CHAPTER 4: OFFSITE CONSEQUENCE ANALYSIS

You are required to conduct an offsite consequence analysis to provide information to the government and the public about the potential consequences of an accidental chemical release. The offsite consequence analysis (OCA) consists of two elements:

g   A worst-case release scenario and
g   Alternative release scenarios.

To simplify the analysis and ensure a common basis for comparisons, EPA has defined the worst-case scenario as the release of the largest quantity of a regulated substance from a single vessel or process line failure that results in the greatest distance to an endpoint. In broad terms, the distance to the endpoint is the distance a toxic vapor cloud, heat from a fire, or blast waves from an explosion will travel before dissipating to the point that serious injuries from short-term exposures are no longer likely.

The purpose of this chapter is to give guidance on how to perform the OCA for regulated substances at warehouses.

Section 68.130 lists 77 toxic substances and 63 flammable substances that are subject to regulation; however, it is unlikely that they will all be handled at commercial warehouses. Therefore, during the development of this chapter, EPA consulted representatives of the American Warehouse Association (AWA) and obtained a list of regulated chemicals that are commonly handled at warehouses. These substances are listed in Exhibit 4-1 (toxic substances) and 4-2 (flammable substances). In addition, generic guidance is given for substances that are not listed in Exhibit 4-1 or Exhibit 4-2.

This guidance is based on EPA's *RMP Offsite Consequence Analysis Guidance* (OCAG). Those parts of the OCAG that you need to use are included in Appendix 4A (which is located at the end of this chapter). See the OCAG (available from EPA) for more information on the methodology presented here.

RMP*Comp™

To assist those using this guidance, the National Oceanic and Atmospheric Administration (NOAA) and EPA have developed a software program, RMP*Comp™, that performs the calculations described in this document. This software can be downloaded from the EPA Internet website at http://www.epa.gov/swercepp/tools/rmp-comp/rmp-comp.html.

EXHIBIT 4-1
EXAMPLES OF REGULATED TOXIC SUBSTANCES IN WAREHOUSES

Chemical	Toxic Endpoint (mg/L)	Typical Container	Potential Quantity in Warehouse	Comments	Buoyant (B) or Dense (D)
Boron Trifluoride Compound with Methyl Ether (1:1)	0.023	55-gallon drum	Truckload[a]	Pure liquid	D/B[b]
Cyclohexylamine	0.16	55-gallon drum	1-3 truckloads	Pure liquid	D/B
Diborane	0.0011	150-lb cylinder	10 cylinders	30% conc. in hydrogen	B/B
Epichlorohydrin	0.076	55-gallon drum	Truckload	Pure liquid	D/B
Ethylenediamine	0.49	55-gallon drum	2 truckloads	80% with other solvent-type materials, alcohol and ethyl acetate	D/B
Ethylene Oxide	0.090	150-lb cylinder	100 cylinders	Pressurized gas	D/D
Formaldehyde	0.012	55-gallon drum and smaller containers	2 truckloads	10%-50% solutions in water[c]	B/B
Hydrazine	0.011	55-gallon drum	3 truckloads	35%, 50%, 85% solutions in water[c]	B/B
Hydrochloric Acid	0.030	55-gallon drum	2 truckloads	30-38% solutions in water[e]	D/B
Methyl Chloride	0.82	150-lb cylinder	100-200 cylinders	Pressurized gas	D/D
Nitric Acid	0.026	55-gallon drum	2 truckloads	80-90% solutions in water	D/B
Propylene Oxide	0.59	55-gallon drum	2-3 truckloads	Pure liquid	D/D
Sulfur Dioxide	0.0078	150-lb cylinder	100-200 cylinders	Pressurized gas	D/D
Titanium Tetrachloride	0.02	55-gallon drum	**	Pure liquid	D/B
Toluene 2,4- and 2,6-diisocyanate, plus unspecified mixtures	0.007	55-gallon drum	1 or more truckloads	Pure liquid[d]	B/B

See next page for footnotes.

Footnotes for Exhibit 4-1:

[a]A truckload typically contains 78 55-gallon drums
[b]D/B indicates that the material behaves as a dense gas in worst-case weather conditions and as a neutrally buoyant (passive) gas in the case of the alternative scenarios, etc.
[c]For these solutions in water, the vapor pressures of formaldehyde and hydrazine over the solutions are less than 10 mm Hg. Such mixtures do not fall under the requirements of 40 CFR Part 68 and are not considered further in this guidance.
[d]Toluene diisocyanate can also be present as – 1 to ~ 10 wt% in a mixture of resins, plastics, etc., in 5-gallon pails up to 350-gallon totes. It is also used as a catalyst in the production of polyurethane foam and may be present in small quantities in, for example, furniture. These forms of toluene diisocyanate are not considered further in this guidance.
[e]Hydrochloric acid in concentrations below 37% is not regulated.

EXHIBIT 4-2
EXAMPLES OF REGULATED FLAMMABLE SUBSTANCES IN WAREHOUSES

Chemical	Typical Container	Potential Quantity in Warehouse	Comments
Acetylene	150-lb cylinder	One or two cylinders	Generally not enough to be covered by the RMP[a]
Dimethylamine[b]	55-gallon drum	1-2 truckloads	40% solution in water
Isopropyl Chloride	55-gallon drum	2 truckloads	Pure liquid
Methylamine[b]	55-gallon drum	2+ truckloads	40% solution in water
Pentane	-	-	Residual pentane in packages of pellets[a,c]
Propane	33.3-lb steel kegs or 5,000-7,000-lb tanks	Potentially more than 10,000 lb	Used for fueling forklifts and other purposes; not covered if used as a fuel on site
Trimethylamine[b]	55-gallon drum	3 truckloads	40% solution in water
Vinyl Ethyl Ether	55-gallon drum	1 truckload	Pure liquid

Footnotes for Table 4-2:
[a]Not considered further in this model guidance.
[b]According to Ullman's *Encyclopedia of Industrial Chemistry*, the boiling point of 40% monomethylamine is 121 °F and that of 40% dimethylamine is 125 °F. Therefore, these mixtures are not regulated under 40 CFR Part 68, which places an upper limit of 100 °F on the boiling point of regulated flammable substances. However, 40% trimethylamine has a boiling point of 87 °F and is covered.
[c]Some studies indicate that there is no residual pentane.

The methodology and reference tables of distances presented here are optional. You are not required to use this guidance. You may use publicly available or proprietary air dispersion models to do your offsite consequence analysis, subject to certain conditions. If you choose to use other models, you should review the rule and Chapter 4 of the *General Guidance for Risk Management Programs*, which outline required conditions for use of other models.

The results obtained using the methods in this document may be conservative (i.e., they may overestimate the distance to endpoints). Complex models that can account for many site-specific factors may give less conservative estimates of offsite consequences than the simple methods in this guidance. This is particularly true for alternative scenarios, for which EPA has not specified many assumptions. However, complex models may be expensive and require considerable expertise to use; this guidance is designed to be simple and straightforward. You will need to consider these tradeoffs in deciding how to carry out your required consequence analyses.

This chapter presents discussions and tables for the worst-case scenario for warehouses in section 4.1, followed by discussions and tables for alternative scenarios for warehouses in section 4.2. Mitigation provided by buildings is discussed in section 4.3. Section 4.4 provides information on estimating offsite receptors, and section 4.5 discusses required documentation.

4.1   WORST-CASE RELEASE SCENARIOS

This section provides guidance on how to analyze worst-case scenarios. Information is provided on the general requirements of the regulations, followed by specific guidance relevant to warehouses. Exhibit 4-3 presents the parameters that must be used in worst-case and alternative release scenarios.

GENERAL REQUIREMENTS FOR TOXIC SUBSTANCES

The following input is required for toxic substances:

g   The *worst-case release quantity* Q (lb) is the greater of the following:

-    For substances in a vessel, the greatest amount held in that vessel, taking into account administrative controls that limit the maximum quantity; or

-    For substances in pipes, the greatest amount in a pipe, taking into account administrative controls that limit the maximum quantity.

g   For a release from a vessel, you need only consider the largest amount in the vessel. For the specific case of a warehouse, the largest vessels are 350-gallon totes, 55-gallon drums, 10-gallon pails, 150-lb cylinders, and other containers that are small relative to typical vessels in a chemical plant. Therefore, the spillage of the contents of one of these containers constitutes the worst-case scenario, although you may well be able to think of scenarios

EXHIBIT 4-3
REQUIRED PARAMETERS FOR MODELING (40 CFR 68.22)

WORST CASE	ALTERNATIVE SCENARIO
Endpoints (§68.22(a))	
Toxic endpoints are listed in part 68 Appendix A.	Toxic endpoints are listed in part 68 Appendix A.
For flammable substances, endpoint is overpressure of 1 pound per square inch (psi) for vapor cloud explosions.	gFor flammable substances, endpoint is overpressure of 1 psi for vapor cloud explosions gRadiant heat level of 5 kilowatts per square meter (kW/m^2) for 40 seconds for heat from fires (or equivalent dose) gLower flammability limit (LFL) as specified in NFPA documents or other generally recognized sources.
Wind speed/stability (§68.22(b))	
This guidance assumes 1.5 meters per second and F stability. For other models, use wind speed of 1.5 meters per second and F stability class unless you can demonstrate that local meteorological data applicable to the site show a higher minimum wind speed or less stable atmosphere at all times during the previous three years. If you can so demonstrate, these minimums may be used for site-specific modeling.	This guidance assumes wind speed of 3 meters per second and D stability. For other models, you must use typical meteorological conditions for your site.
Ambient temperature/humidity (§68.22(c))	
This guidance assumes 25EC (77EF) and 50 percent humidity. For other models for toxic substances, you must use the highest daily maximum temperature and average humidity for the site during the past three years.	This guidance assumes 25EC and 50 percent humidity. For other models, you may use average temperature/humidity data gathered at the site or at a local meteorological station.
Height of release (§68.22(d))	
For toxic substances, you must assume a ground level release.	This guidance assumes a ground-level release. For other models, release height may be determined by the release scenario.
Surface roughness (§68.22(e))	
Use urban (obstructed terrain) or rural (flat terrain) topography, as appropriate.	Use urban (obstructed terrain) or rural (flat terrain) topography, as appropriate.
Dense or neutrally buoyant gases (§68.22(f))	
Tables or models used for dispersion of regulated toxic substances must appropriately account for gas density.	Tables or models used for dispersion must appropriately account for gas density.
Temperature of released substance (§68.22(g))	
You must consider liquids (other than gases liquefied by refrigeration) to be released at the highest daily maximum temperature, from data for the previous three years, or at process temperature, whichever is higher. Assume gases liquefied by refrigeration at atmospheric pressure to be released at their boiling points.	Substances may be considered to be released at a process or ambient temperature that is appropriate for the scenario.

in which a quantity greater than Q as defined above can be released. Other credible scenarios could involve simultaneous damage to more than one vessel. EPA recommends that you consider multiple-vessel release scenarios, if credible and appropriate, as alternative release scenarios (see Section 4.2).

g   *Weather conditions.* The rule allows anyone who conducts their OCA based on this guidance to use specific default weather conditions for wind speed, stability class, average temperature, and humidity. Liquids other than gases liquefied by refrigeration should be considered to be released at the highest daily maximum temperature, based on local data for the previous three years, or at process temperature, whichever is the higher. For warehouses, the liquids are assumed to be stored at ambient temperature. You can obtain weather data from local weather stations. You can also obtain temperature and wind speed data from the National Climatic Data Center at (828) 271-4800.

g   For the worst-case scenario, the release must be assumed to take place at *ground level*.

g   *The toxic endpoints* for toxic regulated substances are listed 40 CFR Part 68, Appendix A and in Appendix A of this document. Many of these endpoints (which are airborne concentrations) have been published by the American Industrial Hygiene Association (AIHA) as the second level of the Emergency Response Planning Guidelines (ERPG-2) and are the maximum airborne concentrations below which it is believed that nearly all individuals can be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action. These endpoints should be applied independent of the exposure time.

g   *Rural vs. urban sites*. The regulations require you to take account of whether your site is rural or urban. To decide whether the site is rural or urban, the rule offers the following: "Urban means that there are many obstacles in the immediate area; obstacles include buildings or trees. Rural means that there are no buildings in the immediate area and the terrain is generally flat or unobstructed." Some areas outside of cities may still be considered urban if they are forested.

The distinction between urban and rural sites is important because the atmosphere at urban sites is generally more turbulent than at rural sites, causing more rapid dilution of the cloud as it travels downwind. Therefore, for ground-level releases, predicted distances to toxic endpoints are always smaller at urban sites than at rural sites.

g   *Gas density*. The regulations require you to use tables or models that appropriately account for gas density. This guidance provides lookup tables for dense or neutrally buoyant gases or vapors (i.e., for gases that are denser-than-air or for gases that have the same density as air, respectively).

g   *Mitigation.* You are only allowed to take account of passive mitigation
        systems. Passive mitigation systems could include diked areas and buildings
        (see Section 4.3 for more information on buildings). You are not allowed to
        consider active mitigation systems such as sprinkler systems or remotely
        operated valves.

g   The predicted frequency of occurrence of the worst-case scenario is not an
        allowable consideration. You are not required to determine a possible cause
        of the failure of the vessel.

TOXIC LIQUIDS

The worst-case scenario for toxic liquids is a spill of the total quantity in the largest
vessel. The quantity spilled is assumed to spread instantaneously to a depth of one
centimeter in an undiked area or to cover a diked area instantaneously. (This
guidance does not consider diked areas.) The distance to the endpoint is estimated
based on evaporation from the pool and downwind dispersion of the vapor.

For this guidance, the basic assumption is that the container spills and forms an
unconfined pool with a depth of one centimeter. The spill is assumed to be outside,
on or near the loading dock. For discussion of spills inside buildings, see Section
4.3. No credit is taken for drains or other features that might contain the spilled
liquid. For liquids listed in Exhibit 4-1, Exhibit 4-4 provides the distance to the
endpoint for spills from vessels usually found at warehouses. The procedure for
calculating the worst-case distance for liquids is as follows:

1.   For a specific toxic material, identify the largest container and the quantity Q
        (lb) in it.

2.   Use the following equation to calculate the rate of evaporation QR (lb/min)
        from the pool:

$$QR = 1.4\ Q \times LFA \times DF = {''}Q \tag{1}$$

where LFA is the "Liquid Factor Ambient," DF is the "Density Factor," and $'' = 1.4$
x LFA x DF. LFA and DF have values that depend on the specific liquid that has
been spilled. Their values at 25EC[1] are tabulated in Exhibits B-2 (toxic liquids) and
B-3 (water solutions) in Appendix 4A at the end of this chapter. For the convenience
of the reader, the values of $''$ for the toxic liquids and solutions that are listed in
Exhibit 4-1 are provided in Exhibit 4-4.

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[1]For spills at a temperature greater than 25EC, see the footnote to Exhibit B-4 in Appendix 4A. Unless
otherwise stated, all spills are assumed to be at 25EC.

EXHIBIT 4-4
PREDICTED DISTANCES TO TOXIC ENDPOINTS FOR REGULATED TOXIC MATERIALS
Worst Case Scenario, Stability Class F, Wind Speed 1.5 m/s

Chemical/Solution Name	"	Container Size	Density (lb/gallon)[b]	Quantity Q (lb)	Rate of Release (lb/min)	Distance Rural Site (mi)	Distance Urban Site (mi)
Boron Trifluoride Compound with Methyl Ether (1:1)	0.002	55 gallon	8.29	456	0.91	0.3	0.2
Cyclohexylamine	0.002	55 gallon	7.0	385	0.780	<0.1	<0.1
Diborane	NA[a]	150 lb	NA[a]	50	5	2.5	1.3
Epichlorohydrin	0.0024	55 gallon	10.0	550	1.32	0.2	0.10
Ethylenediamine	0.0017	55 gallon	8.0	440	0.748	<0.1	<0.1
Ethylene Oxide	NA[a]	150 lb	NA[a]	150	15	0.5	0.3
Hydrochloric Acid 30%[c]	0.0009	55 gallon	9.64	530	0.47	0.1	<0.1
Hydrochloric Acid 34%[c]	0.0028	55 gallon	9.67	532	1.49	0.3	0.2
Hydrochloric Acid 36%[c]	0.0042	55 gallon	9.69	533	2.23	0.3	0.2
Hydrochloric Acid 37%	0.0050	55 gallon	9.69	533	2.66	0.4	0.2
Hydrochloric Acid 38%	0.0060	55 gallon	9.69	533	3.19	0.5	0.2
Methyl Chloride	NA[a]	150 lb	NA[a]	150	15	0.1	<0.1
Nitric Acid 80%	0.0009	55 gallon	11.13	612	0.55	0.1	0.1
Nitric Acid 85%	0.0015	55 gallon	11.69	643	0.96	0.3	0.2
Nitric Acid 90%	0.0021	55 gallon	12.55	690	1.45	0.4	0.2
Propylene Oxide	0.0770	55 gallon	7.44	409	31.5	0.3	<0.1
Sulfur Dioxide	NA[a]	150 lb	NA[a]	150	15	0.7	0.3
Titanium Tetrachloride	0.0020	55 gallon	14.42	793	1.586	0.4	0.2
Toluene 2,4-diisocyanate	3.36×10^{-6}	55 gallon	10.0	550	0.0018	<0.1	<0.1
Toluene 2,6-diisocyanate	1.0×10^{-5}	55 gallon	10.0	550	0.0055	<0.1	<0.1

Footnotes:

[a]Not applicable—chemical is a gas

[b]The density can be obtained from the density factor DF, which is given in Exhibits B-2 and B-3 of Appendix 4A. The density is $1/(DF \times 0.033)$ lb/ft^3. Thus, for epichlorohydrin, DF = 0.42, so that the density is $1/(0.42 \times 0.033) = 72$ lb/ft^3. There are 0.134 gallons/ft^3, so that the density becomes $0.134 \times 72 \sim 10$ lb/gallon.

[c]Hydrochloric acid in concentrations below 37% is not regulated.

3.   Obtain the toxic endpoint from Exhibit 4-1, together with information on whether the vapor cloud should be regarded as neutrally buoyant or dense. For liquids not included in Exhibit 4-1, you can find this information in Exhibit B-2 (pure liquids) or B-3 (solutions) in Appendix 4A at the end of this chapter.

4.   Determine whether your site is rural or urban.

5.   Take the release rate QR and read the predicted distances to the toxic endpoint from the following tables in Appendix 4A[2]:

  -       Reference Table 1 (rural site, 10-minute release, neutrally buoyant vapor cloud)
  -       Reference Table 2 (rural site, 60-minute release, neutrally buoyant vapor cloud)
  -       Reference Table 3 (urban site, 10-minute release, neutrally buoyant vapor cloud)
  -       Reference Table 4 (urban site, 60-minute release, neutrally buoyant vapor cloud)
  -       Reference Table 5 (rural site, 10-minute release, dense vapor cloud)
  -       Reference Table 6 (rural site, 60-minute release, dense vapor cloud)
  -       Reference Table 7 (urban site, 10-minute release, dense vapor cloud)
  -       Reference Table 8 (urban site, 60-minute release, dense vapor cloud).
  -       Reference Table 10 (specifically for aqueous ammonia).

For the specific case of the toxic liquids and solutions listed on Table 4-1, predicted distances for the failure of 55-gallon drums are given on Table 4-4 and can simply be quoted in your Risk Management Plan if the scenario matches your own worst-case scenario.

Example 1. You have epichlorohydrin above the threshold quantity (TQ) in your warehouse. The largest container is a 55-gallon drum. You determine that your site is rural. From Table 4-4, the distance D to the toxic endpoint is 0.2 mi.

Example 2. You have epichlorohydrin in 10-gallon pails, which is a quantity that is not represented on Exhibit 4-4. Therefore, you need to use both Exhibit 4-4 and the tables in Appendix 4A, as follows. The density of epichlorohydrin is 10 lb/gallon (Exhibit 4-4), so a pail contains 100 lb. From Exhibit 4-4, " = 0.0024 so that, from Equation 1, QR = (0.0024)(100) = 0.24 lb/min. From Exhibit 4-1, the toxic endpoint of epichlorohydrin is 0.076 mg/L, and it should be treated as a dense vapor. You

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[2]The 60-minute release tables are generally appropriate for spills of toxic liquids because the materials kept in warehouses usually have low vapor pressures and, hence, low rates of evaporation should they be spilled. For the examples given in Exhibit 4-4, the time to complete evaporation is greater than 10 minutes for all the liquids. The time would be several hours for all the liquids except propylene oxide. For solutions of toxic substances in water, the 10-minute tables should be used.

determine that your site is rural. Therefore, refer to Reference Table 6 in Appendix 4A.

