52-4	C ₁₂ H ₁₀	154.21	—		—	1.01e-01	-1.00	7.5	—	—
71	Epichlorohydrin	106-89-8	C ₃ H ₅ ClO	92.53	17	0.0860	8.45E+07	3.23e-05	-4.49		9.08e-6	0.15
72	1,2-Epoxybutane	106-88-7	C ₄ H ₈ O	72.0	—		—			(72)?	—	—
73	Ethanol	64-17-5	C ₂ H ₆ O	46.07	50	0.1230	1.24E+08	3.03e-05	-4.52	inf	1.30e-5	-0.32
74	Ethyl acetate	141-78-6	C ₄ H ₈ O ₂	88.11	100	—	4.74E+08	1.28e-04	-3.89	79,000	—	—
75	Ethyl acrylate	140-88-5	C ₅ H ₈ O ₂	100.12	40	0.0770	2.15E+08	3.50e-04	-3.46	—	—	—

Appendix A. (Continued)

No.	Organic Compound	CAS NO.	Formula	Molecular Weight (g/g-mol)	Vapor Pressure (mm Hg)*	Diffusivity in Air (cm ² /sec)	Saturated Vapor Conc. (µg/m ³)	Henry's Law Constant		Maximum Water Solubility (mg/L)	Diffusivity in Water (cm ² /sec)	Log Kow
								H*	Log H			
76	Ethyl amine	75-04-7	C ₂ H ₇ N	45.08	1057		2.56E+09	5.24e-06	-5.28	inf	-	-
77	Ethylbenzene	100-41-4	C ₈ H ₁₀	106.16	10	0.0750	5.71E+07	6.44e-03	-2.19	152	7.8e-6	3.15
78	Ethyl Bromide	74-96-4	C ₂ H ₅ Br	108.97	-	-	-	1.00e-02	-2.00	-	-	-
79	Ethyl carbamate	51-79-6	C ₃ H ₇ NO ₂	89.09	10		4.79E+07			(79)?	-	-
80	Ethyl Chloride	75-00-3	C ₂ H ₅ Cl	64.51	1200	0.2710	4.16E+09	1.40e-02	-1.85	5,740	1.15e-5	-
81	Ethylenediamine	107-15-3	C ₂ H ₆ N ₂	60.10	10.7	-	3.46E+07	8.46e-06	-5.07	inf	-	-
82	Ethylene dibromide	106-93-4	C ₂ H ₄ Br ₂	187.88	14	0.0	1.41E+08			inf	0.0	1.76
83	Ethylene glycol	107-21-1	C ₂ H ₆ O ₂	62.07	0.13	0.1080	4.34E+05	1.03e-07	-6.99	inf	1.22e-5	-
84	Ethylene imine	151-56-4	C ₂ H ₅ N	43.07	-	-	-	4.54e-04	-3.34	inf	-	-
85	Ethylene oxide	75-21-8	C ₂ H ₄ O	44.06	1250	0.1040	2.96E+09	1.42e-04	-3.85	-	1.45e-5	-0.22
86	Formaldehyde	50-00-0	CH ₂ O	30.03	3500	0.1780	5.65E+09	5.76e-05	-4.24	550,000	1.98e-5	0.0
87	Formic acid	64-18-6	CH ₂ O ₂	46.03	42	0.0790	1.04E+08	7.00e-07	-6.15	inf	1.37e-6	0.54
88	Furan	110-00-9	C ₄ H ₄ O	68.08	596	0.1040	2.18E+09	5.76e-03	-2.27	10,000	1.22e-5	-
89	Glycerol	56-81-5	C ₃ H ₈ O ₃	92.09	1.60E-04	0.0	7.92E+02	1.94e-08	-7.89	10,000	0.0	-
90	N-Heptane	142-82-5	C ₇ H ₁₆	100.2	46	0.0	2.48E+08	2.02e+00	0.31	3	0.0	-
91	N-Hexane	110-54-3	C ₆ H ₁₄	86.18	150.3	0.2000	6.96E+08	0.122	-0.91	13	7.77e-6	-
92	Hydrazine	302-01-2	H ₂ N ₂	32.05	14.4	-	2.48E+07	6.66e-07	-6.18	-	-	-3.08
93	Hydrochloric acid	7647-01-0	HCl	36.46	32,450		6.36E+10			(93)?	-	-
94	Hydrogen cyanide	74-90-8	HCN	27.03	-		-	4.65e-07	-6.33	inf	-	-
95	Hydrogen sulfide	7783-06-4	H ₂ S	34.08	15,200	0.1760	2.78E+10			4,000	-	-
96	Isobutanol	78-83-1	C ₄ H ₁₀ O	74.12	10	0.0860	3.98E+07	2.20e-06	-5.66	95,000	2.20e-6	-
97	Isobutyl acetate	110-19-0	C ₆ H ₁₂ O ₂	116.16	-		-	1.64e-04	-3.79	6,300	-	-
98	Isopropyl alcohol	67-63-0	C ₃ H ₈ O	60.1	42.8	0.0980	1.38E+08	1.50e-04	-3.82	inf	1.04e-5	-0.16/0.28
99	Isopropyl amine	75-31-0	C ₃ H ₉ N	59.11	460		1.46E+09	3.58e-04	-3.45	100,000	-	-
100	Isopropylbenzene	98-82-8	C ₉ H ₁₂	120.19	10.9@40C		7.04E+07	6.59e-03	-2.18	50	-	-

