Subject: Determination of Downsind Hazardous Area Chemical Transport Spills

Reference: Illinois Environmental Protection Agency Engineers Incident/Episode Manual

The following procedure is excerpted from page 3-18 of the reference engineer's manual.

When Dispatched to Incident Scene:

1. Before departing for the scene of an incident, make sure that you have your response equipment. This equipment should include:

   a. Windmeter
   b. Thermometer
   c. Compass
   d. Flashlight
   e. Protective clothing (hardhat, smock (coveralls))
   f. Air sampling equipment (if necessary)
   g. Sliderule
   h. MCA Chem-card Manual
   i. Engineers' Manual
   j. Identification

2. Upon arrival at the scene of an air pollution incident, report to the individual in charge. This person will usually be the highest ranking law enforcement official or civil defense official or the fire marshal. If it is not known who is in charge, then make the assumption that the senior law enforcement official will be ultimately in charge. Inform him of your presence, responsibilities, and capabilities. Tell him that you are responsible for providing information as to the toxicity, flammability, explosiveness, and concentration of hazardous air contaminants. Let him know the monitoring equipment you have on hand and of your ability to obtain outside assistance. Determine if he has specific relevant duties for you to perform. Obtain his name and record on Response Sheet (Figure 4) and Checklist (Figure 5).

3. Visually examine the incident scene. Determine the location of the release or spillage of bazardous material.

4. Determine identity of hazardous material(s) from personnel at scene. If this is not possible, determine material(s) in accordance with the following instructions:

   a. Fixed Sites: Situations where released material is unidentified seldom occur at fixed sites, since persons at industrial plants usually know what hazardous substances are handled there.

   b. Mobile Sites: In many cases material escaping from mobile sources is not immediately identifiable since the tank trŭck driver, barge captain, or railroad engineer may have fled the scene or may himself be overcome by the materials. The following actions should be taken to help identify the material: if tne source can be approached with safety from upwind, look for identifying labels of all kinds that might give the name of the carrier or shipper, vehicle registration number, or warnings or cargo characteristics and handling. Look for placards displayed on the trucks in accordance with the Department of Transportation regulations. If the cab of the vehicle is accessible, look for a Chem-card that is required to be in every vehicle carrying hazardous materials. If you are unable to identify the cargo, determine as much information as you possibly can and inform the DAPC Emergency Action Center. You should obtain and report the following information, if available: the name of the factory or carrier, the physical characteristics of the hazardous material, its color and smell, its physical affects upon people or foliage, and whether it is readily rising into the air. If you are unable to contact Emergency Action Center personnel, then contact the Chemical Transportation Emergency Center (CHEMTREC) at the toll-free number, (800) 424-9300. Provide them with the information you have gathered concerning the nature of the material. CHEMTREC is available 24-hours a day to provide immediate guidance on what to do in case of spills or leaks, fire, or exposure to hazardous materials.

   c. Actions if materials cannot be identified: Materials that cannot be identified from labels or other readily available sources should be assumed to be dangerous until proven otherwise. The responsibility of our Division in this case is not altered. We are the experts who must determine the nature of the chemical or gas involved in the incident. A first attempt to determine the material will be made by the Emergency Action Center. If the material cannot be identified in this manner, then you should attempt to determine the material by using the chemical detection tubes

5. Estimate the quantity of material being released and enter on the response checklist. If the source strength (Q) is not known and cannot be estimated, assume a source strength of 1 kg/sec (1000 gm/sec). This emission rate is typical of what has been observed or calculated for rocket fuel spills and no other estimates are available at this time.

   Hazardous substances that are transported as liquids may have been either liquid or gaseous at normal pressure and temperature. In the latter case, the gases are liquefied and pressurized to several atmospheres within their container. When vented to the atmosphere, pressurized liquid rapidly returns to the gaseous state, carrying along aerosolized liquid particles that vaporize in a few seconds. In such cases, the source strength may be assumed to be 100% of the material emitted. You will have to estimate the amount of liquid being released per second and use the conversion factor of 1 gal/sec $\approx$ 3 kg/sec (3000 gm/sec).