The predicted release rate of 0.24 lb/min is below the lowest release rate of 1 lb/min on Reference Table 6. The closest toxic endpoint to 0.076 mg/L is 0.075 mg/L. The corresponding distance is 0.1 mi[3].

Example 3. You have dimethyldichlorosilane in your warehouse in 55-gallon drums at a rural site. This is an example of a material that is <u>not</u> listed in Exhibit 4-1.

From Exhibit B-2, Appendix 4A, the toxic endpoint of dimethyldichlorosilane is 0.026 mg/L, the LFA is 0.042, and the DF is 0.46. The density D of liquid dimethyldichlorosilane is 65.9 lb/ft^3 (the density can be calculated from the DF by using the formula $D = 1/(0.033DF)$, as described in the footnote to Exhibit 4-4). This converts to 8.83 lb/gallon (1 gallon is 0.134 ft^3). Therefore, a 55-gallon drum contains $Q = 55 \times 8.76 = 486$ lb.

The quantity " in Equation 1 is $1.4 \times LFA \times DF = 0.027$. The rate of evaporation is "$Q = 0.027 \times 486 = 13$ lb/min.

According to Exhibit B-2 of Appendix 4A, dimethyldichlorosilane should be modeled as a dense vapor. Turning to Reference Table 6 in Appendix 4A, for a rural site, look for the closest evaporation rate and toxic endpoint to 13 lb/min and 0.026 mg/L. The closest release rate is 10 lb/min, and the closest endpoint is 0.02 mg/L, giving a distance of 1.4 mi.

TOXIC GASES

For toxic gases, the worst-case scenario is release of the contents of the largest vessel over 10 minutes. For toxic gases listed in Exhibit 4-1, Exhibit 4-4 provides the distance to the endpoint for the release of a toxic gas from the largest vessel usually found at a warehouse. The procedure to use for analysis of the worst-case scenario for toxic gases is as follows.

1.   Estimate the quantity Q (lb) in the largest container

2.   Assume that the quantity Q is released over 10 minutes, so that the release rate is (Q/10) lb/min.

3.   Obtain the toxic endpoint from Exhibit B-1 of Appendix 4A, together with information on whether the vapor cloud should be regarded as neutrally buoyant or dense.

4.   Determine whether your site is rural or urban.

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[3]In Reference Table 6 and other tables in Appendix 4-A, results are rounded to the nearest tenth of a mile for distances under ten miles, and to the nearest mile for distances over ten miles. This is a reminder that the results of atmospheric dispersion modeling are uncertain and that more accurate predictions are not warranted.

5.   Determine the distance to the toxic endpoint by using one of the following tables:

-       Reference Table 1 (rural site, 10-minute release, neutrally buoyant vapor cloud)
-       Reference Table 3 (urban site, 10-minute release, neutrally buoyant vapor cloud)
-       Reference Table 5 (rural site, 10-minute release, dense vapor cloud), or
-       Reference Table 7 (urban site, 10-minute release, dense vapor cloud).
-       Reference Table 9 - specifically for anhydrous ammonia
-       Reference Table 11 - specifically for chlorine
-       Reference Table 12 - specifically for sulfur dioxide

Only 10-minute tables are relevant because the rule mandates that for the worst-case scenario, gases are released over 10 minutes.

Example 4. Diborane is one of the gaseous materials listed on Exhibit 4-1. The steps listed above have already been carried out for this material, and the results are displayed on Exhibit 4-4 —3 mi at a rural site and 2.1 mi at an urban site. (Note that the diborane is assumed to be in a 150-lb cylinder, but as only about 30 wt% in hydrogen. Therefore, only 50 lb of diborane is released and the predicted release rate is 5 lb/min, not 15 lb/min.)

Example 5. You have arsine in 150-lb cylinders at a rural site. This is another example of a material that is not on Exhibit 4-1. The worst-case release rate is 15 lb/min. From Exhibit B-1 of Appendix 4A, the toxic endpoint is 0.0019 mg/L and the release should be treated as a dense vapor cloud. Turning to reference Table 5 of Appendix 4A, the closest tabulated toxic endpoint is 0.002 mg/L. The closest release rate is 10 lb/min, for a predicted distance of 3 mi.

FLAMMABLE SUBSTANCES

For the worst-case scenario involving a release of a regulated flammable substance (a flammable gas or volatile flammable liquid), you must assume that the quantity of the flammable substance is released into a vapor cloud. A vapor cloud explosion is assumed to result from the release. You must estimate the distance D (mi) to an endpoint to an overpressure level of 1 pound per square inch (psi) from the explosion of the vapor cloud.

g   If the flammable substance is normally a gas at ambient temperature and handled as gas or liquid under pressure or if the flammable substance is a gas handled as a refrigerated liquid and is not contained when released or the contained pool is one centimeter or less deep, you must assume the total quantity is released as a gas and is involved in a vapor cloud explosion.

g   If the flammable substance is a liquid or a refrigerated gas released into a containment area with a depth greater than one centimeter, you may assume

that the quantity that volatilizes in 10 minutes is involved in a vapor cloud explosion.

A simple method of obtaining an approximate answer is to use the TNT equivalency method, which states that:

$$D = 0.0037(Q \times H/H_{TNT})^{1/3} \tag{2}$$

where Q (lb) is the quantity of flammable material released, H is the heat of combustion of the flammable substance and H_{TNT} is the heat of combustion of trinitrotoluene (TNT). Implicit in Equation 2 is the assumption that the yield factor is 10%, as required by the rule. The yield factor is the fraction of the material in the vessel that effectively participates in the explosion. Equation 2 can be rewritten as

$$D = \mathbf{8} \ (Q)^{1/3} \ \text{miles} \tag{3}$$

The values of **8** for the flammable materials listed in Table 4-2 are given below:

	8
Ethyl Mercaptan	0.0067
Isopropyl Chloride	0.0063
Propane	0.0080
Trimethylamine	0.0074
Vinyl Ethyl Ether	0.0070

If you prefer, you can find the distance to 1 psi overpressure for the quantity released from Reference Table 13 in Appendix 4A, instead of using Equation 3. Reference Table 13 also includes flammable substances that are not in the above list.

Example 6. If 5,000 lb of propane explodes, Equation 3 gives:

$$D = 0.0080 \ (5,000)^{1/3} = 0.14 \ \text{mi}$$

For reporting, you would round the distance to 0.1 mile.

Example 7. If a 55-gallon drum of vinyl ethyl ether spills and forms a vapor cloud, this vapor cloud will contain (55 gallons)(6.36 lb/gallon) = 350 lb of vinyl ethyl ether. If it explodes, then:

$$D = (0.0070)(350)^{1/3} = 0.05 \ \text{mi}$$

Example 8. A 55-gallon drum containing a 40 wt% solution of trimethylamine spills. The density of this solution is 6 lb/gallon, so there is a total of (0.4)(55)(6) = 132 lb of trimethylamine. From Equation 3, $D = 0.0074(132)^{1/3} = 0.038$ mi, which you would round to 0.04 mi.

Vapor cloud explosions involving small quantities generally are considered very unlikely. If you have a flammable chemical above the threshold quantity, however,

you must assume a vapor cloud explosion for your worst-case scenario, even if your largest vessel contains a relatively small quantity.

The explosions discussed above are assumed to take place outside. Many warehouses keep flammable materials in a room that is specially designed with explosion venting per NFPA requirements. However, the intention of this section is to provide information on the worst-case scenario. There are probably times when you handle the containers of flammable substances outside. Nevertheless, in discussions with local agencies and local communities you may want to explain how your facility is designed to ensure that worst-case explosions do not occur or are effectively mitigated.

4.2   ALTERNATIVE SCENARIOS

The purpose of this section is to give guidance on how to model alternative scenarios.

GENERAL REQUIREMENTS

The requirements that differ from those for the worst-case scenarios are as follows:

g   You can take into account active as well as passive mitigation systems, as long as these systems are expected to withstand the causes of the accident. For warehouses, the building itself could function as a passive system and the fire sprinklers could be regarded as an active system.

g   The alternative scenario should reach an endpoint offsite, unless no such scenario exists.

g   If you are doing your own modeling, you should use "typical meteorological conditions for the stationary source." You may obtain these data from local weather stations. You can obtain wind speed and temperature data from the National Climatic Data Center at (828) 271-4800. This guidance uses an "average" weather condition of wind speed 3 m/s and D stability class with an ambient temperature of 25EC.

g   The number of alternative scenarios you are required to develop is as follows:

        Í   At least one scenario for each regulated toxic substance held in Program 2 and Program 3 processes.
        Í   At least one scenario to represent all flammables held in Program 2 and Program 3 processes.

g   The release is not necessarily restricted to ground level. It can be elevated if appropriate. An elevated release might be appropriate for a warehouse with several floors (analysis of elevated releases would be site-specific and is not considered in this guidance).

CHOICE OF ALTERNATIVE SCENARIOS FOR TOXIC LIQUIDS

There are some significant issues when it comes to choosing alternative scenarios for warehouses:

g   As already noted, plausible alternative scenarios could well be larger than the single-container worst-case scenarios;

g   The alternative scenario should be more probable than the worst-case scenario, yet spillage from a single container is among the more probable scenarios.

The following subsections contain some suggested alternative scenarios.

SINGLE-CONTAINER ALTERNATIVE SCENARIO

One possibility is to take the same scenario as the worst-case (i.e., a spill of the contents of a single vessel), but to assume that it takes place in typical weather conditions. Exhibit 4-5 provides distances to the endpoint for this scenario for the substances listed in Exhibit 4-1. The procedure for calculating the alternative scenario distance is very similar to that for the worst-case scenario:

g   For a specific toxic material, identify the largest vessel and the quantity Q (lb) in it.

g   Use Equation 4 below to calculate the rate of evaporation QR (lb/min.) from the pool formed by the spill of quantity Q in alternative weather conditions:

$$QR = 2.4 \, Q \times LFA \times DF = \$Q \qquad\qquad (4)$$

where LFA is the "Liquid Factor Ambient," DF is the "Density Factor," and $\$ = 2.4 \times LFA \times DF$. LFA and DF have values that depend on the specific liquid that has been spilled. Their values are tabulated in Exhibits B-2 (toxic liquids) and B-3 (water solutions) of Appendix 4A. For the convenience of the reader, the values of $ that are appropriate for alternative scenarios are provided in Exhibit 4-5.

g   Determine whether your site is rural or urban.

g   Read the toxic endpoint from Exhibit B-2 or Exhibit B-3 of Appendix 4A, together with whether the vapor should be modeled as neutrally buoyant or dense.

g   Take the release rate QR and read the predicted distances to the toxic endpoint from the following tables in Appendix 4A:

-       Reference Table 14 (rural site, 10-minute release, neutrally buoyant vapor cloud)

- Reference Table 15 (rural site, 60-minute release, neutrally buoyant vapor cloud)
- Reference Table 16 (urban site, 10-minute release, neutrally buoyant vapor cloud)
- Reference Table 17 (urban site, 60-minute release, neutrally buoyant vapor cloud)
- Reference Table 18 (rural site, 10-minute release, dense vapor cloud)
- Reference Table 19 (rural site, 60-minute release, dense vapor cloud)
- Reference Table 20 (urban site, 60-minute release, dense vapor cloud)
- Reference Table 21 (urban site, 60-minute release, dense vapor cloud)
- Reference Table 23 - specifically for aqueous ammonia

For spilled water solutions, you should assume a 10-minute duration of release because LFA is calculated as a 10-minute average. For the other toxic liquids, the predicted time to total evaporation of the pool at the rate given by Equation 4 is generally much more than 10 minutes, so you will need to use the 60-minute tables unless your alternative scenario has been terminated in 10 minutes or less (e.g., by some emergency countermeasure).

For the specific case of the toxic liquids and solutions listed on Exhibit 4-1, predicted distances are given on Exhibit 4-5 and can simply be quoted in your Risk Management Plan if the scenario matches one of your own alternative scenarios.

Example 9. You have ethylenediamine above the TQ in your warehouse. The largest container is a 55-gallon drum. You determine that your site is rural. Ethylenediamine is on Exhibit 4-5, and the corresponding distance to the toxic endpoint is < 0.1 mi.

Example 10. You have epichlorohydrin in 10-gallon pails, which are not represented on Exhibit 4-5. Therefore, you need to use the tables in Appendix 4A, as follows. The density of epichlorohydrin is 10 lb/gallon, so a pail contains $Q = 100$ lb. From Exhibit 4-5, $\$ = 0.0040$ so that, from Equation 4, $QR = (0.0040)(100) = 0.40$ lb/min. From Exhibit 4-1, the toxic endpoint of epichlorohydrin is 0.076 mg/L, and it should be modeled as a buoyant vapor. You determine that your site is rural. Turning to Reference Table 15 in Appendix 4A, you need to calculate the ratio between the release rate and the toxic endpoint, which, for convenience, we call $\star$. In this case, $\star = 0.38/0.076 = 5$, which lies in the lowest tabulated range for $\star$ on Reference Table 15, corresponding to a distance to the toxic endpoint of 0.1 mi.

MULTIPLE CONTAINER ALTERNATIVE SCENARIO

A plausible scenario is that two or more containers could be punctured by a fork lift truck. The procedure to follow for this scenario for toxic liquids is the same procedure presented in the previous subsection; only the quantity spilled is different. The evaporation rate displayed in Exhibit 4-5 should then be multiplied by the

number of ruptured containers. The predicted distances to the toxic endpoint are given on Exhibit 4-6 for the example of two ruptured containers.

Example 11. You have an accident in which four containers of 37% hydrochloric acid are ruptured in typical weather conditions at a rural site. The predicted rate of evaporation is then four times that on Exhibit 4-5, i.e., $4 \times 4.58 = 18.32$ lb/min. From Exhibit 4-1, 37% hydrochloric acid is neutrally buoyant in alternative scenarios, and its toxic endpoint is 0.03 mg/L. Hence, $* = 18.32/0.03 = 610$. Turning to Reference Table 1 in Appendix 4A, this value of $*$ is close to the tabulated value of 630, corresponding to 0.2 mi.

ALTERNATIVE SCENARIO - TOXIC GASES

For alternative scenarios for toxic gases, you may consider the worst-case release under typical weather conditions or a release involving multiple containers, as discussed above for liquids. Exhibits 4-5 and 4-6 provide distances to the endpoint for these alternative scenarios for toxic gases listed in Exhibit 4-1. The procedure to use is as follows.

1.   Estimate the release rate in lb/min for the alternative scenario.

2.   Obtain the toxic endpoint from Exhibit B-1 of Appendix 4A, together with information on whether the vapor cloud should be regarded as neutrally buoyant or dense.

3.   Determine whether your site is rural or urban.

4.   Determine the distance to the toxic endpoint by using one of the following tables:

-        Reference Table 14 (rural site, 10-minute release, neutrally buoyant vapor cloud)
-        Reference Table 15 (rural site, 60-minute release, neutrally buoyant vapor cloud)
ſ   Reference Table 16 (urban site, 10-minute release, neutrally buoyant vapor cloud)
-        Reference Table 17 (urban site, 60-minute release, neutrally buoyant vapor cloud)
-        Reference Table 18 (rural site, 10-minute release, dense vapor cloud)
-        Reference Table 19 (rural site, 60-minute release, dense vapor cloud)
-        Reference Table 20 (urban site, 10-minute release, dense vapor cloud)

EXHIBIT 4-5
PREDICTED DISTANCES TO TOXIC ENDPOINTS FOR REGULATED TOXIC MATERIALS
Alternative Case Scenario No. 1 - Release from Single Container, Stability Class D, Wind Speed 3.0 m/s

Chemical/Solution Name	$	Container Size	Quantity Q (lb)	Rate of Release (lb/min)	Distance Rural Site (mi)	Distance Urban Site (mi)
Boron Trifluoride Compound with Methyl Ether (1:1)	0.0035	55 gallon	570	1.93	0.2	<0.1
Cyclohexylamine	0.0034	55 gallon	385	1.30	<0.1	<0.1
Diborane	NA[a]	150 lb	50	5	0.	0.4
Epichlorohydrin	0.0040	55 gallon	550	2.20	<0.1	<0.1
Ethylenediamine	0.0029	55 gallon	440	1.28	<0.1	<0.1
Ethylene Oxide	NA[a]	150 lb	150	15	0.1	<0.1
Hydrochloric Acid 30%[b]	0.0016	55 gallon	530	0.85	<0.1	<0.1
Hydrochloric Acid 34%[b]	0.0048	55 gallon	532	2.55	<0.1	<0.1
Hydrochloric Acid 36%[b]	0.0073	55 gallon	533	3.89	0.1	<0.1
Hydrochloric Acid 37%	0.0086	55 gallon	533	4.58	0.1	<0.1
Hydrochloric Acid 38%	0.0098	55 gallon	533	5.22	0.1	<0.1
Methyl Chloride	NA[a]	150 lb	150	15	<0.1	<0.1
Nitric Acid 80%	0.0015	55 gallon	612	0.92	<0.1	<0.1
Nitric Acid 85%	0.0025	55 gallon	643	1.61	<0.1	<0.1
Nitric Acid 90%	0.0036	55 gallon	690	2.48	0.1	<0.1
Propylene Oxide	0.13	55 gallon	409	53.17	0.1	<0.1
Sulfur Dioxide	NA[a]	150 lb	150	15	0.4	0.3
Titanium Tetrachloride	0.0032	55 gallon	793	2.54	0.1	<0.1
Toluene 2,4-diisocyanate	5.76×10^{-6}	55 gallon	550	0.0032	<0.1	<0.1
Toluene 2,6-diisocyanate	1.7×10^{-5}	55 gallon	550	0.0095	<0.1	<0.1

Footnotes:
[a]Not applicable—chemical is a gas
[b]Hydrochloric acid in concentrations below 37% is not regulated.

-        Reference Table 21 (urban site, 60-minute release, dense vapor
         cloud)
-        Reference Table 22 - specifically for anhydrous ammonia
-        Reference Table 24 - specifically for chlorine
-        Reference Table 25 - specifically for sulfur dioxide

Example 12. Diborane is one of the gaseous materials listed on Exhibit 4-1.
Assuming that the alternative scenario is the same as the worst-case scenario,
Example 4, except that the weather conditions have changed from worst-case to
typical, the steps listed above have already been carried out for this material. The
results are listed on Exhibit 4-5: ~ 0.8 mi at a rural site and ~ 0.4 mi at an urban site.

For an alternative scenario that consists of the release of two cylinders of diborane
over a period of 10 minutes, the results may be read from Exhibit 4-6 and are - 1.0
mi at a rural site and - 0.6 mi at an urban site.

Example 13. You have arsine in 150-lb cylinders at a rural site. Arsine is not on
Exhibit 4-5. The worst-case release rate is 15 lb/min for 10 min. Assume that this
release rate is the same for the alternative scenario and that the only difference is in
the weather conditions. From Exhibit B-1 of Appendix 4A, the toxic endpoint is
0.0019 mg/L and the release should be treated as a dense vapor cloud. Turning to
Reference Table 18 of Appendix 4A, the closest tabulated toxic endpoint is 0.002
mg/L. The closest release rate is 10 lb/min, for a predicted distance of 0.9 mi.

ALTERNATIVE SCENARIOS FOR FLAMMABLE SUBSTANCES

For many owners of warehouses, a fire is potentially the most damaging scenario.
However, there are several considerations involved in modeling scenarios for
flammable substances within the context of the RMP.

g   Toxic materials in plumes generated by fires do not have to be considered
         under the RMP rule, although toxic combustion products might be generated.

g   Under the RMP rule, endpoints for regulated flammable substances are
         specified for explosions, radiant heat, and dispersion to the lower
         flammability limit (LFL).

g   Effects such as heat released by unregulated materials are not considered
         under the RMP rule; such effects might be a major problem in warehouse
         fires.

Alternative scenarios for regulated flammable substances at warehouses could
include pool fires and vapor cloud fires (assuming dispersion to the LFL), as
discussed below.