Appendix A. (Continued)

No.	Organic Compound	CAS NO.	Formula	Molecular Weight (g/g-mol)	Vapor Pressure (mm Hg) ^a	Diffusivity in Air (cm ² /sec)	Saturated Vapor Conc. (μg/m ³) ^b	Henry's Law Constant		Maximum Water Solubility (mg/L)	Diffusivity in Water (cm ² /sec)	Log K _{ow}
								H ^c	Log H			
101	Methanol	67-56-1	CH ₃ O	32.04	114	0.1500	1.96E+08	2.70e-06	-5.57	inf	1.64e-5	-
102	Methyl acetate	79-20-9	C ₃ H ₆ O ₂	74.08	235	0.1040	9.36E+08	1.02e-04	-3.99	194,000	1.00e-5	-
103	Methyl acrylate	96-33-3	C ₅ H ₈ O ₂	86.09	-	-	-	1.44e-07	-6.84	60,000	-	-
104	Methyl amine	74-89-5	CH ₃ N	31.06	770@ -6C	-	1.29E+09	5.38e-03	-2.27	11,500	-	-
105	Methyl bromide	74-83-9	CH ₃ BR	94.94	-	-	-	2.21e-01	-0.66	17,500	-	-
106	Methyl-tert-butyl-ether	1634-04-4	C ₅ H ₁₂ O	88.15	245	0.0806	1.16E+09	5.92e-04	-3.23	48,000	8.02e-6	0.26
107	Methyl chloride	74-87-3	CH ₃ Cl	50.49	3830	0.1260	1.04E+10	8.14e-03	-2.09	6,360	6.5e-6	0.95
108	Methylcyclohexane	108-87-2	C ₇ H ₁₄	98.19	43	-	2.27E+08	9.79e-01	-0.01	14	-	-
109	Methyl-ethyl-ketone	78-93-3	C ₅ H ₁₀ O	72.11	100	0.0808	3.88E+08	2.16e-04	-3.67	275,000	0.98e-5	1.74±0.12
110	Methyl formate	107-31-3	C ₂ H ₄ O ₂	60.05	500	-	1.61E+09	1.30e-01	-0.89	304	-	-
111	Methyl hydrazine	60-34-4	CH ₃ N ₂	46.07	49.6	-	1.23E+08	3.44e-06	-5.46	inf	-	-
112	Methyl iodide	74-88-4	CH ₃ I	141.94	91	-	-	2.53e-03	-2.60	14,000	-	-
113	Methyl-Isobutyl-Ketone	108-10-1	C ₆ H ₁₂ O	100.16	19.31	0.0750	1.04E+08	4.95e-05	-4.31	19,000	7.08e-6	-
114	Methyl isocyanate	624-83-9	C ₂ H ₃ NO	57.05	348	-	1.07E+09	-	-	**	-	-
115	Methyl-Isopropyl-Ketone	563-80-4	C ₅ H ₁₀ O	86.13	15.7	0.0750	7.27E+07	4.58e-04	-3.34	47,000	0.78e-05	-
116	Methyl mercaptan	74-93-1	CH ₃ S	48.1	-	-	-	4.18e-03	-2.38	23,300	-	-
117	Methyl methacrylate	80-62-6	C ₅ H ₈ O ₂	100.10	39	0.0770	2.10E+08	6.60e-05	-4.18	15,000	8.50e-6	0.79
118	Methyl-N-Propyl-Ketone	107-87-9	C ₅ H ₁₀ O	86.13	-	-	-	4.58e-04	-3.34	-	-	-
119	Alpha-Methyl-Styrene	98-83-9	C ₉ H ₁₀	118.18	0.076	0.2640	4.83E+05	5.91e-03	-2.23	2	-	-
120	Monoethanolamine	141-43-5	C ₂ H ₇ NO	61.08	-	-	-	3.22e-07	-6.49	100,000	-	-
121	Morpholine	110-91-8	C ₄ H ₉ NO	87.12	10.08	0.0910	4.72E+07	5.73e-05	-4.24	inf	9.60e-6	-1.08
122	Naphthalene	91-20-3	C ₁₀ H ₈	128.19	0.023	0.0590	1.58E+05	4.80e-04	-3.32	30	7.50e-6	3.01/3.45
123	2-Nitropropane	79-46-9	C ₃ H ₇ NO ₂	89.09	12.9	-	6.18E+07	2.23e-04	-3.65	100,000	-	-
124	N-Nitrosodimethylamine	62-75-9	C ₂ H ₆ N ₂ O	74.08	-	-	-	3.0x10 ⁻⁸	-7.52	1.2x10 ⁷	-	-