   However, other hazardous substances that are liquid though volatile at normal pressure and temperature may spill from their container to the ground, and enter the atmosphere only through vaporization. In such cases the source strength for the same quantity of spill as a liquefied gas will be somewhat less than that of the gas by a factor that depends on its rate of evaporation. The rate of evaporation is not constant; it depends upon the temperature, pressure, and wind speed of interfacing ambient air, and in the case of hydroscopic material like anhydrous ammonia, on the relative humidity as well. It also depends upon its vapor pressure curve. In the event of a volatile liquid spillage, vapor source strength, Q, may be determined by the following procedure:

   a. Estimate the rate of liquid spillage, expressed in gm/sec.

   b. From Table 1, read the percentage of source strength.

   c. Determine vapor source strength, Q, by multiplying the liquid source strength by the percentage of source strength for the material involved.

TABLE 1

Hazardous Material	Percentage of Liquid Spill Rate
Acetaldehyde	100
Acetic anhydride	Negligible
Acetone	60
Acetone cyanohydrin	Negligible
Acrylonitrile	25
Ammonia	100
Aniline	Negligible
Benzene	15
Butadiene (inhibited)	100
Butane	100
Butenes	100
Butyl alcohol	Negligible
Carbon disulfide	80
Carbon tetrachloride	25
Chlorine	100
Chlorosulfonic acid	Negligible
Cumene (isopropyl benzene)	Negligible
Dichloro difluoromethane	100
Dodecyl benzene	100
Ethyl alcohol (ethanol)	Negligible
Ethyl benzene	Negligible
Ethyl chloride	100
Ethylene dichloride	60
Ethylene oxide	100
Fluorine	Negligible
Formaldehyde	100
Hexamethylenediamine	Negligible
Hydrogen chloride	100
Hydrogen cyanide	100
Hydrogen fluoride	100
Hydrogen sulfide	100
Insecticides (parathion), etc.	Negligible
Isopropyl alcohol	Negligible
LPG (see propane)	100
Methyl alcohol	25
Methyl ethyl ketone	5
Methyl methacrylate	Negligible
Nitric acid (fumes)	
Perchloric acid	Negligible
Perchloroethylene	Negligible
Phenol	Negligible
Phthalic anhydride	Negligible
Propane	100
Sulfur dioxide	100
Sulfuric acid (fumes)	Negligible
Styrene	Negligible
Tetraethyl lead	Negligible
Toluene	Negligible
Trichloro-ethane	Negligible
Trichloroethylene	Negligible
Vinyl acetate	25
Vinyl chloride	100
Xylenes (xylols)	Negligible
Cyclohexane	15

"CAUTION"

Ensure that all persons at the scene, including yourself, follow these instructions:

"DO NOT ENTER OR MOVE ABOUT INSIDE A POTENTIALLY HAZARDOUS CLOUD WITHOUT PROPER PROTECTIVE GEAR. KEEP SPARKS, OPEN FLAMES, AND LIT TOBACCO OUT OF THE HAZARDOUS AREA."

Each Regional Office has a multiple purpose detection kit that will be used to detect unknown gases. The detector kit contains a hand pump and sample tubes. A prescribed amount of gas is drawn into the pump and then forced back through a hollow needle into the detector tube. If the proper gas is in the air, a chemical reaction will take place in the detector tube. Concentration of the gas is estimated by comparing the color change or length of stain of the reagent in the tube with a reference calibration chart included with the tubes.

When sampling for an unknown gas, it would be senseless to start searching at random or in alphabetical order. For this reason, a list of the 15 most common gases has been prepared. Measures to identify the material should be started with the first chemical on the list and then continued until all tubes are used up or until a determination of the chemical is obtained.