EXHIBIT 4-6
PREDICTED DISTANCES TO TOXIC ENDPOINTS FOR REGULATED TOXIC MATERIALS
Alternative Case Scenario No. 2 - Release from Two Containers, Stability Class D, Wind Speed 3.0 m/s

Chemical/Solution Name	$	Container Size	Quantity Q (lb)	Rate of Release (lb/min)	Distance Rural Site (mi)	Distance Urban Site (mi)
Boron Trifluoride Compound with Methyl Ether (1:1)	0.0035	55 gallon	1140	3.87	<0.1	<0.1
Cyclohexylamine	0.0034	55 gallon	770	2.61	<0.1	<0.1
Diborane	NA[a]	150 lb	100	10	1.0	0.6
Epichlorohydrin	0.0040	55 gallon	1100	4.40	<0.1	<0.1
Ethylenediamine	0.0029	55 gallon	880	2.55	<0.1	<0.1
Ethylene Oxide	NA[a]	150 lb	300	30	0.1	<0.1
Hydrochloric Acid 30%[b]	0.0016	55 gallon	1060	1.7	<0.1	<0.1
Hydrochloric Acid 34%[b]	0.0048	55 gallon	1064	5.1	<0.1	<0.1
Hydrochloric Acid 36%[b]	0.0073	55 gallon	1066	7.78	0.1	<0.1
Hydrochloric Acid 37%	0.0086	55 gallon	1066	9.16	0.1	<0.1
Hydrochloric Acid 38%	0.0098	55 gallon	1066	10.44	0.1	0.1
Methyl Chloride	NA[a]	150 lb	300	30	<0.1	<0.1
Nitric Acid 80%	0.0015	55 gallon	1224	1.84	<0.1	<0.1
Nitric Acid 85%	0.0025	55 gallon	1286	3.22	<0.1	<0.1
Nitric Acid 90%	0.0036	55 gallon	1380	4.96	0.1	<0.1
Propylene Oxide	0.13	55 gallon	818	106	0.1	<0.1
Sulfur Dioxide	NA[a]	150 lb	300	30	0.6	0.3
Titanium Tetrachloride	0.0032	55 gallon	1586	5.08	0.1	<0.1
Toluene 2,4-diisocyanate	5.79×10^{-6}	55 gallon	1100	0.0064	<0.1	<0.1
Toluene 2,6-diisocyanate	1.7×10^{-5}	55 gallon	1100	0.019	<0.1	<0.1

Footnotes:
[a]Not applicable—chemical is a gas.
[b]Hydrochloric acid in concentrations below 37% is not regulated.

For <u>pool fires</u> involving spillages of flammable liquids, the following equation gives an estimate for the distance D (ft) from a pool fire at which people could potentially receive a second-degree burn after 40 seconds:

$$D = PFF\ A^{0.5} \tag{5}$$

where PFF is the "Pool Fire Factor", and A is the area of the pool in ft^2. The PFF is tabulated in Exhibits C-2 and C-3 of Appendix 4A.

Example 14. You have vinyl ethyl ether in a 55-gallon drum (350 lb). It spreads to form a pool of depth 1 cm. The area is given by $A = 350 \times DF$, where DF is tabulated in Exhibit C-3 and is 0.65 for vinyl ethyl ether: $A = 350 \times 0.65 = 228$ ft^2 so that $A^{0.5} = 15$ ft. From Exhibit C-3 of the OCAG, PFF = 4.2 so that $D = 4.2 \times 15$ ~ 60 ft. (You also can consider spills from multiple drums. Multiply A for one drum by the number of drums involved.)

Another alternative flammable scenario is a vapor cloud fire. You would calculate the <u>distance to the LFL</u>, that is, the distance to which the cloud propagates before diluting below the lower flammable limit, assuming the vapor cloud then ignites. You need to determine the release rate, as described for toxic substances. The data you need for flammable substances, including the LFL, are in Exhibits C-2 (for flammable gases) and C-3 (for flammable liquids) in Appendix 4A.

The appropriate reference tables for determining the predicted distance to the LFL are as follows:

- Neutrally buoyant plume, rural site, Reference Table 26
- Neutrally buoyant plume, urban site, Reference Table 27
- Dense plume, rural site, Reference Table 28
- Dense plume, urban site, Reference Table 29

Example 15. Vinyl ethyl ether is spilled from a 55-gallon drum (containing 350 lb) at an urban site. As shown in Example 14, it forms a pool of depth 1 cm and area 228 ft^2. The rate of evaporation is given by $QR = 2.4Q \times LFA \times DF$. LFA is 0.10 and DF is 0.65, from Exhibit C-3 of Appendix 4A. Hence, $QR = (2.4)(350)(0.1)(0.65) = 55$ lb/min. From Exhibit C-3 of Appendix 4A, the LFL for vinyl ethyl ether is 50 mg/L, and it should be treated as a dense gas. From Reference Table 28, the predicted distance to the LFL at a rural site is < 0.1 mi for any release rate < 1,500 lb/min.

4.3   BUILDINGS

Buildings may be considered provide passive mitigation in some cases. Unless your containers of regulated substances are delivered directly into the building (i.e., they are not unloaded outdoors and moved inside later), you should not consider buildings in your worst-case scenario, because there will be some time when the vessels are outdoors. If your containers are delivered indoors or if your largest vessel is indoors,

you may want to analyze the mitigating effects of the building when you do your worst-case analysis. You may also want to consider alternative scenarios that consider buildings as mitigation systems. However, warehouses vary over a wide range in their strength of construction, the surface area of ventilation outlets, and their purpose. In addition, warehouse doors are often left open for considerable periods.

For toxic liquids, EPA has provided simple building release rate reduction factors for indoor releases of 10% for worst-case scenarios and 5% for alternative scenarios (i.e., the predicted rate of release is 10% or 5% of that for the same accident if it should occur outdoors). These factors are based on data for a building with a ventilation rate of 0.5 air changes per hour. The factors are applicable to releases in a fully enclosed, non-airtight space that is directly adjacent to the outside air. They do not apply to a space that has doors or windows that could be open during a release. (See Appendix D of the OCAG for more discussion of the mitigation factors.)

For toxic gases, the EPA's reduction factor is 55%, for both worst-case and alternative scenarios. This factor also is based on 0.5 air changes per hour. It is applicable to releases in the same type of enclosure as the factors for liquids. (See Appendix D of the OCAG for more discussion.)

You are at liberty to provide building-specific models of the mitigating effects of structures. Generally, such modeling requires the use of numerical simulation and specialized computer programs.

Example 16. Returning to Example 3, you have dimethyldichlorosilane in your warehouse in 55-gallon drums at a rural site. Assume that the release takes place inside the warehouse in worst-case weather conditions. The effective release rate is then reduced by a factor of 10 from 13 lb/min to 1.3 lb/min. From Exhibit B-2 of Appendix 4A, the toxic endpoint of dimethyldichlorosilane is 0.026 mg/L, and it should be modeled as a dense vapor. Turning to Reference Table 6 of Appendix 4A, for a rural site, look for the evaporation rate closest to 1.3 lb/min and the toxic endpoint closest to 0.026 mg/L. This is 1 lb/min and 0.02 mg/L, giving a distance of 0.3 mi.

4.4   ESTIMATING OFFSITE RECEPTORS

The rule requires that you estimate in the RMP residential populations within the circle defined by the endpoint for your worst-case and alternative release scenarios (i.e., the center of the circle is the point of release and the radius is the distance to the endpoint). In addition, you must report in the RMP whether certain types of public receptors and environmental receptors are within the circles.

RESIDENTIAL POPULATIONS

To estimate residential populations, you may use the most recent Census data or any other source of data that you believe is more accurate. You are not required to update Census data or conduct any surveys to develop your estimates. Census data are available in public libraries and in the LandView system, which is available on CD-ROM (see box below). The rule requires that you estimate populations to two-significant digits. For example, if there are 1,260 people within the circle, you

may report 1,300 people. If the number of people is between 10 and 100, estimate to the nearest 10. If the number of people is less than 10, provide the actual number. Census data are presented by Census tract. If your circle covers only a portion of the tract, you should develop an estimate for that portion. The easiest way to do this is to determine the population density per square mile (total population of the Census tract divided by the number of square miles in the tract) and apply that density figure to the number of square miles within your circle. Because there is likely to be considerable variation in actual densities within a Census tract, this number will be approximate. The rule, however, does not require you to correct the number.

OTHER PUBLIC RECEPTORS

Other public receptors must be noted in the RMP (see the discussion of public receptors in Chapter 2). If there are any schools, residences, hospitals, prisons, public recreational areas or arenas, or commercial or industrial areas within the circle, you must report that. You are not required to develop a list of all public receptors; you must simply check off that one or more such areas is within the circle. Most receptors can be identified from local street maps.

ENVIRONMENTAL RECEPTORS

Environmental receptors are defined as natural areas such as national or state parks, forests, or monuments; officially designated wildlife sanctuaries, preserves, refuges, or areas; and Federal wilderness areas. Only environmental receptors that can be identified on local U.S. Geological Survey (USGS) maps (see box below) need to be considered. You are not required to locate each of these specifically. You are only required to check off in the RMP which specific types of areas are within the circle. If any part of one of these receptors is within your circle, you must note that in the RMP.

Important: The rule does not require you to assess the likelihood, type, or severity of potential impacts on either public or environmental receptors. Identifying them as within the circle simply indicates that they could be adversely affected by the release.

Besides the results you are required to report in the RMP, you may want to consider submitting to EPA or providing your local community with a map showing the distances to the endpoint. Figure 4-1 is one suggested example of how the consequences of worst-case and alternative scenarios might be presented. It is a simplified map that shows the radius to which the vapor cloud might extend, given the worst-case release in worst-case weather conditions (the owner or operator should use a real map of the area surrounding the site).

Organizations that have already begun to prepare Risk Management Programs and Plans have used this form of presentation (for example, in the Kanawha Valley or in Tampa Bay).

HOW TO OBTAIN CENSUS DATA AND LANDVIEW®

Census data can be found in publications of the Bureau of the Census, available in public libraries, including *County and City Data Book*.

LandView ®III is a desktop mapping system that includes database extracts from EPA, the Bureau of the Census, the U.S. Geological Survey, the Nuclear Regulatory Commission, the Department of Transportation, and the Federal Emergency Management Agency. These databases are presented in a geographic context on maps that show jurisdictional boundaries, detailed networks of roads, rivers, and railroads, census block group and tract polygons, schools, hospitals, churches, cemeteries, airports, dams, and other landmark features.

CD-ROM for IBM-compatible PCS
CD-TGR95-LV3-KIT $99 per disc (by region) or $549 for 11 disc set

U.S. Department of Commerce
Bureau of the Census
P.O. Box 277943
Atlanta, GA 30384-7943
Phone: 301-457-4100 (Customer Services — orders)
Fax: (888) 249-7295 (toll-free)
Fax: (301) 457-3842 (local)
Phone: (301) 457-1128 (Geography Staff — content)
http://www.census.gov/ftp/pub/geo/www/tiger/

Further information on LandView and other sources of Census data is available at the Bureau of the Census web site at www.census.gov.

HOW TO OBTAIN USGS MAPS

The production of digital cartographic data and graphic maps comprises the largest component of the USGS National Mapping Program. The USGS's most familiar product is the 1:24,000-scale Topographic Quadrangle Map. This is the primary scale of data produced, and depicts greater detail for a smaller area than intermediate-scale (1:50,000 and 1:100,000) and small-scale (1:250,000, 1:2,000,000 or smaller) products, which show selectively less detail for larger areas.

U.S. Geological Survey
508 National Center
12201 Sunrise Valley Drive
Reston, VA 20192
http://mapping.usgs.gov/

To order USGS maps by fax, select, print, and complete one of the online forms and fax to 303-202-4693. A list of commercial dealers also is available at http://mapping.usgs.gov/esic/usimage/dealers.html/. For more information or ordering assistance, call 1-800-HELP-MAP, or write:

USGS Information Services
Box 25286
Denver, CO 80225

For additional information, contact any USGS Earth Science Information Center or call 1-800-USA-MAPS.

4.5   DOCUMENTATION

You need to maintain onsite the following records on the offsite consequence analyses:

For the worst-case scenario, a description of the vessel or pipeline selected as worst-case, assumptions and parameters used and the rationale for selection; assumptions include use of any administrative controls and any passive mitigation systems that you assumed to limit the quantity that could be released.

For alternative release scenarios, a description of the scenarios identified, assumptions and parameters used and the rationale for the selection of specific scenarios; assumptions include use of any administrative controls and any mitigation that were assumed to limit the quantity that could be released. Documentation includes the effect of the controls and mitigation on the release quantity and rate.

Other data that you should provide includes:

g   Documentation of estimated quantity released, release rate and duration of release.

g   Methodology used to determine distance to endpoints (it will be sufficient to reference this guidance).

g   Data used to identify potentially affected population and environmental receptors.

Figure 4-1 Simplified Presentation of Worst-Case
and Alternative Scenario on a Local Map

C Avenue

B

Avene

Hospital

Facility Boundary

Prison

Radius for
Alternative
Scenario

A Street

School

0   1/2   1

Radius for
Worst-case Scenario

Miles
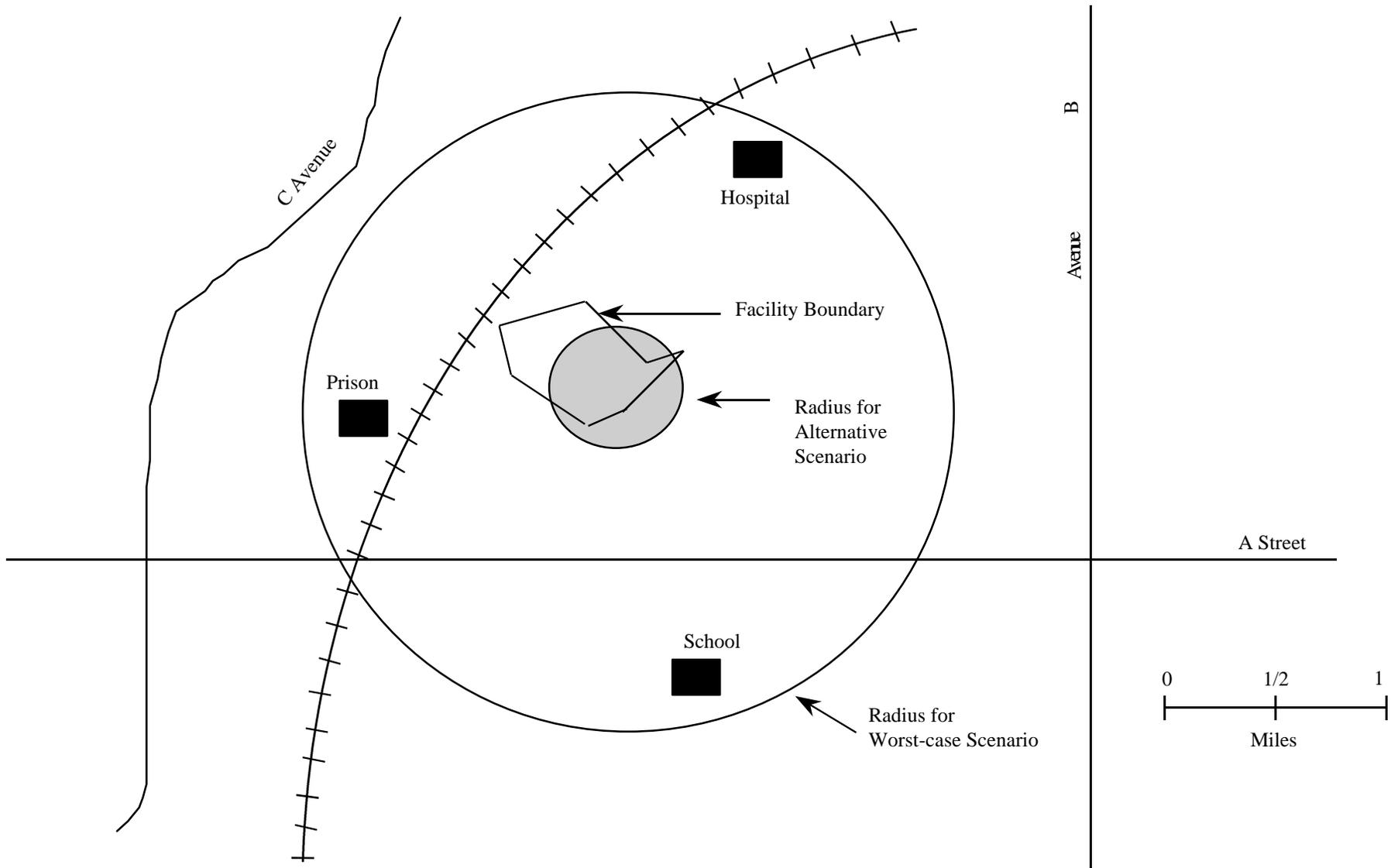
APPENDIX 4A

REFERENCE TABLES OF DISTANCES AND TABLES OF DATA FROM THE OFFSITE CONSEQUENCE ANALYSIS GUIDANCE

The following tables from the *RMP Offsite Consequence Analysis Guidance* are reproduced here for the convenience of the reader.

Reference Tables of Distances

Reference Table 1—Neutrally Buoyant Plume Distances to Toxic Endpoint for Release Rate Divided by Endpoint, 10-Minute Release, Rural Conditions, F Stability, Wind Speed 1.5 Meters per Second
Reference Table 2—Neutrally Buoyant Plume Distances to Toxic Endpoint for Release Rate Divided by Endpoint, 60-Minute Release, Rural Conditions, F Stability, Wind Speed 1.5 Meters per Second
Reference Table 3—Neutrally Buoyant Plume Distances to Toxic Endpoint for Release Rate Divided by Endpoint, 10-Minute Release, Urban Conditions, F Stability, Wind Speed 1.5 Meters per Second
Reference Table 4—Neutrally Buoyant Plume Distances to Toxic Endpoint for Release Rate Divided by Endpoint, 60-Minute Release, Urban Conditions, F Stability, Wind Speed 1.5 Meters per Second
Reference Table 5—Dense Gas Distances to Toxic Endpoint, 10-Minute Release, Rural Conditions, F Stability, Wind Speed 1.5 Meters per Second
Reference Table 6—Dense Gas Distances to Toxic Endpoint, 60-Minute Release, Rural Conditions, F Stability, Wind Speed 1.5 Meters per Second
Reference Table 7—Dense Gas Distances to Toxic Endpoint, 10-Minute Release, Urban Conditions, F Stability, Wind Speed 1.5 Meters per Second
Reference Table 8—Dense Gas Distances to Toxic Endpoint, 60-Minute Release, Urban Conditions, F Stability, Wind Speed 1.5 Meters per Second
Reference Table 9—Distances to Toxic Endpoint for Anhydrous Ammonia Liquefied Under Pressure, F Stability, Wind Speed 1.5 Meters per Second
Reference Table 10—Distances to Toxic Endpoint for Aqueous Ammonia, F Stability, Wind Speed 1.5 Meters per Second
Reference Table 11—Distances to Toxic Endpoint for Chlorine, F Stability, Wind Speed 1.5 Meters per Second
Reference Table 12—Distances to Toxic Endpoint for Sulfur Dioxide, F Stability, Wind Speed 1.5 Meters per Second
Reference Table 13—Distance to Overpressure of 1.0 psi for Vapor Cloud Explosions of 500 - 2,000,000 Pounds of Regulated Flammable Substances Based on TNT Equivalent Method, 10 Percent Yield Factor
Reference Table 14—Neutrally Buoyant Plume Distances to Toxic Endpoint for Release Rate Divided by Endpoint, 10-Minute Release, Rural Conditions, D Stability, Wind Speed 3.0 Meters per Second
Reference Table 15—Neutrally Buoyant Plume Distances to Toxic Endpoint for Release Rate Divided by Endpoint, 60-Minute Release, Rural Conditions, D Stability, Wind Speed 3.0 Meters per Second
Reference Table 16—Neutrally Buoyant Plume Distances to Toxic Endpoint for Release Rate Divided by Endpoint, 10-Minute Release, Urban Conditions, D Stability, Wind Speed 3.0 Meters per Second
Reference Table 17—Neutrally Buoyant Plume Distances to Toxic Endpoint for Release Rate Divided by Endpoint, 60-Minute Release, Urban Conditions, D Stability, Wind Speed 3.0 Meters per Second
Reference Table 18—Dense Gas Distances to Toxic Endpoint, 10-Minute Release, Rural Conditions, D Stability, Wind Speed 3.0 Meters per Second