Appendix A. (Continued)

No.	Organic Compound	CAS NO.	Formula	Molecular Weight (g/g-mol)	Vapor Pressure (mm Hg)*	Diffusivity in Air (cm ² /sec)	Saturated Vapor Conc. (µg/m ³)*	Henry's Law Constant		Maximum Water Solubility (mg/L)	Diffusivity in Water (cm ² /sec)	Log Kow
								H [†]	Log H			
125	N-Nitrosomorpholine	59-89-2	C ₄ H ₈ N ₂ O ₂	116.11	—	0.0590	—			0.059	1.00e-5	—
126	N-Nonane	111-84-2	C ₉ H ₂₀	128.26	4.28		2.95E+07	4.48e-01	-0.35	79	—	—
127	N-Octane	111-65-9	C ₈ H ₁₈	114.23	17	0.0	1.04E+08	3.87e+00	0.59	20	0.0	—
128	N-Pentane	109-66-0	C ₅ H ₁₂	72.15	513		1.99E+09	1.22e-01	-0.91	360	—	—
129	Phenanthrene	85-01-8	C ₁₄ H ₁₀	178.23	2.00E-04	0.0	1.92E+03	6.05e-03	-2.22	0.82	0.0	4.46
130	Phenol	108-95-2	C ₆ H ₆ O	94.11	0.0341	0.0820	1.72E+05	4.54e-07	-6.34	80,000	9.10e-6	1.46
131	Phosgene	75-44-5	CCl ₂ O	98.92	1.394	0.1080	7.41E+09	1.71e-01	-0.767	slightly	1.12e-6	—
132	Phosphine	7803-51-2	H ₃ P	34.00	2,000	—	3.66E+09			6,200	—	—
133	Phthalic anhydride	85-44-9	C ₈ H ₄ O ₃	148.11	0.0015	0.0710	1.19E+04	9.00e-07	-6.05	153,000	8.60e-6	—
134	Propane	74-98-6	C ₃ H ₈	44.1	7600	—	1.80E+09	2.20e-02	-1.66	2,000	—	2.36
135	1,2-Propanediol	57-55-6	C ₃ H ₈ O ₂	76.11	0.3		—	1.50e-06	-5.82	20,000	—	—
136	1-Propanol	71-23-8	C ₃ H ₈ O	60.1	20.85		6.74E+07	1.50e-04	-3.82	inf	—	—
137	beta-Propiolactone	57-57-8	C ₃ H ₄ O ₂	72.06	3.4	—	1.32E+07			350,000	—	—
138	Propionaldehyde	123-38-7	C ₃ H ₆ O	58.08	300	0.102	9.37E+08	1.15e-06	-5.94	200,000	1.14e-5	—
139	Propionic acid	79-09-4	C ₃ H ₆ O ₂	74.08	10	—	3.98E+07	4.87e-05	-4.31	inf	—	—
140	N-Propyl-Acetate	109-60-4	C ₇ H ₁₄ O ₂	102.12	35	0.0	1.92E+08	2.94e-04	-3.53	20,400	0.0	—
141	Propylene oxide	75-56-9	C ₃ H ₆ O	58.08	524.5	0.1040	1.64E+09	1.34e-03	-2.87	30,000	1.00e-5	—
142	1,2-Propylenimine	75-55-8	C ₃ H ₇ N	54.1	112		3.26E+08			(142)?	—	-0.48
143	Pyridine	110-86-1	C ₅ H ₅ N	79.1	20	0.0910	8.50E+07	2.36e-05	-4.63	inf	8.10e-6	0.66
144	Quinone	106-51-4	C ₆ H ₄ O ₂	108.09	—		—			(144)?	—	—
145	Styrene	100-42-5	C ₈ H ₈	104.15	7.3	0.0710	4.09E+07	2.61e-03	-2.58	300	8.00e-6	2.95
146	1,1,1,2-Tetrachloro-2,2-Difluoroethane	76-11-9	C ₂ Cl ₄ F ₂	203.83	—		—	2.45e-01	-0.61	—	—	—
147	1,1,2,2-Tetrachloroethane	79-34-5	C ₂ H ₂ Cl ₄	167.85	6.5	0.0710	5.86E+07	2.50e-04	-3.60	2,900	7.90e-6	2.39
148	Tetrachloroethylene	127-18-4	C ₂ Cl ₄	165.83	19	0.0720	1.69E+08	2.90e-02	-1.54	150	8.2e-6	2.60*
149	Tetrahydrofuran	109-99-9	C ₄ H ₈ O	72.11	72.1	0.0980	2.79E+08	4.90e-05	-4.31	inf	1.05e-5	—