15 MOST COMMON GASES INVOLVED IN AIR POLLUTION INCIDENTS

Hydrogen sulfide
Vinyl chloride (chloroethylene)
Ethylene oxide
Chlorine
Anhydrous ammonia
Acetaldehyde
Hydrogen cyanide (hydrocyanic acid)
Acrylonitrile (vinyl cyanide)
Methanol (methyl alcohol)
Benzene (benzol)
Formaldehyde
Acetone
Butane(s)
Propane
Ethyl chloride (chloroethane)

Once the substance has been identified, further information will be furnished to the engineer at the scene by the Emergency Action Center regarding the characteristics of the hazardous materials including its toxicity, flammability, explosibility, and reactivity.

If unable to determine the chemical or gas after these actions, then collect, if possible, samples of the material and call the Emergency Action Center for instructions. The Emergency Action Center will make arrangements for the samples to be analyzed at the nearest chemical analysis laboratory. If, after these actions, the material is still unidentified, the Episode Unit will take action to procure experts from the academic community to analyze the situation.

6. Estimate windspeed and direction. Take windmeter in one hand and compass in the other. Hold windmeter in vertical position in front of you with your arm extended. Do not block holes in bottom of meter. If wind is stronger than 10 mph, hold your finger over the red cover hole and read wind speed on high scale. Rotate yourself slowly until highest windspeed is obtained; record this windspeed on checklist in meters per second (Figure 1). Examine compass to determine wind direction. Remember, you are facing the direction from which the wind is blowing. Hold compass horizontally and wait-a short period of time to insure that the compass needle has stabilized. Record direction from which wind is blowing by degrees on checklist. Place in terms of compass points by rounding direction to the nearest 10 degrees and using Table 2.

TABLE 2

Direction in Degrees	Compass Direction
350°-10°	N
20°-30°	NNE
40°-50°	NE
60°-70°	ENE
80°-100°	E
110°-120°	ESE
130°-140°	SE
150°-160°	SSE
170°-190°	S
200°-210°	SSW
220°-230°	SW
240°-250°	WSW
260°-280°	W
290°-300°	WNW
310°-320°	NW
330°-340°	NNW

7. Record temperatures on checklist.

8. Identify stability class (in general the following will apply):

Unstable - Category B - Fair to partly cloudy day with light wind
Neutral - Category D - Cloudy day or night or anytime wind over 10 mph
Stable - Category F - Fair night with light wind

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Observe the cloud cover and determine which cloud cover classification in Table 3 is appropriate. From Table 3 determine the Net Radiation class. Enter this category on the checklist.