Reference Table 19—Dense Gas Distances to Toxic Endpoint, 60-Minute Release, Rural Conditions, D Stability, Wind Speed 3.0 Meters per Second
Reference Table 20—Dense Gas Distances to Toxic Endpoint, 10-Minute Release, Urban Conditions, D Stability, Wind Speed 3.0 Meters per Second
Reference Table 21—Dense Gas Distances to Toxic Endpoint, 60-Minute Release, Urban Conditions, D Stability, Wind Speed 3.0 Meters per Second
Reference Table 22—Distances to Toxic Endpoint for Anhydrous Ammonia, D Stability, Wind Speed 3.0 Meters per Second
Reference Table 23—Distances to Toxic Endpoint for Aqueous Ammonia, D Stability, Wind Speed 3.0 Meters per Second
Reference Table 24—Distances to Toxic Endpoint for Chlorine, D Stability, Wind Speed 3.0 Meters per Second
Reference Table 25—Distances to Toxic Endpoint for Sulfur Dioxide, D Stability, Wind Speed 3.0 Meters per Second
Reference Table 26—Neutrally Buoyant Plume Distances to Lower Flammability Limit (LFL) for Release Rate Divided by LFL, Rural Conditions, D Stability, Wind Speed 3.0 Meters per Second
Reference Table 27—Neutrally Buoyant Plume Distances to Lower Flammability Limit (LFL) for Release Rate Divided by LFL, Urban Conditions, D Stability, Wind Speed 3.0 Meters per Second
Reference Table 28—Dense Gas Distances to Lower Flammability Limit Rural Conditions, D Stability, Wind Speed 3.0 Meters per Second
Reference Table 29—Dense Gas Distances to Lower Flammability Limit Urban Conditions, D Stability, Wind Speed 3.0 Meters per Second

Tables of Data

Exhibit B-1—Data for Toxic Gases
Exhibit B-2—Data for Toxic Liquids
Exhibit B-3—Data for Water Solutions of Toxic Substances and for Oleum, Average Vapor Pressure and Liquid Factors over 10 Minutes for Wind Speeds of 1.5 and 3.0 Meters per Second (m/s)
Exhibit B-4—Temperature Correction Factors for Liquids Evaporating from Pools at Temperatures Between 25EC and 50EC (77EF and 122EF)
Exhibit C-1—Heats of Combustion for Flammable Substances
Exhibit C-2—Data for Flammable Gases
Exhibit C-3—Data for Flammable Liquids

Reference Table 1
Neutrally Buoyant Plume Distances to Toxic Endpoint for Release Rate Divided by Endpoint
10-Minute Release, Rural Conditions, F Stability, Wind Speed 1.5 Meters per Second

Release Rate/Endpoint [(lbs/min)/(mg/L)] (*)	Distance to Endpoint (miles)	Release Rate/Endpoint [(lbs/min)/(mg/L)] (*)	Distance to Endpoint (miles)
0 - 4.4	0.1	16,000 - 18,000	4.8
4.4 - 37	0.2	18,000 - 19,000	5.0
37 - 97	0.3	19,000 - 21,000	5.2
97 - 180	0.4	21,000 - 23,000	5.4
180 - 340	0.6	23,000 - 24,000	5.6
340 - 530	0.8	24,000 - 26,000	5.8
530 - 760	1.0	26,000 - 28,000	6.0
760 - 1,000	1.2	28,000 - 29,600	6.2
1,000 - 1,500	1.4	29,600 - 35,600	6.8
1,500 - 1,900	1.6	35,600 - 42,000	7.5
1,900 - 2,400	1.8	42,000 - 48,800	8.1
2,400 - 2,900	2.0	48,800 - 56,000	8.7
2,900 - 3,500	2.2	56,000 - 63,600	9.3
3,500 - 4,400	2.4	63,600 - 71,500	9.9
4,400 - 5,100	2.6	71,500 - 88,500	11
5,100 - 5,900	2.8	88,500 - 107,000	12
5,900 - 6,800	3.0	107,000 - 126,000	14
6,800 - 7,700	3.2	126,000 - 147,000	15
7,700 - 9,000	3.4	147,000 - 169,000	16
9,000 - 10,000	3.6	169,000 - 191,000	17
10,000 - 11,000	3.8	191,000 - 215,000	19
11,000 - 12,000	4.0	215,000 - 279,000	22
12,000 - 14,000	4.2	279,000 - 347,000	25
14,000 - 15,000	4.4	>347,000	>25*
15,000 - 16,000	4.6		

* Report distance as 25 miles

Reference Table 2
Neutrally Buoyant Plume Distances to Toxic Endpoint for Release Rate Divided by Endpoint
60-Minute Release, Rural Conditions, F Stability, Wind Speed 1.5 Meters per Second

Release Rate/Endpoint [(lbs/min)/(mg/L)] (*)	Distance to Endpoint (miles)	Release Rate/Endpoint [(lbs/min)/(mg/L)] (*)	Distance to Endpoint (miles)
0 - 5.5	0.1	7,400 - 7,700	4.8
5.5 - 46	0.2	7,700 - 8,100	5.0
46 - 120	0.3	8,100 - 8,500	5.2
120 - 220	0.4	8,500 - 8,900	5.4
220 - 420	0.6	8,900 - 9,200	5.6
420 - 650	0.8	9,200 - 9,600	5.8
650 - 910	1.0	9,600 - 10,000	6.0
910 - 1,200	1.2	10,000 - 10,400	6.2
1,200 - 1,600	1.4	10,400 - 11,700	6.8
1,600 - 1,900	1.6	11,700 - 13,100	7.5
1,900 - 2,300	1.8	13,100 - 14,500	8.1
2,300 - 2,600	2.0	14,500 - 15,900	8.7
2,600 - 2,900	2.2	15,900 - 17,500	9.3
2,900 - 3,400	2.4	17,500 - 19,100	9.9
3,400 - 3,700	2.6	19,100 - 22,600	11
3,700 - 4,100	2.8	22,600 - 26,300	12
4,100 - 4,400	3.0	26,300 - 30,300	14
4,400 - 4,800	3.2	30,300 - 34,500	15
4,800 - 5,200	3.4	34,500 - 38,900	16
5,200 - 5,600	3.6	38,900 - 43,600	17
5,600 - 5,900	3.8	43,600 - 48,400	19
5,900 - 6,200	4.0	48,400 - 61,500	22
6,200 - 6,700	4.2	61,500 - 75,600	25
6,700 - 7,000	4.4	>75,600	>25*
7,000 - 7,400	4.6		

* Report distance as 25 miles

Reference Table 3
Neutrally Buoyant Plume Distances to Toxic Endpoint for Release Rate Divided by Endpoint
10-minute Release, Urban Conditions, F Stability, Wind Speed 1.5 Meters per Second

Release Rate/Endpoint [(lbs/min)/(mg/L)] (*)	Distance to Endpoint (miles)	Release Rate/Endpoint [(lbs/min)/(mg/L)] (*)	Distance to Endpoint (miles)
0 - 21	0.1	76,000 - 83,000	4.8
21 - 170	0.2	83,000 - 90,000	5.0
170 - 420	0.3	90,000 - 100,000	5.2
420 - 760	0.4	100,000 - 110,000	5.4
760 - 1,400	0.6	110,000 - 120,000	5.6
1,400 - 2,100	0.8	120,000 - 130,000	5.8
2,100 - 3,100	1.0	130,000 - 140,000	6.0
3,100 - 4,200	1.2	140,000 - 148,000	6.2
4,200 - 6,100	1.4	148,000 - 183,000	6.8
6,100 - 7,800	1.6	183,000 - 221,000	7.5
7,800 - 9,700	1.8	221,000 - 264,000	8.1
9,700 - 12,000	2.0	264,000 - 310,000	8.7
12,000 - 14,000	2.2	310,000 - 361,000	9.3
14,000 - 18,000	2.4	361,000 - 415,000	9.9
18,000 - 22,000	2.6	415,000 - 535,000	11
22,000 - 25,000	2.8	535,000 - 671,000	12
25,000 - 29,000	3.0	671,000 - 822,000	14
29,000 - 33,000	3.2	822,000 - 990,000	15
33,000 - 39,000	3.4	990,000 - 1,170,000	16
39,000 - 44,000	3.6	1,170,000 - 1,370,000	17
44,000 - 49,000	3.8	1,370,000 - 1,590,000	19
49,000 - 55,000	4.0	1,590,000 - 2,190,000	22
55,000 - 63,000	4.2	2,190,000 - 2,890,000	25
63,000 - 69,000	4.4	>2,890,000	>25*
69,000 - 76,000	4.6		

* Report distance as 25 miles

Reference Table 4
Neutrally Buoyant Plume Distances to Toxic Endpoint for Release Rate Divided by Endpoint
60-Minute Release, Urban Conditions, F Stability, Wind Speed 1.5 Meters per Second

Release Rate/Endpoint [(lbs/min)/(mg/L)] (*)	Distance to Endpoint (miles)	Release Rate/Endpoint [(lbs/min)/(mg/L)] (*)	Distance to Endpoint (miles)
0 - 26	0.1	34,000 - 36,000	4.8
26 - 210	0.2	36,000 - 38,000	5.0
210 - 530	0.3	38,000 - 41,000	5.2
530 - 940	0.4	41,000 - 43,000	5.4
940 - 1,700	0.6	43,000 - 45,000	5.6
1,700 - 2,600	0.8	45,000 - 47,000	5.8
2,600 - 3,700	1.0	47,000 - 50,000	6.0
3,700 - 4,800	1.2	50,000 - 52,200	6.2
4,800 - 6,400	1.4	52,200 - 60,200	6.8
6,400 - 7,700	1.6	60,200 - 68,900	7.5
7,700 - 9,100	1.8	68,900 - 78,300	8.1
9,100 - 11,000	2.0	78,300 - 88,400	8.7
11,000 - 12,000	2.2	88,400 - 99,300	9.3
12,000 - 14,000	2.4	99,300 - 111,000	9.9
14,000 - 16,000	2.6	111,000 - 137,000	11
16,000 - 17,000	2.8	137,000 - 165,000	12
17,000 - 19,000	3.0	165,000 - 197,000	14
19,000 - 21,000	3.2	197,000 - 232,000	15
21,000 - 23,000	3.4	232,000 - 271,000	16
23,000 - 24,000	3.6	271,000 - 312,000	17
24,000 - 26,000	3.8	312,000 - 357,000	19
26,000 - 28,000	4.0	357,000 - 483,000	22
28,000 - 30,000	4.2	483,000 - 629,000	25
30,000 - 32,000	4.4	>629,000	>25*
32,000 - 34,000	4.6		

* Report distance as 25 miles

Reference Table 5
Dense Gas Distances to Toxic Endpoint, 10-minute Release, Rural Conditions, F Stability, Wind Speed 1.5 Meters per Second

Release Rate (lbs/min)	Toxic Endpoint (mg/L)															
	0.0004	0.0007	0.001	0.002	0.0035	0.005	0.0075	0.01	0.02	0.035	0.05	0.075	0.1	0.25	0.5	0.75
	Distance (Miles)															
1	??	??	??	??	0.8	0.7	0.5	0.5	0.3	0.2	0.2	0.2	0.1	0.1	??	#
2	??	??	??	??	??	0.9	0.7	0.7	0.4	0.3	0.3	0.2	0.2	0.1	<0.1	<0.1
5	??	??	??	??	??	??	??	1.0	0.7	0.5	0.4	0.3	0.3	0.2	0.1	0.1
10	??	??	??	??	??	??	??	??	1.0	0.7	0.6	0.5	0.4	0.2	0.2	0.1
30	??	??	??	??	??	??	??	??	??	??	??	0.9	0.7	0.4	0.3	0.2
50	??	??	??	??	??	??	??	??	??	??	??	??	0.9	0.6	0.4	0.3
100	??	??	??	??	??	??	??	??	??	??	??	??	??	0.8	0.5	0.4
150	??	??	??	??	??	??	??	??	??	??	??	??	??	0.9	0.6	0.5
250	??	??	??	??	??	??	??	??	??	??	??	??	??	??	0.8	0.6
500	??	??	??	??	??	??	??	??	??	??	??	??	??	??	??	0.9
750	*	*	??	??	??	??	??	??	??	??	??	??	??	??	??	1.0
1,000	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??	??
1,500	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??	??
2,000	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??
2,500	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??
3,000	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??
4,000	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??
5,000	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??
7,500	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
10,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
15,000	*	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??
20,000	*	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??
50,000	*	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??
75,000	*	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??
100,000	*	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??
150,000	*	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??
200,000	*	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??

* > 25 miles (report distance as 25 miles)   # <0.1 mile (report distance as 0.1 mile)

Reference Table 6
Dense Gas Distances to Toxic Endpoint, 60-minute Release, Rural Conditions, F Stability, Wind Speed 1.5 Meters per Second

Release Rate (lbs/min)	Toxic Endpoint (mg/L)															
	0.0004	0.0007	0.001	0.002	0.0035	0.005	0.0075	0.01	0.02	0.035	0.05	0.075	0.1	0.25	0.5	0.75
	Distance (Miles)															
1	??	2.7	??	??	1.0	0.8	0.6	0.5	0.3	0.2	0.2	0.1	0.1	<0.1	??	#
2	??	??	??	??	??	??	1.0	0.8	0.5	0.4	0.3	0.2	0.2	0.1	<01	<0.1
5	??	??	??	??	??	??	??	??	0.9	0.6	0.5	0.4	0.3	0.2	0.1	0.1
10	??	??	??	??	??	??	??	??	??	1.0	0.8	0.6	0.5	0.3	0.2	0.1
30	??	??	??	??	??	??	??	??	??	??	??	??	1.0	0.5	0.3	0.2
50	??	??	??	??	??	??	??	??	??	??	??	??	??	0.7	0.4	0.3
100	??	??	??	??	??	??	??	??	??	??	??	??	??	??	0.7	0.5
150	*	*	??	??	??	??	??	??	??	??	??	??	??	??	0.9	0.6
250	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??	0.9
500	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??
750	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??
1,000	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??
1,500	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
2,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
2,500	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
3,000	*	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??
4,000	*	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??
5,000	*	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??
7,500	*	*	*	*	*	*	*	*	*	??	??	??	??	??	??	??
10,000	*	*	*	*	*	*	*	*	*	*	??	??	??	??	??	??
15,000	*	*	*	*	*	*	*	*	*	*	??	??	??	??	??	??
20,000	*	*	*	*	*	*	*	*	*	*	*	??	??	??	??	??
50,000	*	*	*	*	*	*	*	*	*	*	*	??	??	??	??	??
75,000	*	*	*	*	*	*	*	*	*	*	*	??	??	??	??	??
100,000	*	*	*	*	*	*	*	*	*	*	*	??	??	??	??	??
150,000	*	*	*	*	*	*	*	*	*	*	*	??	??	??	??	??
200,000	*	*	*	*	*	*	*	*	*	*	*	??	??	??	??	??

* > 25 miles (report distance as 25 miles)   # <0.1 mile (report distance as 0.1 mile)

Reference Table 7
Dense Gas Distances to Toxic Endpoint, 10-minute Release, Urban Conditions, F Stability, Wind Speed 1.5 Meters per Second

Release Rate (lbs/min)	Toxic Endpoint (mg/L)															
	0.0004	0.0007	0.001	0.002	0.0035	0.005	0.0075	0.01	0.02	0.035	0.05	0.075	0.1	0.25	0.5	0.75
	Distance (Miles)															
1	??	??	??	0.7	0.6	0.4	0.4	0.3	0.2	0.2	0.1	0.1	0.1	??	#	#
2	??	??	??	??	0.8	0.6	0.5	0.4	0.3	0.2	0.2	0.1	0.1	<0.1	#	#
5	??	??	??	??	??	1.0	0.8	0.7	0.5	0.4	0.3	0.2	0.2	0.1	<0.1	#
10	??	??	??	??	??	??	??	1.0	0.7	0.5	0.4	0.3	0.2	0.1	0.1	<0.1
30	??	??	??	??	??	??	??	??	??	0.9	0.7	0.6	0.4	0.2	0.1	0.1
50	??	??	??	??	??	??	??	??	??	??	0.9	0.7	0.6	0.3	0.2	0.1
100	??	??	??	??	??	??	??	??	??	??	??	1.0	0.9	0.5	0.3	0.2
150	??	??	??	??	??	??	??	??	??	??	??	??	??	0.6	0.4	0.2
250	??	??	??	??	??	??	??	??	??	??	??	??	??	0.7	0.5	0.3
500	??	??	??	??	??	??	??	??	??	??	??	??	??	??	0.7	0.5
750	??	??	??	??	??	??	??	??	??	??	??	??	??	??	0.8	0.6
1,000	*	*	??	??	??	??	??	??	??	??	??	??	??	??	0.9	0.7
1,500	*	*	??	??	??	??	??	??	??	??	??	??	??	??	??	0.8
2,000	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??	0.9
2,500	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??	??
3,000	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??
4,000	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??
5,000	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??
7,500	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??
10,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
15,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
20,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
50,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
75,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
100,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
150,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
200,000	*	*	*	*	*	*	*	??	??	??	??	??	>25	??	??	??

* > 25 miles (report distance as 25 miles)　　　　　　　　　　　　　　　　　　　# <0.1 mile (report distance as 0.1 mile)

Reference Table 8
Dense Gas Distances to Toxic Endpoint, 60-minute Release, Urban Conditions, F Stability, Wind Speed 1.5 Meters per Second

Release Rate (lbs/min)	Toxic Endpoint (mg/L)															
	0.0004	0.0007	0.001	0.002	0.0035	0.005	0.0075	0.01	0.02	0.035	0.05	0.075	0.1	0.25	0.5	0.75
	Distance (Miles)															
1	??	??	??	??	0.7	0.6	0.4	0.4	0.2	0.2	0.1	0.1	0.1	??	#	#
2	??	??	??	??	??	0.9	0.7	0.6	0.4	0.2	0.2	0.1	0.1	<0.1	#	#
5	??	??	??	??	??	??	??	0.9	0.6	0.4	0.3	0.2	0.2	0.1	<0.1	#
10	??	??	??	??	??	??	??	??	0.9	0.7	0.5	0.4	0.3	0.2	0.1	<0.1
30	??	??	??	??	??	??	??	??	??	??	1.0	0.7	0.6	0.3	0.2	0.1
50	??	??	??	??	??	??	??	??	??	??	??	??	0.9	0.4	0.2	0.2
100	??	??	??	??	??	??	??	??	??	??	??	??	??	0.7	0.4	0.3
150	??	??	??	??	??	??	??	??	??	??	??	??	??	0.9	0.5	0.3
250	*	*	??	??	??	??	??	??	??	??	??	??	??	??	0.7	0.5
500	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??	0.7
750	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??	1.0
1,000	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??
1,500	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??
2,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
2,500	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
3,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
4,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
5,000	*	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??
7,500	*	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??
10,000	*	*	*	*	*	*	*	*	*	??	??	??	??	??	??	??
15,000	*	*	*	*	*	*	*	*	*	??	??	??	??	??	??	??
20,000	*	*	*	*	*	*	*	*	*	*	??	??	??	??	??	??
50,000	*	*	*	*	*	*	*	*	*	*	??	??	??	??	??	??
75,000	*	*	*	*	*	*	*	*	*	*	??	??	??	??	??	??
100,000	*	*	*	*	*	*	*	*	*	*	??	??	??	??	??	??
150,000	*	*	*	*	*	*	*	*	*	*	??	??	??	??	??	??
200,000	*	*	*	*	*	*	*	*	*	*	??	??	??	??	??	??