Appendix A. (Continued)

No.	Organic Compound	CAS NO.	Formula	Molecular Weight (g/mol)	Vapor Pressure (mm Hg) ^a	Diffusivity in Air (cm ² /sec)	Saturated Vapor Conc. (µg/m ³) ^a	Henry's Law Constant		Maximum Water Solubility (mg/L)	Diffusivity in Water (cm ² /sec)	Log K _{ow}
								H ^b	Log H			
150	Toluene	108-88-3	C ₇ H ₈	92.14	30	0.0870	1.49E+08	6.68e-03	-2.18	515	8.60e-6	2.73
151	p-Toluidine	106-49-0	C ₇ H ₉ N	107.16	0.3	—	1.73E+06	1.91e-05	-4.72	7,400	—	—
152	1,1,1-Trichloroethane	71-55-6	C ₂ H ₃ Cl ₃	133.41	123	0.0780	8.82E+08	1.74e-02	-1.76	4,400	8.8e-6	2.5
153	1,1,2-Trichloroethane	79-00-5	C ₂ H ₃ Cl ₃	133.41	25	0.0792	1.79E+08	7.40e-04	-3.13	4,500	8.80e-6	2.47
154	Trichloroethylene	79-01-6	C ₂ HCl ₃	131.4	75	0.0790	5.30E+08	9.10e-03	-2.04	1,100	9.10e-6	2.38
155	Trichlorofluoromethane	75-69-4	CCl ₃ F	137.37	667	0.0870	4.92E+09	5.83e-02	-1.23	1,100	9.70e-6	2.53
156	1,2,3-Trichloropropane	96-18-4	C ₃ H ₃ Cl ₃	147.43	3.1	0.0710	2.46E+07	2.80e-02	-1.55	—	7.90e-6	—
157	1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1	C ₂ Cl ₃ F ₃	187.38	300	0.0780	3.02E+09	2.45e-01	-0.61	170	8.20e-6	2.00
158	Triethylamine	121-44-8	C ₆ H ₁₅ N	101.19	400	—	2.18E+09	2.66e-03	-2.58	20,000	—	—
159	Trifluorobromomethane	75-63-8	CBR ₃ F ₃	148.91	—	—	—	1.00e-01	-1.00	—	—	—
160	1,2,3-Trimethylbenzene	526-73-8	C ₉ H ₁₂	120.19	—	—	—	1.47e-01	-0.83	—	—	—
161	1,2,4-Trimethylbenzene	95-63-6	C ₉ H ₁₂	120.19	—	—	—	1.47e-01	-0.83	57	—	—
162	1,3,5-Trimethylbenzene	108-67-8	C ₉ H ₁₂	120.19	1.86	—	1.20E+07	1.47e-01	-0.83	20	—	—
163	Vinyl Acetate	108-05-4	C ₄ H ₈ O ₂	86.09	115	0.0850	5.32E+08	6.20e-04	-3.21	20,000	9.20e-6	—
164	Vinyl bromide	593-60-2	C ₂ H ₃ Br	107.0	895	—	5.15E+09	—	—	(164)?	—	—
165	Vinyl-Chloride	75-01-4	C ₂ H ₃ Cl	62.5	2660	0.0900	8.94E+09	8.60e-02	-1.07	1.1	1.04e-5	1.38
166	m-Xylene	108-38-3	C ₈ H ₁₀	106.2	8	0.0700	4.57E+07	5.20e-03	-2.28	200	7.80e-6	3.26
167	o-Xylene	95-47-6	C ₈ H ₁₀	106.2	7	0.0870	4.00E+07	5.27e-03	-2.28	175	1.00e-5	2.95
168	p-Xylene	106-42-3	C ₈ H ₁₀	106.2	9.5	0.0	5.42E+07	5.27e-03	-2.28	198	0.0	3.15

At 25°C

$$H \left(\frac{\text{atm} \cdot \text{m}^3}{\text{g} \cdot \text{mol}} \right)$$

APPENDIX B

PHYSICAL PROPERTY DATA FOR SELECTED SEMI-VOLATILE ORGANIC COMPOUNDS (For compounds in Table 6 of the report)

Appendix B - Physical Property Data For Selected Semi-Volatile Organic Compounds

No.	Organic Compound	CAS No.	Formula	Molecular Weight (g/g-mol)	Vapor Pressure (mm Hg) ^a	Diffusivity in Air (cm ² /sec)	Saturated Vapor Conc (ug/m ³) ^a	Henry's Law Constant		Max H ₂ O Solubility (mg/L)	Diffusivity in H ₂ O (cm ² /sec)	Log K _{ow}
								H ^b	Log H			
1	Acenaphthene	83-32-9	C12H10	154.21	0.005	0.0	4.15e+04	7.71e-08	-7.11	2	0.0	
2	2-Acetaminofluorene	53-96-3	C15H13NO	223.26	0.017		2.01e+05	2.65e-08	-7.58	6.5		3.28
3	2-Acetylfuran	1192-62-7	C6H6O2	110.11		0.0		1.10e-04	-3.96	100	0.0	
4	Benzidine	92-87-5	C12H12N2	184.24		0.0298		3.66e-07	-6.44	400		1.55
5	Benzo(a)anthracene	56-55-3	C18H12	228.30	1.50e-07	0.051	1.84e+00	1.38e-09	-8.86	0.012	9.00e-08	5.23
6	Benzo(a)pyrene	50-32-8	C20H12	252.32	0.000568	0.043	7.71e+03	1.38e-09	-8.86	0.003	9.00e-08	6.16
7	Benzo(b)fluoranthene	205-99-2	C20H12	252.32	1626	0.044	2.21e+10	2.01e-05	-4.70	0.0011	4.70e-06	6.33
8	Benzo(g,h,i)perylene	191-24-2	C22H12	276.34								
9	Benzo(k)fluoranthene	207-08-9	C20H12	252.32	3.84e-04	0.044	5.21e+03	1.06e-07	-6.98	0.0006	4.70e-06	6.46
10	Bis(2-ethylhexyl)phthalate	117-81-7	C24H38O4	390.56	2.53e-03		5.31e+04	1.38e-07	-6.86	0.35		5.61
11	Chlordane	57-74-9	C10H6Cl8	410.00	1.00e-05	0.0	2.20e+02	3.67e-05	-4.44	0.93	0.0	5.58
12	Chrysene	218-01-9	C18H12	228.30	5.76e-10	0.046	7.07e-03	1.18e-09	-8.93	0.0017	5.00e-06	4.96
13	Cresol	1319-77-3	C7H8O	108.15	0.3		1.74e+06	2.13e-05	-4.67	2000		1.95
14	Dioxin (2,3,7,8-TCDD)	1746-01-6	C12H4Cl4O2	321.96	1.94e-04		3.36e+03	4.44e-05	-4.35	1.68e-04		6.37
15	Dibenzofuran	132-64-9	C12H8O	168.21								
16	Dibenzo(a,h)anthracene	53-70-3	C22H14	278.36	5.20e-11	0.042	7.78e-04	3.81e-08	-7.42	0.0015	4.50e-06	6.85