* > 25 miles (report distance as 25 miles)   # <0.1 mile (report distance as 0.1 mile)

Reference Table 9
Distances to Toxic Endpoint for Anhydrous Ammonia Liquefied Under Pressure
F Stability, Wind Speed 1.5 Meters per Second

Release Rate (lbs/min)	Distance to Endpoint (miles)		Release Rate (lbs/min)	Distance to Endpoint (miles)	
	Rural	Urban		Rural	Urban
1	0.1	<0.1*	1,000	1.8	1.2
2	0.1	0.1	1,500	2.2	1.5
5	0.1	0.1	2,000	2.6	1.7
10	0.2	0.1	2,500	2.9	1.9
15	0.2	0.2	3,000	3.1	2.0
20	0.3	0.2	4,000	3.6	2.3
30	0.3	0.2	5,000	4.0	2.6
40	0.4	0.3	6,000	4.4	2.8
50	0.4	0.3	7,000	4.7	3.1
60	0.5	0.3	7,500	4.9	3.2
70	0.5	0.3	8,000	5.1	3.3
80	0.5	0.4	9,000	5.4	3.4
90	0.6	0.4	10,000	5.6	3.6
100	0.6	0.4	15,000	6.9	4.4
150	0.7	0.5	20,000	8.0	5.0
200	0.8	0.6	25,000	8.9	5.6
250	0.9	0.6	30,000	9.7	6.1
300	1.0	0.7	40,000	11	7.0
400	1.2	0.8	50,000	12	7.8
500	1.3	0.9	75,000	15	9.5
600	1.4	0.9	100,000	18	10
700	1.5	1.0	150,000	22	13
750	1.6	1.0	200,000	**	15
800	1.6	1.1	250,000	**	17
900	1.7	1.2	750,000	**	**

*Report distance as 0.1 mile

** More than 25 miles (report distance as 25 miles)

Reference Table 10
Distances to Toxic Endpoint for Aqueous Ammonia
F Stability, Wind Speed 1.5 Meters per Second

Release Rate (lbs/min)	Distance to Endpoint (miles)		Release Rate (lbs/min)	Distance to Endpoint (miles)	
	Rural	Urban		Rural	Urban
1	0.1	<0.1*	1,000	1.6	0.6
2	0.1		1,500	2.0	0.7
5	0.1		2,000	2.2	0.8
10	0.2	0.1	2,500	2.5	0.9
15	0.2	0.1	3,000	2.7	1.0
20	0.3	0.1	4,000	3.1	1.1
30	0.3	0.1	5,000	3.4	1.2
40	0.4	0.1	6,000	3.7	1.3
50	0.4	0.1	7,000	4.0	1.4
60	0.4	0.2	7,500	4.1	1.5
70	0.5	0.2	8,000	4.2	1.5
80	0.5	0.2	9,000	4.5	1.6
90	0.5	0.2	10,000	4.7	1.7
100	0.6	0.2	15,000	5.6	2.0
150	0.7	0.2	20,000	6.5	2.4
200	0.8	0.3	25,000	7.2	2.6
250	0.8	0.3	30,000	7.8	2.8
300	0.9	0.3	40,000	8.9	3.3
400	1.1	0.4	50,000	9.8	3.6
500	1.2	0.4	75,000	12	4.4
600	1.3	0.4	100,000	14	5.0
700	1.4	0.5	150,000	16	6.1
750	1.4	0.5	200,000	19	7.0
800	1.5	0.5	250,000	21	7.8
900	1.5	0.6	750,000	**	13

*Report distance as 0.1 mile   ** More than 25 miles (report distance as 25 miles)

Reference Table 11
Distances to Toxic Endpoint for Chlorine
F Stability, Wind Speed 1.5 Meters per Second

Release Rate (lbs/min)	Distance to Endpoint (miles)		Release Rate (lbs/min)	Distance to Endpoint (miles)	
	Rural	Urban		Rural	Urban
1	0.2	0.1	750	5.8	2.6
2	0.3	0.1	800	5.9	2.7
5	0.5	0.2	900	6.3	2.9
10	0.7	0.3	1,000	6.6	3.0
15	0.8	0.4	1,500	8.1	3.8
20	1.0	0.4	2,000	9.3	4.4
30	1.2	0.5	2,500	10	4.9
40	1.4	0.6	3,000	11	5.4
50	1.5	0.6	4,000	13	6.2
60	1.7	0.7	5,000	14	7.0
70	1.8	0.8	6,000	16	7.6
80	1.9	0.8	7,000	17	8.3
90	2.0	0.9	7,500	18	8.6
100	2.2	0.9	8,000	18	8.9
150	2.6	1.2	9,000	19	9.4
200	3.0	1.3	10,000	20	9.9
250	3.4	1.5	15,000	25	12
300	3.7	1.6	20,000	*	14
400	4.2	1.9	25,000	*	16
500	4.7	2.1	30,000	*	18
600	5.2	2.3	40,000	*	20
700	5.6	2.5	50,000	*	*

* More than 25 miles (report distance as 25 miles)

Reference Table 12
Distances to Toxic Endpoint for Anhydrous Sulfur Dioxide
F Stability, Wind Speed 1.5 Meters per Second

Release Rate (lbs/min)	Distance to Endpoint (miles)		Release Rate (lbs/min)	Distance to Endpoint (miles)	
	Rural	Urban		Rural	Urban
1	0.2	0.1	750	6.6	2.6
2	0.2	0.1	800	6.8	2.7
5	0.4	0.2	900	7.2	2.9
10	0.6	0.2	1,000	7.7	3.1
15	0.7	0.3	1,500	9.6	3.8
20	0.9	0.4	2,000	11	4.5
30	1.1	0.5	2,500	13	5.0
40	1.3	0.5	3,000	14	5.6
50	1.4	0.6	4,000	17	6.5
60	1.6	0.7	5,000	19	7.3
70	1.8	0.7	6,000	21	8.1
80	1.9	0.8	7,000	23	8.8
90	2.0	0.8	7,500	24	9.1
100	2.1	0.9	8,000	25	9.5
150	2.7	1.1	9,000	*	10
200	3.1	1.3	10,000	*	11
250	3.6	1.4	15,000	*	13
300	3.9	1.6	20,000	*	16
400	4.6	1.9	25,000	*	18
500	5.2	2.1	30,000	*	19
600	5.8	2.3	40,000	*	23
700	6.3	2.5	50,000	*	*

* More than 25 miles (report distance as 25 miles)

Reference Table 13
Distance to Overpressure of 1.0 psi for Vapor Cloud Explosions of 500 - 2,000,000 Pounds of Regulated Flammable Substances Based on TNT Equivalent Method, 10 Percent Yield Factor

	Quantity in Cloud (pounds)	500	2,000	5,000	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000
CAS No.	Chemical Name	Distance (Miles) to 1 psi Overpressure										
75-07-0	Acetaldehyde	0.05	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.8
74-86-2	Acetylene	0.07	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.8	1.0
598-73-2	Bromotrifluoroethylene	0.02	0.04	0.05	0.06	0.08	0.1	0.1	0.2	0.2	0.3	0.4
106-99-0	1,3-Butadiene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
106-97-8	Butane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
25167-67-3	Butene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
590-18-1	2-Butene-cis	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
624-64-6	2-Butene-trans	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
106-98-9	1-Butene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
107-01-7	2-Butene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
463-58-1	Carbon oxysulfide	0.04	0.06	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6
7791-21-1	Chlorine monoxide	0.02	0.03	0.04	0.05	0.06	0.08	0.1	0.1	0.2	0.2	0.3
590-21-6	1-Chloropropylene	0.05	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8
557-98-2	2-Chloropropylene	0.05	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8
460-19-5	Cyanogen	0.05	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8
75-19-4	Cyclopropane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
4109-96-0	Dichlorosilane	0.04	0.06	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6
75-37-6	Difluoroethane	0.04	0.06	0.09	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6
124-40-3	Dimethylamine	0.06	0.09	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9
463-82-1	2,2-Dimethylpropane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0

	Quantity in Cloud (pounds)	500	2,000	5,000	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000
CAS No.	Chemical Name	Distance (Miles) to 1 psi Overpressure										
74-84-0	Ethane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
107-00-6	Ethyl acetylene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
75-04-7	Ethylamine	0.06	0.09	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9
75-00-3	Ethyl chloride	0.05	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8
74-85-1	Ethylene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.8	1.0
60-29-7	Ethyl ether	0.06	0.09	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9
75-08-1	Ethyl mercaptan	0.05	0.09	0.1	0.2	0.2	0.2	0.3	0.4	0.5	0.7	0.9
109-95-5	Ethyl nitrite	0.05	0.07	0.1	0.1	0.2	0.2	0.3	0.3	0.5	0.6	0.7
1333-74-0	Hydrogen	0.09	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.9	1.1	1.4
75-28-5	Isobutane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
78-78-4	Isopentane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
78-79-5	Isoprene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
75-31-0	Isopropylamine	0.06	0.09	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9
75-29-6	Isopropyl chloride	0.05	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8
74-82-8	Methane	0.07	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.8	1.0
74-89-5	Methylamine	0.06	0.09	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9
563-45-1	3-Methyl-1-butene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
563-46-2	2-Methyl-1-butene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
115-10-6	Methyl ether	0.05	0.09	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.7	0.9
107-31-3	Methyl formate	0.04	0.07	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7
115-11-7	2-Methylpropene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
504-60-9	1,3-Pentadiene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
109-66-0	Pentane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
109-67-1	1-Pentene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0

Quantity in Cloud (pounds)		500	2,000	5,000	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000
CAS No.	Chemical Name	Distance (Miles) to 1 psi Overpressure										
646-04-8	2-Pentene, (E)-	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
627-20-3	2-Pentene, (Z)-	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
463-49-0	Propadiene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
74-98-6	Propane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
115-07-1	Propylene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
74-99-7	Propyne	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
7803-62-5	Silane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
116-14-3	Tetrafluoroethylene	0.02	0.03	0.04	0.05	0.07	0.09	0.1	0.1	0.2	0.2	0.3
75-76-3	Tetramethylsilane	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
10025-78-2	Trichlorosilane	0.03	0.04	0.06	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.4
79-38-9	Trifluorochloroethylene	0.02	0.03	0.05	0.06	0.07	0.1	0.1	0.2	0.2	0.3	0.3
75-50-3	Trimethylamine	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.6	0.8	1.0
689-97-4	Vinyl acetylene	0.06	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0
75-01-4	Vinyl chloride	0.05	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8
109-92-2	Vinyl ethyl ether	0.06	0.09	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9
75-02-5	Vinyl fluoride	0.02	0.04	0.05	0.06	0.08	0.1	0.1	0.2	0.2	0.3	0.4
75-35-4	Vinylidene chloride	0.04	0.06	0.08	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6
75-38-7	Vinylidene fluoride	0.04	0.06	0.09	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6
107-25-5	Vinyl methyl ether	0.06	0.09	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9

Reference Table 14
Neutrally Buoyant Plume Distances to Toxic Endpoint for Release Rate Divided by Endpoint
10-Minute Release, Rural Conditions, D Stability, Wind Speed 3.0 Meters per Second

Release Rate/Endpoint [(lbs/min)/(mg/L)] (*)	Distance to Endpoint (miles)	Release Rate/Endpoint [(lbs/min)/(mg/L)] (*)	Distance to Endpoint (miles)
0 - 64	0.1	130,000 - 140,000	4.8
64 - 510	0.2	140,000 - 160,000	5.0
510 - 1,300	0.3	160,000 - 180,000	5.2
1,300 - 2,300	0.4	180,000 - 190,000	5.4
2,300 - 4,100	0.6	190,000 - 210,000	5.6
4,100 - 6,300	0.8	210,000 - 220,000	5.8
6,300 - 8,800	1.0	220,000 - 240,000	6.0
8,800 - 12,000	1.2	240,000 - 261,000	6.2
12,000 - 16,000	1.4	261,000 - 325,000	6.8
16,000 - 19,000	1.6	325,000 - 397,000	7.5
19,000 - 22,000	1.8	397,000 - 477,000	8.1
22,000 - 26,000	2.0	477,000 - 566,000	8.7
26,000 - 30,000	2.2	566,000 - 663,000	9.3
30,000 - 36,000	2.4	663,000 - 769,000	9.9
36,000 - 42,000	2.6	769,000 - 1,010,000	11
42,000 - 47,000	2.8	1,010,000 - 1,280,000	12
47,000 - 54,000	3.0	1,280,000 - 1,600,000	14
54,000 - 60,000	3.2	1,600,000 - 1,950,000	15
60,000 - 70,000	3.4	1,950,000 - 2,340,000	16
70,000 - 78,000	3.6	2,340,000 - 2,770,000	17
78,000 - 87,000	3.8	2,770,000 - 3,240,000	19
87,000 - 97,000	4.0	3,240,000 - 4,590,000	22
97,000 - 110,000	4.2	4,590,000 - 6,190,000	25
110,000 - 120,000	4.4	>6,190,000	>25*
120,000 - 130,000	4.6		

* Report distance as 25 miles

Reference Table 15
Neutrally Buoyant Plume Distances to Toxic Endpoint for Release Rate Divided by Endpoint
60-Minute Release, Rural Conditions, D Stability, Wind Speed 3.0 Meters per Second

Release Rate/Endpoint [(lbs/min)/(mg/L)] (*)	Distance to Endpoint (miles)	Release Rate/Endpoint [(lbs/min)/(mg/L)] (*)	Distance to Endpoint (miles)
0 - 79	0.1	100,000 - 108,000	4.8
79 - 630	0.2	108,000 - 113,000	5.0
630 - 1,600	0.3	113,000 - 120,000	5.2
1,600 - 2,800	0.4	120,000 - 126,000	5.4
2,800 - 5,200	0.6	126,000 - 132,000	5.6
5,200 - 7,900	0.8	132,000 - 140,000	5.8
7,900 - 11,000	1.0	140,000 - 150,000	6.0
11,000 - 14,000	1.2	150,000 - 151,000	6.2
14,000 - 19,000	1.4	151,000 - 171,000	6.8
19,000 - 23,000	1.6	171,000 - 191,000	7.5
23,000 - 27,000	1.8	191,000 - 212,000	8.1
27,000 - 32,000	2.0	212,000 - 233,000	8.7
32,000 - 36,000	2.2	233,000 - 256,000	9.3
36,000 - 42,000	2.4	256,000 - 280,000	9.9
42,000 - 47,000	2.6	280,000 - 332,000	11
47,000 - 52,000	2.8	332,000 - 390,000	12
52,000 - 57,000	3.0	390,000 - 456,000	14
57,000 - 61,000	3.2	456,000 - 529,000	15
61,000 - 68,000	3.4	529,000 - 610,000	16
68,000 - 73,000	3.6	610,000 - 699,000	17
73,000 - 79,000	3.8	699,000 - 796,000	19
79,000 - 84,000	4.0	796,000 - 1,080,000	22
84,000 - 91,000	4.2	1,080,000 - 1,410,000	25
91,000 - 97,000	4.4	>1,410,000	>25*
97,000 - 100,000	4.6		

* Report distance as 25 miles

Reference Table 16
Neutrally Buoyant Plume Distances to Toxic Endpoint for Release Rate Divided by Endpoint
10-Minute Release, Urban Conditions, D Stability, Wind Speed 3.0 Meters per Second

Release Rate/Endpoint [(lbs/min)/(mg/L)] (*)	Distance to Endpoint (miles)	Release Rate/Endpoint [(lbs/min)/(mg/L)] (*)	Distance to Endpoint (miles)
0 - 160	0.1	600,000 - 660,000	4.8
160 - 1,400	0.2	660,000 - 720,000	5.0
1,400 - 3,600	0.3	720,000 - 810,000	5.2
3,600 - 6,900	0.4	810,000 - 880,000	5.4
6,900 - 13,000	0.6	880,000 - 950,000	5.6
13,000 - 22,000	0.8	950,000 - 1,000,000	5.8
22,000 - 31,000	1.0	1,000,000 - 1,100,000	6.0
31,000 - 42,000	1.2	1,100,000 - 1,220,000	6.2
42,000 - 59,000	1.4	1,220,000 - 1,530,000	6.8
59,000 - 73,000	1.6	1,530,000 - 1,880,000	7.5
73,000 - 88,000	1.8	1,880,000 - 2,280,000	8.1
88,000 - 100,000	2.0	2,280,000 - 2,710,000	8.7
100,000 - 120,000	2.2	2,710,000 - 3,200,000	9.3
120,000 - 150,000	2.4	3,200,000 - 3,730,000	9.9
150,000 - 170,000	2.6	3,730,000 - 4,920,000	11
170,000 - 200,000	2.8	4,920,000 - 6,310,000	12
200,000 - 230,000	3.0	6,310,000 - 7,890,000	14
230,000 - 260,000	3.2	7,890,000 - 9,660,000	15
260,000 - 310,000	3.4	9,660,000 - 11,600,000	16
310,000 - 340,000	3.6	11,600,000 - 13,800,000	17
340,000 - 390,000	3.8	13,800,000 - 16,200,000	19
390,000 - 430,000	4.0	16,200,000 - 23,100,000	22
430,000 - 490,000	4.2	23,100,000 - 31,300,000	25
490,000 - 540,000	4.4	>31,300,000	>25*
540,000 - 600,000	4.6		

* Report distance as 25 miles

Reference Table 17
Neutrally Buoyant Plume Distances to Toxic Endpoint for Release Rate Divided by Endpoint
60-Minute Release, Urban Conditions, D Stability, Wind Speed 3.0 Meters per Second

Release Rate/Endpoint [(lbs/min)/(mg/L)] (*)	Distance to Endpoint (miles)	Release Rate/Endpoint [(lbs/min)/(mg/L)] (*)	Distance to Endpoint (miles)
0 - 200	0.1	460,000 - 490,000	4.8
200 - 1,700	0.2	490,000 - 520,000	5.0
1,700 - 4,500	0.3	520,000 - 550,000	5.2
4,500 - 8,600	0.4	550,000 - 580,000	5.4
8,600 - 17,000	0.6	580,000 - 610,000	5.6
17,000 - 27,000	0.8	610,000 - 640,000	5.8
27,000 - 39,000	1.0	640,000 - 680,000	6.0
39,000 - 53,000	1.2	680,000 - 705,000	6.2
53,000 - 73,000	1.4	705,000 - 804,000	6.8
73,000 - 90,000	1.6	804,000 - 905,000	7.5
90,000 - 110,000	1.8	905,000 - 1,010,000	8.1
110,000 - 130,000	2.0	1,010,000 - 1,120,000	8.7
130,000 - 150,000	2.2	1,120,000 - 1,230,000	9.3
150,000 - 170,000	2.4	1,230,000 - 1,350,000	9.9
170,000 - 200,000	2.6	1,350,000 - 1,620,000	11
200,000 - 220,000	2.8	1,620,000 - 1,920,000	12
220,000 - 240,000	3.0	1,920,000 - 2,250,000	14
240,000 - 270,000	3.2	2,250,000 - 2,620,000	15
270,000 - 300,000	3.4	2,620,000 - 3,030,000	16
300,000 - 320,000	3.6	3,030,000 - 3,490,000	17
320,000 - 350,000	3.8	3,490,000 - 3,980,000	19
350,000 - 370,000	4.0	3,980,000 - 5,410,000	22
370,000 - 410,000	4.2	5,410,000 - 7,120,000	25
410,000 - 430,000	4.4	>7,120,000	>25*
430,000 - 460,000	4.6		

* Report distance as 25 miles

Reference Table 18
Dense Gas Distances to Toxic Endpoint, 10-minute Release, Rural Conditions, D Stability, Wind Speed 3.0 Meters per Second

Release Rate (lbs/min)	Toxic Endpoint (mg/L) Distance (Miles)															
	0.0004	0.0007	0.001	0.002	0.0035	0.005	0.0075	0.01	0.02	0.035	0.05	0.075	0.1	0.25	0.5	0.75
1	0.6	0.4	0.4	0.2	0.2	0.1	0.1	0.1	<0.1	<0.1	??	#	#	#	#	#
2	0.9	0.6	0.5	0.4	0.3	0.2	0.2	0.1	0.1	0.1	<0.1	<0.1	#	#	#	#
5	??	??	0.9	0.6	0.4	0.4	0.3	0.2	0.2	0.1	0.1	0.1	<0.1	#	#	#
10	??	??	??	0.9	0.6	0.5	0.4	0.4	0.2	0.2	0.1	0.1	0.1	<0.1	<0.1	#
30	??	??	??	??	??	0.9	0.7	0.7	0.5	0.3	0.3	0.2	0.2	0.1	0.1	<0.1
50	??	??	??	??	??	??	1.0	0.9	0.6	0.4	0.4	0.3	0.2	0.2	0.1	0.1
100	??	??	??	??	??	??	??	??	0.9	0.6	0.6	0.4	0.4	0.2	0.2	0.1
150	??	??	??	??	??	??	??	??	??	0.8	0.7	0.6	0.5	0.3	0.2	0.2
250	??	??	??	??	??	??	??	??	??	??	0.9	0.7	0.5	0.4	0.3	0.2
500	??	??	??	??	??	??	??	??	??	??	??	??	0.9	0.6	0.4	0.3
750	??	??	??	??	??	??	??	??	??	??	??	??	??	0.7	0.5	0.4
1,000	??	??	??	??	??	??	??	??	??	??	??	??	??	0.8	0.6	0.4
1,500	??	??	??	??	??	??	??	??	??	??	??	??	??	1.0	0.7	0.6
2,000	??	??	??	??	??	??	??	??	??	??	??	??	??	??	0.8	0.6
2,500	??	??	??	??	??	??	??	??	??	??	??	??	??	??	0.9	0.7
3,000	*	*	??	??	??	??	??	??	??	??	??	??	??	??	1.0	0.8
4,000	*	*	??	??	??	??	??	??	??	??	??	??	??	??	??	0.9
5,000	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??	??
7,500	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??	??
10,000	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??
15,000	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??
20,000	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??
50,000	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??
75,000	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??
100,000	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??
150,000	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??
200,000	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??