17	Di-n-butylphthalate	84-74-2	C16H22O4	278.35	1.00e-05	0.0439	1.50e+02	2.80e-07	-6.55	400	7.80e-06	5.60
18	Ethylenamine	593-67-9										
19	Fluoranthene	206-44-0	C16H10	202.26	0.0177	0.049	1.93e+05	6.73e-02	-1.17	0.3	5.30e-06	5.00
20	Fluorene	86-73-7	C13H10	166.23	1.63e-05	0.055	1.46e+02	1.78e-08	-7.75	2	5.70e-06	4.12
21	Heptachlor	76-44-8	C10H5Cl7	373.32	0.0008	0.0	1.61e+04	2.30e-08	-7.64	0.056	0.0	5.19
22	Hexachlorocyclopentadiene	77-47-4	C5Cl6	272.77	0.081	0.0561	1.19e+06	1.60e-02	-1.80		6.16e-08	
23	Indeno(1,2,3-CD)pyrene	193-39-5	C22H12	276.34	7.60e-08	0.044	1.13e+00	5.07e-13	-12.29	0.00017	4.50e-06	7.09
24	Lindane	58-89-9	C6H6Cl6	290.83	9.40e-06		1.47e+02	3.16e-06	-5.50	12.4		3.71
25	Maleic anhydride	108-31-6	C4H2O3	98.06	0.0001	0.095	5.27e+02	4.00e-08	-7.40	788	1.11e-05	
26	2-Methylnaphthalene	91-57-6	C11H10	142.20	0.054	0.0	4.15e+05	5.80e-05	-4.24	26		

Appendix B - (Continued)

No.	Organic Compound	CAS No.	Formula	Molecular Weight (g/g-mol)	Vapor Pressure (mm Hg) ^a	Diffusivity in Air (cm ² /sec)	Saturated Vapor Conc (ug/m ³) ^a	Henry's Law Constant		Max H ₂ O Solubility (mg/L)	Diffusivity in H ₂ O (cm ² /sec)	Log K _{ow}
								H ^b	Log H			
27	p-Nitrosodiphenylamine	156-10-5	C ₁₂ H ₁₀ N ₂ O	198.23								
28	Nitrobenzene	98-95-3	C ₆ H ₅ NO ₂	123.11	0.3	0.076	1.99e+06	1.13e-05	-4.95	1950	8.60e-08	1.91
29	PCBs	1336-36-3		328.00	1.42	0.104	2.51e+07	2.94e-04	-3.53	0.0077	1.00e-05	9.21
30	PAHs	61-78-9	C ₉ H ₁₀ N ₂ O ₃	194.19								
31	Parathion	56-38-2	C ₁₀ H ₁₄ NO ₅ PS	291.27	0.003	0.0	4.70e+04	4.80e-05	-4.32	19	0.0	3.38
32	Pyrene	129-00-0	C ₁₆ H ₁₀	202.26	9.74e-04	0.051	1.06e+04	7.00e-09	-8.15	2	5.50e-06	4.88
33	Tridecane	629-50-5	C ₁₃ H ₂₈	184.37	1.55e-09		1.54e-02					
34	Undecane	1120-21-4	C ₁₁ H ₂₃	156.32	1.20e-08		1.01e-01	1.83e+00	0.26			

^a At 25°C

$$H \left(\frac{\text{atm} \cdot \text{m}^3}{\text{g} \cdot \text{mol}} \right)$$