* > 25 miles (report distance as 25 miles)   # <0.1 mile (report distance as 0.1 mile)

Reference Table 19
Dense Gas Distances to Toxic Endpoint, 60-minute Release, Rural Conditions, D Stability, Wind Speed 3.0 Meters per Second

Release Rate (lbs/min)	Toxic Endpoint (mg/L)															
	0.0004	0.0007	0.001	0.002	0.0035	0.005	0.0075	0.01	0.02	0.035	0.05	0.075	0.1	0.25	0.5	0.75
	Distance (Miles)															
1	0.5	0.4	0.3	0.2	0.2	0.1	0.1	0.1	<0.1	#	#	#	#	#	#	#
2	0.8	0.6	0.5	0.3	0.2	0.2	0.2	0.1	0.1	<0.1	<0.1	??	#	#	#	#
5	??	1.0	0.8	0.5	0.4	0.3	0.2	0.2	0.2	0.1	0.1	0.1	<0.1	#	#	#
10	??	??	??	0.8	0.6	0.5	0.4	0.3	0.2	0.2	0.1	0.1	0.1	<0.1	<0.1	#
30	??	??	??	??	??	0.9	0.7	0.6	0.4	0.3	0.2	0.2	0.2	0.1	0.1	<0.1
50	??	??	??	??	??	??	1.0	0.8	0.6	0.4	0.3	0.3	0.2	0.1	0.1	0.1
100	??	??	??	??	??	??	??	??	0.8	0.6	0.5	0.4	0.3	0.2	0.1	0.1
150	??	??	??	??	??	??	??	??	??	0.7	0.6	0.5	0.4	0.3	0.2	0.1
250	??	??	??	??	??	??	??	??	??	??	0.9	0.7	0.6	0.4	0.2	0.2
500	??	??	??	??	??	??	??	??	??	??	??	1.0	0.9	0.5	0.4	0.3
750	??	??	??	??	??	??	??	??	??	??	??	??	??	0.6	0.4	0.4
1,000	??	??	??	??	??	??	??	??	??	??	??	??	??	0.7	0.5	0.4
1,500	*	*	??	??	??	??	??	??	??	??	??	??	??	1.0	0.7	0.5
2,000	*	*	??	??	??	??	??	??	??	??	??	??	??	??	0.7	0.6
2,500	*	*	*	??	??	??	??	??	??	??	??	??	??	??	0.9	0.7
3,000	*	*	*	??	??	??	??	??	??	??	??	??	??	??	1.0	0.8
4,000	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??	0.9
5,000	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??
7,500	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??
10,000	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??
15,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
20,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
50,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
75,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
100,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
150,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
200,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??

* > 25 miles (report distance as 25 miles)   # <0.1 mile (report distance as 0.1 mile)

Reference Table 20
Dense Gas Distances to Toxic Endpoint, 10-minute Release, Urban Conditions, D Stability, Wind Speed 3.0 Meters per Second

Release Rate (lbs/min)	Toxic Endpoint (mg/L)															
	0.0004	0.0007	0.001	0.002	0.0035	0.005	0.0075	0.01	0.02	0.035	0.05	0.075	0.1	0.25	0.5	0.75
	Distance (Miles)															
1	0.5	0.3	0.2	0.2	0.1	0.1	0.1	0.1	<0.1	#	#	#	#	#	#	#
2	0.7	0.5	0.4	0.3	0.2	0.2	0.1	0.1	0.1	<0.1	<0.1	#	#	#	#	#
5	??	0.8	0.6	0.5	0.3	0.3	0.2	0.2	0.1	0.1	0.1	<0.1	<0.1	#	#	#
10	??	??	1.0	0.7	0.5	0.4	0.3	0.3	0.2	0.1	0.1	0.1	0.1	<0.1	#	#
30	??	??	??	??	0.9	0.8	0.6	0.6	0.4	0.3	0.2	0.2	0.1	0.1	<0.1	#
50	??	??	??	??	??	1.0	0.8	0.7	0.5	0.3	0.3	0.2	0.2	0.1	0.1	<0.1
100	??	??	??	??	??	??	??	1.0	0.7	0.6	0.4	0.4	0.3	0.2	0.1	0.1
150	??	??	??	??	??	??	??	??	0.9	0.7	0.6	0.4	0.4	0.2	0.2	0.1
250	??	??	??	??	??	??	??	??	??	0.9	0.7	0.6	0.5	0.3	0.2	0.1
500	??	??	??	??	??	??	??	??	??	??	1.0	0.8	0.7	0.4	0.3	0.2
750	??	??	??	??	??	??	??	??	??	??	??	1.0	0.9	0.5	0.4	0.3
1,000	??	??	??	??	??	??	??	??	??	??	??	??	1.0	0.6	0.4	0.3
1,500	??	??	??	??	??	??	??	??	??	??	??	??	??	0.7	0.5	0.4
2,000	??	??	??	??	??	??	??	??	??	??	??	??	??	0.9	0.6	0.5
2,500	??	??	??	??	??	??	??	??	??	??	??	??	??	1.0	0.7	0.6
3,000	??	??	??	??	??	??	??	??	??	??	??	??	??	??	0.7	0.6
4,000	*	*	??	??	??	??	??	??	??	??	??	??	??	??	0.9	0.7
5,000	*	*	??	??	??	??	??	??	??	??	??	??	??	??	0.9	0.7
7,500	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??	0.9
10,000	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??	??
15,000	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??	??
20,000	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??
50,000	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??
75,000	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??
100,000	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??
150,000	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??
200,000	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??

* > 25 miles (report distance as 25 miles)   # <0.1 mile (report distance as 0.1 mile)

Reference Table 21
Dense Gas Distances to Toxic Endpoint, 60-minute Release, Urban Conditions, D Stability, Wind Speed 3.0 Meters per Second

Release Rate (lbs/min)	Toxic Endpoint (mg/L)															
	0.0004	0.0007	0.001	0.002	0.0035	0.005	0.0075	0.01	0.02	0.035	0.05	0.075	0.1	0.25	0.5	0.75
	Distance (Miles)															
1	0.4	0.3	0.2	0.2	0.1	0.1	0.1	<0.1	#	#	#	#	#	#	#	#
2	0.7	0.5	0.4	0.2	0.2	0.2	0.1	0.1	<0.1	<0.1	#	#	#	#	#	#
5	??	0.8	0.7	0.4	0.3	0.2	0.2	0.2	0.1	0.1	<0.1	<0.1	<0.1	#	#	#
10	??	??	1.0	0.7	0.5	0.4	0.3	0.3	0.2	0.1	0.1	0.1	0.1	<0.1	#	#
30	??	??	??	??	0.9	0.7	0.6	0.5	0.3	0.2	0.2	0.2	0.1	0.1	<0.1	#
50	??	??	??	??	??	1.0	0.8	0.7	0.4	0.3	0.3	0.2	0.2	0.1	0.1	<0.1
100	??	??	??	??	??	??	??	1.0	0.7	0.5	0.4	0.3	0.3	0.2	0.1	0.1
150	??	??	??	??	??	??	??	??	0.9	0.6	0.5	0.4	0.3	0.2	0.1	0.1
250	??	??	??	??	??	??	??	??	??	0.8	0.7	0.5	0.4	0.3	0.2	0.1
500	??	??	??	??	??	??	??	??	??	??	1.0	0.8	0.7	0.4	0.2	0.2
750	??	??	??	??	??	??	??	??	??	??	??	1.0	0.9	0.5	0.3	0.3
1,000	??	??	??	??	??	??	??	??	??	??	??	??	1.0	0.6	0.4	0.3
1,500	??	??	??	??	??	??	??	??	??	??	??	??	??	0.7	0.5	0.4
2,000	*	*	??	??	??	??	??	??	??	??	??	??	??	0.9	0.6	0.4
2,500	*	*	??	??	??	??	??	??	??	??	??	??	??	1.0	0.6	0.5
3,000	*	*	*	??	??	??	??	??	??	??	??	??	??	??	0.7	0.6
4,000	*	*	*	??	??	??	??	??	??	??	??	??	??	??	0.9	0.7
5,000	*	*	*	*	??	??	??	??	??	??	??	??	??	??	1.0	0.7
7,500	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??	0.9
10,000	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??	??
15,000	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??	??
20,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
50,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
75,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
100,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
150,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??
200,000	*	*	*	*	*	*	*	??	??	??	??	??	??	??	??	??

* > 25 miles (report distance as 25 miles)   # <0.1 mile (report distance as 0.1 mile)

Reference Table 22
Distances to Toxic Endpoint for Anhydrous Ammonia
D Stability, Wind Speed 3.0 Meters per Second

Release Rate (lbs/min)	Distance to Endpoint (miles)		Release Rate (lbs/min)	Distance to Endpoint (miles)	
	Rural	Urban		Rural	Urban
<10	<0.1*		900	0.6	0.2
10	0.1		1,000	0.6	0.2
15	0.1		1,500	0.7	0.3
20	0.1	<0.1*	2,000	0.8	0.3
30	0.1		2,500	0.9	0.3
40	0.1		3,000	1.0	0.4
50	0.1		4,000	1.2	0.4
60	0.2	0.1	5,000	1.3	0.5
70	0.2	0.1	7,500	1.6	0.5
80	0.2	0.1	10,000	1.8	0.6
90	0.2	0.1	15,000	2.2	0.7
100	0.2	0.1	20,000	2.5	0.8
150	0.2	0.1	25,000	2.8	0.9
200	0.3	0.1	30,000	3.1	1.0
250	0.3	0.1	40,000	3.5	1.1
300	0.3	0.1	50,000	3.9	1.2
400	0.4	0.2	75,000	4.8	1.4
500	0.4	0.2	100,000	5.4	1.6
600	0.5	0.2	150,000	6.6	1.9
700	0.5	0.2	200,000	7.6	2.1
750	0.5	0.2	250,000	8.4	2.3
800	0.5	0.2			

* Report distance as 0.1 mile

Reference Table 23
Distances to Toxic Endpoint for Aqueous Ammonia
D Stability, Wind Speed 3.0 Meters per Second

Release Rate (lbs/min)	Distance to Endpoint (miles)		Release Rate (lbs/min)	Distance to Endpoint (miles)	
	Rural	Urban		Rural	Urban
8	0.1		800	0.7	0.2
10	0.1		900	0.7	0.3
15	0.1	<0.1*	1,000	0.8	0.3
20	0.1		1,500	1.0	0.4
30	0.1		2,000	1.2	0.4
40	0.1		2,500	1.2	0.4
50	0.2	0.1	3,000	1.5	0.5
60	0.2	0.1	4,000	1.8	0.6
70	0.2	0.1	5,000	2.0	0.7
80	0.2	0.1	7,500	2.2	0.7
90	0.2	0.1	10,000	2.5	0.8
100	0.2	0.1	15,000	3.1	1.0
150	0.3	0.1	20,000	3.6	1.2
200	0.3	0.1	25,000	4.1	1.3
250	0.4	0.2	30,000	4.4	1.4
300	0.4	0.2	40,000	5.1	1.6
400	0.4	0.2	50,000	5.8	1.8
500	0.5	0.2	75,000	7.1	2.2
600	0.6	0.2	100,000	8.2	2.5
700	0.6	0.2	150,000	10	3.1
750	0.6	0.2	200,000	12	3.5

* Report distance as 0.1 mile

Reference Table 24
Distances to Toxic Endpoint for Chlorine
D Stability, Wind Speed 3.0 Meters per Second

Release Rate (lbs/min)	Distance to Endpoint (miles)		Release Rate (lbs/min)	Distance to Endpoint (miles)	
	Rural	Urban		Rural	Urban
1	<0.1*	<0.1*	750	1.2	0.4
2	0.1		800	1.2	0.5
5	0.1		900	1.2	0.5
10	0.2	0.1	1,000	1.3	0.5
15	0.2	0.1	1,500	1.6	0.6
20	0.2	0.1	2,000	1.8	0.6
30	0.3	0.1	2,500	2.0	0.7
40	0.3	0.1	3,000	2.2	0.8
50	0.3	0.1	4,000	2.5	0.8
60	0.4	0.2	5,000	2.8	0.9
70	0.4	0.2	7,500	3.4	1.2
80	0.4	0.2	10,000	3.9	1.3
90	0.4	0.2	15,000	4.6	1.6
100	0.5	0.2	20,000	5.3	1.8
150	0.6	0.2	25,000	5.9	2.0
200	0.6	0.3	30,000	6.4	2.1
250	0.7	0.3	40,000	7.3	2.4
300	0.8	0.3	50,000	8.1	2.7
400	0.8	0.4	75,000	9.8	3.2
500	1.0	0.4	100,000	11	3.6
600	1.0	0.4	150,000	13	4.2
700	1.1	0.4	200,000	15	4.8

* Report distance as 0.1 mile

Reference Table 25
Distances to Toxic Endpoint for Sulfur Dioxide
D Stability, Wind Speed 3.0 Meters per Second

Release Rate (lbs/min)	Distance to Endpoint (miles)		Release Rate (lbs/min)	Distance to Endpoint (miles)	
	Rural	Urban		Rural	Urban
1	<0.1*	<0.1*	750	1.3	0.5
2	0.1		800	1.3	0.5
5	0.1		900	1.4	0.5
10	0.2	0.1	1,000	1.5	0.5
15	0.2	0.1	1,500	1.9	0.6
20	0.2	0.1	2,000	2.2	0.7
30	0.2	0.1	2,500	2.3	0.8
40	0.3	0.1	3,000	2.7	0.8
50	0.3	0.1	4,000	3.1	1.0
60	0.4	0.2	5,000	3.3	1.1
70	0.4	0.2	7,500	4.0	1.3
80	0.4	0.2	10,000	4.6	1.4
90	0.4	0.2	15,000	5.6	1.7
100	0.5	0.2	20,000	6.5	1.9
150	0.6	0.2	25,000	7.3	2.1
200	0.6	0.2	30,000	8.0	2.3
250	0.7	0.3	40,000	9.2	2.6
300	0.8	0.3	50,000	10	2.9
400	0.9	0.4	75,000	13	3.5
500	1.0	0.4	100,000	14	4.0
600	1.1	0.4	150,000	18	4.7
700	1.2	0.4	200,000	20	5.4

* Report distance as 0.1 mile

Reference Table 26
Neutrally Buoyant Plume Distances to Lower Flammability Limit (LFL)
For Release Rate Divided by LFL
Rural Conditions, D Stability, Wind Speed 3.0 Meters per Second

Release Rate/Endpoint [(lbs/min)/(mg/L)]	Distance to Endpoint (miles)	Release Rate/Endpoint [(lbs/min)/(mg/L)]	Distance to Endpoint (miles)
0 - 28	0.1	2,700 - 3,300	0.9
28 - 40	0.1	3,300 - 3,900	1.0
40 - 60	0.1	3,900 - 4,500	1.1
60 - 220	0.2	4,500 - 5,200	1.2
220 - 530	0.3	5,200 - 5,800	1.3
530 - 860	0.4	5,800 - 6,800	1.4
860 - 1,300	0.5	6,800 - 8,200	1.6
1,300 - 1,700	0.6	8,200 - 9,700	1.8
1,700 - 2,200	0.7	9,700 - 11,000	2.0
2,200 - 2,700	0.8	11,000 - 13,000	2.2

Reference Table 27
Neutrally Buoyant Plume Distances to Lower Flammability Limit (LFL)
For Release Rate Divided by LFL
Urban Conditions, D Stability, Wind Speed 3.0 Meters per Second

Release Rate/Endpoint [(lbs/min)/(mg/L)]	Distance to Endpoint (miles)	Release Rate/Endpoint [(lbs/min)/(mg/L)]	Distance to Endpoint (miles)
0 - 68	0.1	5,500 - 7,300	0.7
68 - 100	0.1	7,300 - 9,200	0.8
100 - 150	0.1	9,200 - 11,000	0.9
150 - 710	0.2	11,000 - 14,000	1.0
710 - 1,500	0.3	14,000 - 18,000	1.2
1,500 - 2,600	0.4	18,000 - 26,000	1.4
2,600 - 4,000	0.5	26,000 - 31,000	1.6
4,000 - 5,500	0.6	31,000 - 38,000	1.8

Reference Table 28
Dense Gas Distances to Lower Flammability Limit
Rural Conditions, D Stability, Wind Speed 3.0 Meters per Second

Release Rate (lbs/min)	Lower Flammability Limit (mg/L)									
	27	30	35	40	45	50	60	70	100	>100
	Distance (Miles)									
<1,500	??	#	#	#	#	#	#	#	#	#
1,500	<0.1	<0.1	#	#	#	#	#	#	#	#
2,000	0.1	0.1	<0.1	#	#	#	#	#	#	#
2,500	0.1	0.1	0.1	<0.1	#	#	#	#	#	#
3,000	0.1	0.1	0.1	0.1	<0.1	<0.1	#	#	#	#
4,000	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	#	#	#
5,000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	#	#
7,500	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	#
10,000	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1

\# < 0.1 mile (report distance a 0.1 mile)

Reference Table 29
Dense Gas Distances to Lower Flammability Limit
Urban Conditions, D Stability, Wind Speed 3.0 Meters per Second

Release Rate (lbs/min)	Lower Flammability Limit (mg/L)				
	27	30	35	40	>40
	Distance (Miles)				
<5,000	??	#	#	#	#
5,000	<0.1	<0.1	#	#	#
7,500	0.1	0.1	<0.1	#	#
10,000	0.1	0.1	0.1	<0.1	#

\# < 0.1 mile (report distance as 0.1 mile)

Exhibit B-1
Data for Toxic Gases

CAS Number	Chemical Name	Molecular Weight	Ratio of Specific Heats	Toxic Endpoint[a]			Liquid Factor Boiling (LFB)	Density Factor (DF) (Boiling)	Gas Factor (GF)[k]	Vapor Pressure @25℃ (psi)	Reference Table[b]
				mg/L	ppm	Basis					
7664-41-7	Ammonia (anhydrous)[c]	17.03	1.31	0.14	200	ERPG-2	0.073	0.71	14	145	Buoyant[d]
7784-42-1	Arsine	77.95	1.28	0.0019	0.6	EHS-LOC (IDLH)	0.23	0.30	30	239	Dense
10294-34-5	Boron trichloride	117.17	1.15	0.010	2	EHS-LOC (Tox[e])	0.22	0.36	36	22.7	Dense
7637-07-2	Boron trifluoride	67.81	1.20	0.028	10	EHS-LOC (IDLH)	0.25	0.31	28	[f]	Dense
7782-50-5	Chlorine	70.91	1.32	0.0087	3	ERPG-2	0.19	0.31	29	113	Dense
10049-04-4	Chlorine dioxide	67.45	1.25	0.0028	1	EHS-LOC equivalent (IDLH)[g]	0.15	0.30	28	24.3	Dense
506-77-4	Cyanogen chloride	61.47	1.22	0.030	12	EHS-LOC equivalent (Tox)[h]	0.14	0.41	26	23.7	Dense
19287-45-7	Diborane	27.67	1.17	0.0011	1	ERPG-2	0.13	1.13	17	[f]	Buoyant[d]
75-21-8	Ethylene oxide	44.05	1.21	0.090	50	ERPG-2	0.12	0.55	22	25.4	Dense
7782-41-4	Fluorine	38.00	1.36	0.0039	2.5	EHS-LOC (IDLH)	0.35	0.32	22	[f]	Dense
50-00-0	Formaldehyde (anhydrous)[c]	30.03	1.31	0.012	10	ERPG-2	0.10	0.59	19	75.2	Dense
74-90-8	Hydrocyanic acid	27.03	1.30	0.011	10	ERPG-2	0.079	0.72	18	14.8	Buoyant[d]
7647-01-0	Hydrogen chloride (anhydrous)[c]	36.46	1.40	0.030	20	ERPG-2	0.15	0.41	21	684	Dense
7664-39-3	Hydrogen fluoride (anhydrous)[c]	20.01	1.40	0.016	20	ERPG-2	0.066	0.51	16	17.7	Buoyant[i]
7783-07-5	Hydrogen selenide	80.98	1.32	0.00066	0.2	EHS-LOC (IDLH)	0.21	0.25	31	151	Dense
7783-06-4	Hydrogen sulfide	34.08	1.32	0.042	30	ERPG-2	0.13	0.51	20	302	Dense
74-87-3	Methyl chloride	50.49	1.26	0.82	400	ERPG-2	0.14	0.48	24	83.2	Dense
74-93-1	Methyl mercaptan	48.11	1.20	0.049	25	ERPG-2	0.12	0.55	23	29.2	Dense
10102-43-9	Nitric oxide	30.01	1.38	0.031	25	EHS-LOC (TLV[j])	0.21	0.38	19	[f]	Dense

CAS Number	Chemical Name	Molecular Weight	Ratio of Specific Heats	Toxic Endpoint[a]			Liquid Factor Boiling (LFB)	Density Factor (DF) (Boiling)	Gas Factor (GF)[k]	Vapor Pressure @25EC (psi)	Reference Table[b]
				mg/L	ppm	Basis					
75-44-5	Phosgene	98.92	1.17	0.00081	0.2	ERPG-2	0.20	0.35	33	27.4	Dense
7803-51-2	Phosphine	34.00	1.29	0.0035	2.5	ERPG-2	0.15	0.66	20	567	Dense
7446-09-5	Sulfur dioxide (anhydrous)	64.07	1.26	0.0078	3	ERPG-2	0.16	0.33	27	58.0	Dense
7783-60-0	Sulfur tetrafluoride	108.06	1.30	0.0092	2	EHS-LOC (Tox[e])	0.25	0.25 (at -73 ºC)	36	293	Dense

Notes:

[a] Toxic endpoints are specified in Appendix A to 40 CFR Part 68 in units of mg/L. To convert from units of mg/L to mg/m^3, multiply by 1,000. To convert mg/L to ppm, use the following equation:

$$Endpoint_{ppm} = (Endpoint_{mg/l} \times 1,000 \times 24.5)/Molecular\ Weight$$

[b] "Buoyant" in the Reference Table column refers to the tables for neutrally buoyant gases and vapors; "Dense" refers to the tables for dense gases and vapors. See OCAG, Appendix D, Section D.4.4, for more information on the choice of reference tables.

[c] See Exhibit B-3 of OCAG, Appendix B, for data on water solutions.

[d] Gases that are lighter than air may behave as dense gases upon release if liquefied under pressure or cold; consider the conditions of release when choosing the appropriate table.

[e] LOC is based on the IDLH-equivalent level estimated from toxicity data.

[f] Cannot be liquefied at 25EC.

[g] Not an EHS; LOC-equivalent value was estimated from one-tenth of the IDLH.

[h] Not an EHS; LOC-equivalent value was estimated from one-tenth of the IDLH-equivalent level estimated from toxicity data.

[I] Hydrogen fluoride is lighter than air, but may behave as a dense gas upon release under some circumstances (e.g., release under pressure, high concentration in the released cloud) because of hydrogen bonding; consider the conditions of release when choosing the appropriate table.

[j] LOC based on Threshold Limit Value (TLV) - Time-weighted average (TWA) developed by the American Conference of Governmental Industrial Hygienists (ACGIH).

[k] Use GF for gas leaks under choked (maximum) flow conditions.

Exhibit B-2
Data for Toxic Liquids

CAS Number	Chemical Name	Molecular Weight	Vapor Pressure at 25εC (mm Hg)	Toxic Endpoint[a]			Liquid Factors		Density Factor (DF)	Liquid Leak Factor (LLF)[1]	Reference Table[b]	
				mg/L	ppm	Basis	Ambient (LFA)	Boiling (LFB)			Worst Case	Alternative Case
107-02-8	Acrolein	56.06	274	0.0011	0.5	ERPG-2	0.047	0.12	0.58	40	Dense	Dense
107-13-1	Acrylonitrile	53.06	108	0.076	35	ERPG-2	0.018	0.11	0.61	39	Dense	Dense
814-68-6	Acrylyl chloride	90.51	110	0.00090	0.2	EHS-LOC (Tox[c])	0.026	0.15	0.44	54	Dense	Dense
107-18-6	Allyl alcohol	58.08	26.1	0.036	15	EHS-LOC (IDLH)	0.0046	0.11	0.58	41	Dense	Buoyant[d]
107-11-9	Allylamine	57.10	242	0.0032	1	EHS-LOC (Tox[c])	0.042	0.12	0.64	36	Dense	Dense
7784-34-1	Arsenous trichloride	181.28	10	0.01	1	EHS-LOC (Tox[c])	0.0037	0.21	0.23	100	Dense	Buoyant[d]
353-42-4	Boron trifluoride compound with methyl ether (1:1)	113.89	11	0.023	5	EHS-LOC (Tox[c])	0.0030	0.16	0.49	48	Dense	Buoyant[d]
7726-95-6	Bromine	159.81	212	0.0065	1	ERPG-2	0.073	0.23	0.16	150	Dense	Dense
75-15-0	Carbon disulfide	76.14	359	0.16	50	ERPG-2	0.075	0.15	0.39	60	Dense	Dense
67-66-3	Chloroform	119.38	196	0.49	100	EHS-LOC (IDLH)	0.055	0.19	0.33	71	Dense	Dense
542-88-1	Chloromethyl ether	114.96	29.4	0.00025	0.05	EHS-LOC (Tox[c])	0.0080	0.17	0.37	63	Dense	Dense
107-30-2	Chloromethyl methyl ether	80.51	199	0.0018	0.6	EHS-LOC (Tox[c])	0.043	0.15	0.46	51	Dense	Dense
4170-30-3	Crotonaldehyde	70.09	33.1	0.029	10	ERPG-2	0.0066	0.12	0.58	41	Dense	Buoyant[d]
123-73-9	Crotonaldehyde, (E)-	70.09	33.1	0.029	10	ERPG-2	0.0066	0.12	0.58	41	Dense	Buoyant[d]
108-91-8	Cyclohexylamine	99.18	10.1	0.16	39	EHS-LOC (Tox[c])	0.0025	0.14	0.56	41	Dense	Buoyant[d]
75-78-5	Dimethyldichlorosilane	129.06	141	0.026	5	ERPG-2	0.042	0.20	0.46	51	Dense	Dense
57-14-7	1,1-Dimethylhydrazine	60.10	157	0.012	5	EHS-LOC (IDLH)	0.028	0.12	0.62	38	Dense	Dense
106-89-8	Epichlorohydrin	92.53	17.0	0.076	20	ERPG-2	0.0040	0.14	0.42	57	Dense	Buoyant[d]
107-15-3	Ethylenediamine	60.10	12.2	0.49	200	EHS-LOC (IDLH)	0.0022	0.10	0.54	43	Dense	Buoyant[d]
151-56-4	Ethyleneimine	43.07	211	0.018	10	EHS-LOC (IDLH)	0.030	0.10	0.58	40	Dense	Dense
110-00-9	Furan	68.08	600	0.0012	0.4	EHS-LOC (Tox[c])	0.12	0.14	0.52	45	Dense	Dense
302-01-2	Hydrazine	32.05	14.4	0.011	8	EHS-LOC (IDLH)	0.0017	0.069	0.48	48	Buoyant[d]	Buoyant[d]

CAS Number	Chemical Name	Molecular Weight	Vapor Pressure at 25°C (mm Hg)	Toxic Endpoint[a]			Liquid Factors		Density Factor (DF)	Liquid Leak Factor (LLF)[I]	Reference Table[b]	
				mg/L	ppm	Basis	Ambient (LFA)	Boiling (LFB)			Worst Case	Alternative Case
13463-40-6	Iron, pentacarbonyl-	195.90	40	0.00044	0.05	EHS-LOC (Tox[c])	0.016	0.24	0.33	70	Dense	Dense
78-82-0	Isobutyronitrile	69.11	32.7	0.14	50	ERPG-2	0.0064	0.12	0.63	37	Dense	Buoyant[d]
108-23-6	Isopropyl chloroformate	122.55	28	0.10	20	EHS-LOC (Tox[c])	0.0080	0.17	0.45	52	Dense	Dense
126-98-7	Methacrylonitrile	67.09	71.2	0.0027	1	EHS-LOC (TLV[e])	0.014	0.12	0.61	38	Dense	Dense
79-22-1	Methyl chloroformate	94.50	108	0.0019	0.5	EHS-LOC (Tox[c])	0.026	0.16	0.40	58	Dense	Dense
60-34-4	Methyl hydrazine	46.07	49.6	0.0094	5	EHS-LOC (IDLH)	0.0074	0.094	0.56	42	Dense	Buoyant[d]
624-83-9	Methyl isocyanate	57.05	457	0.0012	0.5	ERPG-2	0.079	0.13	0.52	45	Dense	Dense
556-64-9	Methyl thiocyanate	73.12	10	0.085	29	EHS-LOC (Tox[c])	0.0020	0.11	0.45	51	Dense	Buoyant[d]
75-79-6	Methyltrichlorosilane	149.48	173	0.018	3	ERPG-2	0.057	0.22	0.38	61	Dense	Dense
13463-39-3	Nickel carbonyl	170.73	400	0.00067	0.1	EHS-LOC (Tox[c])	0.14	0.26	0.37	63	Dense	Dense
7697-37-2	Nitric acid (100%)[f]	63.01	63.0	0.026	10	EHS-LOC (IDLH)	0.012	0.12	0.32	73	Dense	Dense
79-21-0	Peracetic acid	76.05	13.9	0.0045	1.5	EHS-LOC (Tox[c])	0.0029	0.12	0.40	58	Dense	Buoyant[d]
594-42-3	Perchloromethylmercaptan	185.87	6	0.0076	1	EHS-LOC (IDLH)	0.0023	0.20	0.29	81	Dense	Buoyant[d]
10025-87-3	Phosphorus oxychloride	153.33	35.8	0.0030	0.5	EHS-LOC (Tox[c])	0.012	0.20	0.29	80	Dense	Dense
7719-12-2	Phosphorus trichloride	137.33	120	0.028	5	EHS-LOC (IDLH)	0.037	0.20	0.31	75	Dense	Dense
110-89-4	Piperidine	85.15	32.1	0.022	6	EHS-LOC (Tox[c])	0.0072	0.13	0.57	41	Dense	Buoyant[d]
107-12-0	Propionitrile	55.08	47.3	0.0037	1.6	EHS-LOC (Tox[c])	0.0080	0.10	0.63	37	Dense	Buoyant[d]
109-61-5	Propyl chloroformate	122.56	20.0	0.010	2	EHS-LOC (Tox[c])	0.0058	0.17	0.45	52	Dense	Buoyant[d]
75-55-8	Propyleneimine	57.10	187	0.12	50	EHS-LOC (IDLH)	0.032	0.12	0.61	39	Dense	Dense
75-56-9	Propylene oxide	58.08	533	0.59	250	ERPG-2	0.093	0.13	0.59	40	Dense	Dense
7446-11-9	Sulfur trioxide	80.06	263	0.010	3	ERPG-2	0.057	0.15	0.26	91	Dense	Dense
75-74-1	Tetramethyllead	267.33	22.5	0.0040	0.4	EHS-LOC (IDLH)	0.011	0.29	0.24	96	Dense	Dense
509-14-8	Tetranitromethane	196.04	11.4	0.0040	0.5	EHS-LOC (IDLH)	0.0045	0.22	0.30	78	Dense	Buoyant[d]
7550-45-0	Titanium tetrachloride	189.69	12.4	0.020	2.6	ERPG-2	0.0048	0.21	0.28	82	Dense	Buoyant[d]

CAS Number	Chemical Name	Molecular Weight	Vapor Pressure at 25℃ (mm Hg)	Toxic Endpoint[a]			Liquid Factors		Density Factor (DF)	Liquid Leak Factor (LLF)[I]	Reference Table[b]	
				mg/L	ppm	Basis	Ambient (LFA)	Boiling (LFB)			Worst Case	Alternative Case
584-84-9	Toluene 2,4-diisocyanate	174.16	0.017	0.0070	1	EHS-LOC (IDLH)	0.000006	0.16	0.40	59	Buoyant[d]	Buoyant[d]
91-08-7	Toluene 2,6-diisocyanate	174.16	0.05	0.0070	1	EHS-LOC (IDLH[g])	0.000018	0.16	0.40	59	Buoyant[d]	Buoyant[d]
26471-62-5	Toluene diisocyanate (unspecified isomer)	174.16	0.017	0.0070	1	EHS-LOC equivalent (IDLH[h])	0.000006	0.16	0.40	59	Buoyant[d]	Buoyant[d]
75-77-4	Trimethylchlorosilane	108.64	231	0.050	11	EHS-LOC (Tox[c])	0.061	0.18	0.57	41	Dense	Dense
108-05-4	Vinyl acetate monomer	86.09	113	0.26	75	ERPG-2	0.026	0.15	0.53	45	Dense	Dense

Notes:

[a] Toxic endpoints are specified in the Appendix A to 40 CFR Part 68 in units of mg/L. To convert from units of mg/L to mg/m^3, multiply by 1,000. To convert mg/L to ppm, use the following equation:

$$Endpoint_{ppm} = (Endpoint_{mg/l} \times 1,000 \times 24.5)/Molecular\ Weight$$

[b] "Buoyant" in the Reference Table column refers to the tables for neutrally buoyant gases and vapors; "Dense" refers to the tables for dense gases and vapors. See OCAG, Appendix D, Section D.4.4, for more information on the choice of reference tables.

[c] LOC is based on IDLH-equivalent level estimated from toxicity data.

[d] Use dense gas table if substance is at an elevated temperature.

[e] LOC based on Threshold Limit Value (TLV) - Time-weighted average (TWA) developed by the American Conference of Governmental Industrial Hygienists (ACGIH).

[f] See Exhibit B-3 of OCAG, Appendix B, for data on water solutions.

[g] LOC for this isomer is based on IDLH for toluene 2,4-diisocyanate.

[h] Not an EHS; LOC-equivalent value is based on IDLH for toluene 2,4-diisocyanate.

[I] Use the LLF only for leaks from tanks at atmospheric pressure.

Exhibit B-3
Data for Water Solutions of Toxic Substances and for Oleum
Average Vapor Pressure and Liquid Factors Over 10 Minutes for
Wind Speeds of 1.5 and 3.0 Meters per Second (m/s)

CAS Number	Regulated Substance in Solution	Molecular Weight	Toxic Endpoint[a]			Initial Concen-tration (Wt %)	10-min. Average Vapor Pressure (mm Hg)		Liquid Factor at 25ᴇ C (LFA)		Density Factor (DF)	Liquid Leak Factor (LLF)	Reference Table[b]	
			mg/L	ppm	Basis		1.5 m/s	3.0 m/s	1.5 m/s	3.0 m/s			Worst	Alternative
7664-41-7	Ammonia	17.03	0.14	200	ERPG-2	30	332	248	0.026	0.019	0.55	43	Buoyant	Buoyant
						24	241	184	0.019	0.014	0.54	44	Buoyant	Buoyant
						20	190	148	0.015	0.011	0.53	44	Buoyant	Buoyant
50-00-0	Formaldehyde	30.027	0.012	10	ERPG-2	37	1.5	1.4	0.0002	0.0002	0.44	53	Buoyant	Buoyant
7647-01-0	Hydrochloric acid	36.46	0.030	20	ERPG-2	38	78	55	0.010	0.0070	0.41	57	Dense	Buoyant
						37	67	48	0.0085	0.0062	0.42	57	Dense	Buoyant
						36[c]	56	42	0.0072	0.0053	0.42	57	Dense	Buoyant
						34[c]	38	29	0.0048	0.0037	0.42	56	Dense	Buoyant
						30[c]	13	12	0.0016	0.0015	0.42	55	Buoyant	Buoyant
7664-39-3	Hydrofluoric acid	20.01	0.016	20	ERPG-2	70	124	107	0.011	0.010	0.39	61	Buoyant	Buoyant
						50	16	15	0.0014	0.0013	0.41	58	Buoyant	Buoyant
7697-37-2	Nitric acid	63.01	0.026	10	EHS-LOC (IDLH)	90	25	22	0.0046	0.0040	0.33	71	Dense	Buoyant
						85	17	16	0.0032	0.0029	0.33	70	Dense	Buoyant
						80	10.2	10	0.0019	0.0018	0.33	70	Dense	Buoyant
8014-95-7	Oleum - based on SO₃	80.06 (SO₃)	0.010	3	ERPG-2	30 (SO₃)	3.5 (SO₃)	3.4 (SO₃)	0.0008	0.0007	0.25	93	Buoyant	Buoyant

Notes:
[a] Toxic endpoints are specified in the Appendix A to 40 CFR Part 68 in units of mg/L. See Notes to Exhibit B-1 or B-2 for converting to other units.
[b] "Buoyant" in the Reference Table column refers to the tables for neutrally buoyant gases and vapors; "Dense" refers to the tables for dense gases and vapors. See OCAG, Appendix D, Section D.4.4, for more information on the choice of reference tables.
[c] Hydrochloric acid in concentrations below 37 percent is not regulated.

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Exhibit B-4
Temperature Correction Factors for Liquids Evaporating from Pools at Temperatures
Between 25EC and 50EC (77EF and 122EF)

CAS Number	Chemical Name	Boiling Point (EC)	Temperature Correction Factor (TCF)				
			30EC (86EF)	35EC (95EF)	40EC (104EF)	45EC (113EF)	50EC (122EF)
107-02-8	Acrolein	52.69	1.2	1.4	1.7	2.0	2.3
107-13-1	Acrylonitrile	77.35	1.2	1.5	1.8	2.1	2.5
814-68-6	Acrylyl chloride	75.00	ND	ND	ND	ND	ND
107-18-6	Allyl alcohol	97.08	1.3	1.7	2.2	2.9	3.6
107-11-9	Allylamine	53.30	1.2	1.5	1.8	2.1	2.5
7784-34-1	Arsenous trichloride	130.06	ND	ND	ND	ND	ND
353-42-4	Boron trifluoride compound with methyl ether (1:1)	126.85	ND	ND	ND	ND	ND
7726-95-6	Bromine	58.75	1.2	1.5	1.7	2.1	2.5
75-15-0	Carbon disulfide	46.22	1.2	1.4	1.6	1.9	LFB
67-66-3	Chloroform	61.18	1.2	1.5	1.8	2.1	2.5
542-88-1	Chloromethyl ether	104.85	1.3	1.6	2.0	2.5	3.1
107-30-2	Chloromethyl methyl ether	59.50	1.2	1.5	1.8	2.1	2.5
4170-30-3	Crotonaldehyde	104.10	1.3	1.6	2.0	2.5	3.1
123-73-9	Crotonaldehyde, (E)-	102.22	1.3	1.6	2.0	2.5	3.1
108-91-8	Cyclohexylamine	134.50	1.3	1.7	2.1	2.7	3.4
75-78-5	Dimethyldichlorosilane	70.20	1.2	1.5	1.8	2.1	2.5
57-14-7	1,1-Dimethylhydrazine	63.90	ND	ND	ND	ND	ND
106-89-8	Epichlorohydrin	118.50	1.3	1.7	2.1	2.7	3.4
107-15-3	Ethylenediamine	117.40	1.3	1.8	2.3	3.0	3.8
151-56-4	Ethyleneimine	55.85	1.2	1.5	1.8	2.2	2.7
110-00-9	Furan	31.35	1.2	LFB	LFB	LFB	LFB
302-01-2	Hydrazine	113.50	1.3	1.7	2.2	2.9	3.6
13463-40-6	Iron, pentacarbonyl-	102.65	ND	ND	ND	ND	ND
78-82-0	Isobutyronitrile	103.61	1.3	1.6	2.0	2.5	3.1
108-23-6	Isopropyl chloroformate	104.60	ND	ND	ND	ND	ND
126-98-7	Methacrylonitrile	90.30	1.2	1.5	1.8	2.2	2.6
79-22-1	Methyl chloroformate	70.85	1.3	1.6	1.9	2.4	2.9
60-34-4	Methyl hydrazine	87.50	ND	ND	ND	ND	ND
624-83-9	Methyl isocyanate	38.85	1.2	1.4	LFB	LFB	LFB
556-64-9	Methyl thiocyanate	130.00	ND	ND	ND	ND	ND
75-79-6	Methyltrichlorosilane	66.40	1.2	1.4	1.7	2.0	2.4

CAS Number	Chemical Name	Boiling Point (EC)	Temperature Correction Factor (TCF)				
			30EC (86EF)	35EC (95EF)	40EC (104EF)	45EC (113EF)	50EC (122EF)
13463-39-3	Nickel carbonyl	42.85	ND	ND	ND	ND	ND
7697-37-2	Nitric acid	83.00	1.3	1.6	2.0	2.5	3.1
79-21-0	Peracetic acid	109.85	1.3	1.8	2.3	3.0	3.8
594-42-3	Perchloromethylmercaptan	147.00	ND	ND	ND	ND	ND
10025-87-3	Phosphorus oxychloride	105.50	1.3	1.6	1.9	2.4	2.9
7719-12-2	Phosphorus trichloride	76.10	1.2	1.5	1.8	2.1	2.5
110-89-4	Piperidine	106.40	1.3	1.6	2.0	2.4	3.0
107-12-0	Propionitrile	97.35	1.3	1.6	1.9	2.3	2.8
109-61-5	Propyl chloroformate	112.40	ND	ND	ND	ND	ND
75-55-8	Propyleneimine	60.85	1.2	1.5	1.8	2.1	2.5
75-56-9	Propylene oxide	33.90	1.2	LFB	LFB	LFB	LFB
7446-11-9	Sulfur trioxide	44.75	1.3	1.7	LFB	LFB	LFB
75-74-1	Tetramethyllead	110.00	ND	ND	ND	ND	ND
509-14-8	Tetranitromethane	125.70	1.3	1.7	2.2	2.8	3.5
7550-45-0	Titanium tetrachloride	135.85	1.3	1.6	2.0	2.6	3.2
584-84-9	Toluene 2,4-diisocyanate	251.00	1.6	2.4	3.6	5.3	7.7
91-08-7	Toluene 2,6-diisocyanate	244.85	ND	ND	ND	ND	ND
26471-62-5	Toluene diisocyanate (unspecified isomer)	250.00	1.6	2.4	3.6	5.3	7.7
75-77-4	Trimethylchlorosilane	57.60	1.2	1.4	1.7	2.0	2.3
108-05-4	Vinyl acetate monomer	72.50	1.2	1.5	1.9	2.3	2.7

Notes:
ND: No data available
LFB: Chemical above boiling point at this temperature; use LFB for analysis

Explanation of Temperature Correction Factors. Temperature correction factors were developed for toxic liquids released at temperatures above 25EC, the temperature used for development of the LFAs. The factors are based on vapor pressures calculated from the coefficients provided in *Physical and Thermodynamic Properties of Pure Chemicals, Data Compilation*, developed by the Design Institute for Physical Property Data (DIPPR), American Institute of Chemical Engineers. The factors are calculated as follows:

$$TCF_T = (VP_T \times 298)/(VP_{298} \times T)$$

where:

TCF_T = Temperature Correction Factor at temperature T
VP_T = Vapor pressure at temperature T
VP_{298} = Vapor pressure at 298K
T = Temperature (K)

Factors were developed at intervals of 5EC for temperatures up to 50EC. The above equation is the same as Equation D-5 in the OCAG.

For temperatures exceeding 25 ºC, the value of LFA in Equation 1 or Equation 4 of Chapter 4 should be multiplied by the appropriate temperature correction factor (TCF), or, equivalently, the calculated evaporation rate should be multiplied by TCF. For example, in Example 3 in Chapter 4, a release rate of 13 lb/min has been calculated following an accidental spillage of dimethyldichlorosilane from a 55-gallon drum at 25EC. If the spill were at 45EC, TCF would be 2.1 (from Exhibit B-4), and the predicted rate of evaporation would be 13 x 2.1 = 27.3 lb/min.

Exhibit C-1
Heats of Combustion for Flammable Substances

CAS No.	Chemical Name	Physical State at 25EC	Heat of Combustion (kjoule/kg)
75-07-0	Acetaldehyde	Gas	25,072
74-86-2	Acetylene [Ethyne]	Gas	48,222
598-73-2	Bromotrifluoroethylene [Ethene, bromotrifluoro-]	Gas	1,967
106-99-0	1,3-Butadiene	Gas	44,548
106-97-8	Butane	Gas	45,719
25167-67-3	Butene	Gas	45,200*
590-18-1	2-Butene-cis	Gas	45,171
624-64-6	2-Butene-trans [2-Butene, (E)]	Gas	45,069
106-98-9	1-Butene	Gas	45,292
107-01-7	2-Butene	Gas	45,100*
463-58-1	Carbon oxysulfide [Carbon oxide sulfide (COS)]	Gas	9,126
7791-21-1	Chlorine monoxide [Chlorine oxide]	Gas	1,011*
590-21-6	1-Chloropropylene [1-Propene, 1-chloro-]	Liquid	23,000*
557-98-2	2-Chloropropylene [1-Propene, 2-chloro-]	Gas	22,999
460-19-5	Cyanogen [Ethanedinitrile]	Gas	21,064
75-19-4	Cyclopropane	Gas	46,560
4109-96-0	Dichlorosilane [Silane, dichloro-]	Gas	8,225
75-37-6	Difluoroethane [Ethane, 1,1-difluoro-]	Gas	11,484
124-40-3	Dimethylamine [Methanamine, N-methyl-]	Gas	35,813
463-82-1	2,2-Dimethylpropane [Propane, 2,2-dimethyl-]	Gas	45,051
74-84-0	Ethane	Gas	47,509
107-00-6	Ethyl acetylene [1-Butyne]	Gas	45,565
75-04-7	Ethylamine [Ethanamine]	Gas	35,210
75-00-3	Ethyl chloride [Ethane, chloro-]	Gas	19,917
74-85-1	Ethylene [Ethene]	Gas	47,145
60-29-7	Ethyl ether [Ethane, 1,1'-oxybis-]	Liquid	33,775
75-08-1	Ethyl mercaptan [Ethanethiol]	Liquid	27,948

CAS No.	Chemical Name	Physical State at 25EC	Heat of Combustion (kjoule/kg)
109-95-5	Ethyl nitrite [Nitrous acid, ethyl ester]	Gas	18,000
1333-74-0	Hydrogen	Gas	119,950
75-28-5	Isobutane [Propane, 2-methyl]	Gas	45,576
78-78-4	Isopentane [Butane, 2-methyl-]	Liquid	44,911
78-79-5	Isoprene [1,3-Butadiene, 2-methyl-]	Liquid	43,809
75-31-0	Isopropylamine [2-Propanamine]	Liquid	36,484
75-29-6	Isopropyl chloride [Propane, 2-chloro-]	Liquid	23,720
74-82-8	Methane	Gas	50,029
74-89-5	Methylamine [Methanamine]	Gas	31,396
563-45-1	3-Methyl-1-butene	Gas	44,559
563-46-2	2-Methyl-1-butene	Liquid	44,414
115-10-6	Methyl ether [Methane, oxybis-]	Gas	28,835
107-31-3	Methyl formate [Formic acid, methyl ester]	Liquid	15,335
115-11-7	2-Methylpropene [1-Propene, 2-methyl-]	Gas	44,985
504-60-9	1,3-Pentadiene	Liquid	43,834
109-66-0	Pentane	Liquid	44,697
109-67-1	1-Pentene	Liquid	44,625
646-04-8	2-Pentene, (E)-	Liquid	44,458
627-20-3	2-Pentene, (Z)-	Liquid	44,520
463-49-0	Propadiene [1,2-Propadiene]	Gas	46,332
74-98-6	Propane	Gas	46,333
115-07-1	Propylene [1-Propene]	Gas	45,762
74-99-7	Propyne [1-Propyne]	Gas	46,165
7803-62-5	Silane	Gas	44,307
116-14-3	Tetrafluoroethylene [Ethene, tetrafluoro-]	Gas	1,284
75-76-3	Tetramethylsilane [Silane, tetramethyl-]	Liquid	41,712
10025-78-2	Trichlorosilane [Silane, trichloro-]	Liquid	3,754
79-38-9	Trifluorochloroethylene [Ethene, chlorotrifluoro-]	Gas	1,837
75-50-3	Trimethylamine [Methanamine, N,N-dimethyl-]	Gas	37,978

CAS No.	Chemical Name	Physical State at 25EC	Heat of Combustion (kjoule/kg)
689-97-4	Vinyl acetylene [1-Buten-3-yne]	Gas	45,357
75-01-4	Vinyl chloride [Ethene, chloro-]	Gas	18,848
109-92-2	Vinyl ethyl ether [Ethene, ethoxy-]	Liquid	32,909
75-02-5	Vinyl fluoride [Ethene, fluoro-]	Gas	2,195
75-35-4	Vinylidene chloride [Ethene, 1,1-dichloro-]	Liquid	10,354
75-38-7	Vinylidene fluoride [Ethene, 1,1-difluoro-]	Gas	10,807
107-25-5	Vinyl methyl ether [Ethene, methoxy-]	Gas	30,549

*Estimated heat of combustion

Exhibit C-2
Data for Flammable Gases

CAS Number	Chemical Name	Molecular Weight	Ratio of Specific Heats	Flammability Limits (Vol %)		LFL (mg/L)	Gas Factor (GF)[g]	Liquid Factor Boiling (LFB)	Density Factor (Boiling) (DF)	Reference Table[a]	Pool Fire Factor (PFF)	Flash Fraction Factor (FFF)[f]
				Lower (LFL)	Upper (UFL)							
75-07-0	Acetaldehyde	44.05	1.18	4.0	60.0	72	22	0.11	0.62	Dense	2.7	0.018
74-86-2	Acetylene	26.04	1.23	2.5	80.0	27	17	0.12	0.78	Buoyant[b]	4.8	0.23[f]
598-73-2	Bromotrifluoroethylene	160.92	1.11	[c]	37.0	[c]	41[c]	0.25[c]	0.29[c]	Dense	0.42[c]	0.15[c]
106-99-0	1,3-Butadiene	54.09	1.12	2.0	11.5	44	24	0.14	0.75	Dense	5.5	0.15
106-97-8	Butane	58.12	1.09	1.5	9.0	36	25	0.14	0.81	Dense	5.9	0.15
25167-67-3	Butene	56.11	1.10	1.7	9.5	39	24	0.14	0.77	Dense	5.6	0.14
590-18-1	2-Butene-cis	56.11	1.12	1.6	9.7	37	24	0.14	0.76	Dense	5.6	0.11
624-64-6	2-Butene-trans	56.11	1.11	1.8	9.7	41	24	0.14	0.77	Dense	5.6	0.12
106-98-9	1-Butene	56.11	1.11	1.6	9.3	37	24	0.14	0.78	Dense	5.7	0.17
107-01-7	2-Butene	56.11	1.10	1.7	9.7	39	24	0.14	0.77	Dense	5.6	0.12
463-58-1	Carbon oxysulfide	60.08	1.25	12.0	29.0	290	26	0.18	0.41	Dense	1.3	0.29
7791-21-1	Chlorine monoxide	86.91	1.21	23.5	NA	830	31	0.19	NA	Dense	0.15	NA
557-98-2	2-Chloropropylene	76.53	1.12	4.5	16.0	140	29	0.16	0.54	Dense	3.3	0.011
460-19-5	Cyanogen	52.04	1.17	6.0	32.0	130	24	0.15	0.51	Dense	2.5	0.40
75-19-4	Cyclopropane	42.08	1.18	2.4	10.4	41	22	0.13	0.72	Dense	5.4	0.23
4109-96-0	Dichlorosilane	101.01	1.16	4.0	96.0	160	33	0.20	0.40	Dense	1.3	0.084
75-37-6	Difluoroethane	66.05	1.14	3.7	18.0	100	27	0.17	0.48	Dense	1.6	0.23
124-40-3	Dimethylamine	45.08	1.14	2.8	14.4	52	22	0.12	0.73	Dense	3.7	0.090
463-82-1	2,2-Dimethylpropane	72.15	1.07	1.4	7.5	41	27	0.16	0.80	Dense	6.4	0.11
74-84-0	Ethane	30.07	1.19	2.9	13.0	36	18	0.14	0.89	Dense	5.4	0.75
107-00-6	Ethyl acetylene	54.09	1.11	2.0	32.9	44	24	0.13	0.73	Dense	5.4	0.091
75-04-7	Ethylamine	45.08	1.13	3.5	14.0	64	22	0.12	0.71	Dense	3.6	0.040

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CAS Number	Chemical Name	Molecular Weight	Ratio of Specific Heats	Flammability Limits (Vol %)		LFL (mg/L)	Gas Factor (GF)[g]	Liquid Factor Boiling (LFB)	Density Factor (Boiling) (DF)	Reference Table[a]	Pool Fire Factor (PFF)	Flash Fraction Factor (FFF)[f]
				Lower (LFL)	Upper (UFL)							
75-00-3	Ethyl chloride	64.51	1.15	3.8	15.4	100	27	0.15	0.53	Dense	2.6	0.053
74-85-1	Ethylene	28.05	1.24	2.7	36.0	31	18	0.14	0.85	Buoyant[b]	5.4	0.63[f]
109-95-5	Ethyl nitrite	75.07	1.30	4.0	50.0	120	30	0.16	0.54	Dense	2.0	NA
1333-74-0	Hydrogen	2.02	1.41	4.0	75.0	3.3	5.0	e	e	d	e	NA
75-28-5	Isobutane	58.12	1.09	1.8	8.4	43	25	0.15	0.82	Dense	6.0	0.23
74-82-8	Methane	16.04	1.30	5.0	15.0	33	14	0.15	1.1	Buoyant	5.6	0.87[f]
74-89-5	Methylamine	31.06	1.19	4.9	20.7	62	19	0.10	0.70	Dense	2.7	0.12
563-45-1	3-Methyl-1-butene	70.13	1.08	1.5	9.1	43	26	0.15	0.77	Dense	6.0	0.030
115-10-6	Methyl ether	46.07	1.15	3.3	27.3	64	22	0.14	0.66	Dense	3.4	0.22
115-11-7	2-Methylpropene	56.11	1.10	1.8	8.8	41	24	0.14	0.77	Dense	5.7	0.18
463-49-0	Propadiene	40.07	1.16	2.1	2.1	34	21	0.13	0.73	Dense	5.2	0.20
74-98-6	Propane	44.10	1.13	2.0	9.5	36	22	0.14	0.83	Dense	5.7	0.38
115-07-1	Propylene	42.08	1.15	2.0	11.0	34	21	0.14	0.79	Dense	5.5	0.35
74-99-7	Propyne	40.07	1.16	1.7	39.9	28	21	0.12	0.72	Dense	4.9	0.18
7803-62-5	Silane	32.12	1.24	c	c	c	19 c	e	e	Dense	e	0.41[f]
116-14-3	Tetrafluoroethylene	100.02	1.12	11.0	60.0	450	33	0.29	0.32	Dense	0.25	0.69
79-38-9	Trifluorochloroethylene	116.47	1.11	8.4	38.7	400	35	0.26	0.33	Dense	0.34	0.27
75-50-3	Trimethylamine	59.11	1.10	2.0	11.6	48	25	0.14	0.74	Dense	4.8	0.12
689-97-4	Vinyl acetylene	52.08	1.13	2.2	31.7	47	24	0.13	0.69	Dense	5.4	0.086
75-01-4	Vinyl chloride	62.50	1.18	3.6	33.0	92	26	0.16	0.50	Dense	2.4	0.14
75-02-5	Vinyl fluoride	46.04	1.20	2.6	21.7	49	23	0.17	0.57	Dense	0.28	0.37
75-38-7	Vinylidene fluoride	64.04	1.16	5.5	21.3	140	27	0.22	0.42	Dense	1.8	0.50
107-25-5	Vinyl methyl ether	58.08	1.12	2.6	39.0	62	25	0.17	0.57	Dense	3.7	0.093

Notes:

NA: Data not available

[a] "Buoyant" in the Reference Table column refers to the tables for neutrally buoyant gases and vapors; "Dense" refers to the tables for dense gases and vapors. See Appendix D, Section D.4.4, for more information on the choice of reference tables.

[b] Gases that are lighter than air may behave as dense gases upon release if liquefied under pressure or cold; consider the conditions of release when choosing the appropriate table.

[c] Reported to be spontaneously combustible.

[d] Much lighter than air; table of distances for neutrally buoyant gases not appropriate.

[e] Pool formation unlikely.

[f] Calculated at 298 K (25EC) with the following exceptions:

Acetylene factor at 250 K as reported in TNO, *Methods for the Calculation of the Physical Effects of the Escape of Dangerous Material* (1980).
Ethylene factor calculated at critical temperature, 282 K.
Methane factor calculated at critical temperature, 191 K.
Silane factor calculated at critical temperature, 270 K.

[g] Use GF for gas leaks under choked (maximum) flow conditions.

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Exhibit C-3
Data for Flammable Liquids

CAS Number	Chemical Name	Molecular Weight	Flammability Limit (Vol%)		LFL (mg/L)	Liquid Factors		Density Factor	Liquid Leak Factor (LLF)[a]	Reference Table[b]	Pool Fire Factor (PFF)
			Lower (LFL)	Upper (UFL)		Ambient (LFA)	Boiling (LFB)				
590-21-6	1-Chloropropylene	76.53	4.5	16.0	140	0.11	0.15	0.52	45	Dense	3.2
60-29-7	Ethyl ether	74.12	1.9	48.0	57	0.11	0.15	0.69	34	Dense	4.3
75-08-1	Ethyl mercaptan	62.14	2.8	18.0	71	0.10	0.13	0.58	40	Dense	3.3
78-78-4	Isopentane	72.15	1.4	7.6	41	0.14	0.15	0.79	30	Dense	6.1
78-79-5	Isoprene	68.12	2.0	9.0	56	0.11	0.14	0.72	32	Dense	5.5
75-31-0	Isopropylamine	59.11	2.0	10.4	48	0.10	0.13	0.71	33	Dense	4.1
75-29-6	Isopropyl chloride	78.54	2.8	10.7	90	0.11	0.16	0.57	41	Dense	3.1
563-46-2	2-Methyl-1-butene	70.13	1.4	9.6	40	0.12	0.15	0.75	31	Dense	5.8
107-31-3	Methyl formate	60.05	5.9	20.0	140	0.10	0.13	0.50	46	Dense	1.8
504-60-9	1,3-Pentadiene	68.12	1.6	13.1	44	0.077	0.14	0.72	33	Dense	5.3
109-66-0	Pentane	72.15	1.3	8.0	38	0.10	0.15	0.78	30	Dense	5.8
109-67-1	1-Pentene	70.13	1.5	8.7	43	0.13	0.15	0.77	31	Dense	5.8
646-04-8	2-Pentene, (E)-	70.13	1.4	10.6	40	0.10	0.15	0.76	31	Dense	5.6
627-20-3	2-Pentene, (Z)-	70.13	1.4	10.6	40	0.10	0.15	0.75	31	Dense	5.6
75-76-3	Tetramethylsilane	88.23	1.5	NA	54	0.17	0.17	0.59	40	Dense	6.3
10025-78-2	Trichlorosilane	135.45	1.2	90.5	66	0.18	0.23	0.37	64	Dense	0.68
109-92-2	Vinyl ethyl ether	72.11	1.7	28.0	50	0.10	0.15	0.65	36	Dense	4.2
75-35-4	Vinylidene chloride	96.94	7.3	NA	290	0.15	0.18	0.44	54	Dense	1.6

NA: Data not available