FIGURE 1

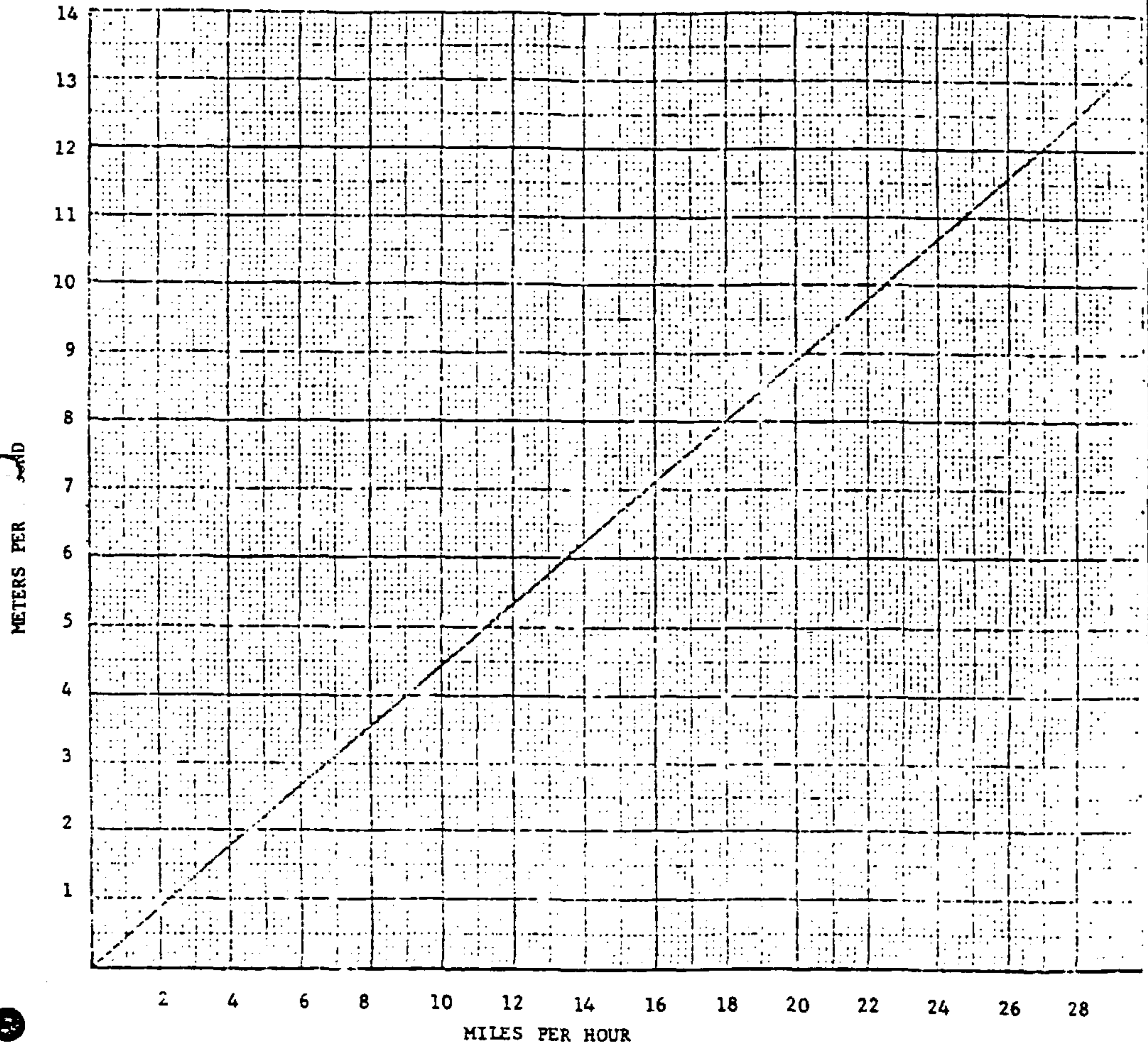

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TABLE 3

NET RADIATION CLASSES

Cloud Cover	Night	Elevation of Sun *All days ≤15°	 >15° but ≤35°	 *Feb. 10-Nov. 2 >35° but ≤60°	 *Apr. 16-Aug. 26 >60°
<3/8	-2	-1	+1	+2	+3
3/8 or 4/8 at any hgt or broken abv 16000 ft (incl. -⊕)	-1	0	+1	+2	+3
⊕ abv 16000 ft or ⦶ between 7000 ft and 16000 ft	-1	0	0	+1	+1
⦶ below 7000 ft	0	0	0	+1	+1
⊕ below 7000 ft	0	0	0	0	0

TABLE 4

STABILITY CATEGORY BASED ON WIND SPEED AND NET RADIATION

Surface Wind Speed m/sec	 knots	Net Radiation Class (see Table 3) +3	 +2	 +1	 0	 -1	 -2
<2	<4	B	B	B	D	F	F
2-3	4-6	B	B	B	D	F	F
3-5	6-10	B	B	D	D	D	D
5-6	10-12	D	D	D	D	D	D
>6	>12	D	D	D	D	D	D

*Note: Dates indicate days on which the maximum elevation of the sun will be in the angular range during some period of the day.

9. Obtain excursion threshold value (ETLV). from Table 5 and enter on checklist.

10. Determine downwind hazardous area by following method:

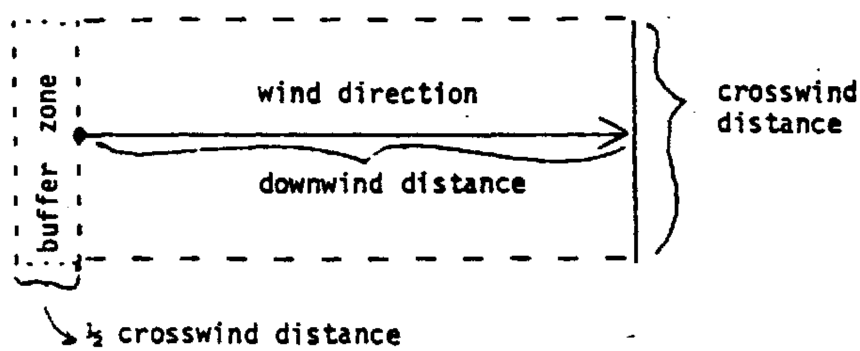
    Enter (ETLV), windspeed, and source strength in following expression:

$$K = \frac{\text{source strength (Q)(gm/sec)} \times 10^3}{\text{windspeed (m/sec)} \times \text{ETLV (mg/m}^3\text{)}}$$

    Enter K in Figure 2 and obtain downwind distance in desired units.

    Enter downwind distance given in meters into Figure 3 and obtain crosswind distance.

    Construct downwind hazardous area.



11. Adjustments for terrain: Predicted hazard areas may require adjustment for variations in terrain. This task can only be approached subjectively, guided by the engineer's familiarity with the terrain in the threatened area. The following generalities may be of help.

    a. Winds under 5 m/sec (11-12 mph) tend to follow paths of least resistence: river channels, valleys, city streets, etc.

    b. Winds are diverted by obstacles such as prominent hills, and in cities by large buildings. With stronger winds that are forced upward, around, and over these obstacles, reverse eddies tend to appear on the lee side in which there are zones of increased and decreased concentrations of airborne contaminants. Hence, the lee side of a hill or building may not offer temporary safety from a toxic cloud.

TABLE 5

SUBSTANCE	CODE	Excursion TLV (Max. conc. permitted for short time) ppm	mg/m³
Acetaldehyde	0006	125	225
Acetic Acid (glacial)	0037	15	38
Acetic Anhydride	0038	5	21
Acetone	0057	1000	2400
Acetone Cyanohydrin	0058	15	52
Acetonitrile (methylcyanide)	0066	60	105
Acetyl Chloride	0082	7.5	24
Acetylene	0131	Asphyxiant	
Acetylene Dichloride (1, 2 Dichloro Ethylene)	0136	250	988
Acrolein	0153	0.3	0.75
Acrylonitrile	0158	30	68
Allyl Alcohol	0205	4	10
Ammonia (anhydrous)	0451	38	27
Amyl Acetate	0542	125	656
Amyl Alcohol	0550	125	450
Aniline	0657	7.5	28
Antimony Trichloride	0714	-	2.8
Arsenic Trioxide	0779	-	4.0
Barium Chlorate	0870	-	0.5
Barium Nitrate	0904	-	0.5
Barium Peroxide	0914	-	0.5
Benzene	0976	25	80
zoyl Peroxide	1086	-	10
Benzyl Chloride	1117	2	10
Bromine	1269	0.3	2.1
Butadiene	1420	1000	2200
Butane(L.P.G.)	1422	500	1200
Butyl Acetate	1430	188	888
Butyl Alcohol	1435	125	378
Butyraldehydes	1564	250	738
Calcium	1643	-	5
Calcium Cyanide	1665	10	38
Calcium Hypochlorite	1675	1	8(bleaching powder 5(anhydrous)
Carbon Disulfide	1778	30	90
Carbon Monoxide	1780	75	82
Carbon Tetrachloride	1792	15	98
Chlorine	1924	2	6
Chlorobenzene	1963	94	438
Chloroisocyanuric Acid	1998	60	402
Chloroform	2023	31	150
Chlorosulfonic Acid	2105	5	23
Chromic Acid	2159	-	0.3
Cresol	2357	7.5	33
Cyanoacetic Acid	2465	60	209
Cyanogen	2471	20	43
lohexane	2485	300	1050
lopropane	2506	500	862
aborane	2517	0.15	0.9
Diborane	2685	0.3	0.3
Dichlorobenzene	2845	50	300

SUBSTANCE	CODE	Excursion TLV (Max. conc. permitted for short time) ppm	mg/m^3
Diesel Fuel Oil	2981	625	4700
Diethyl Amine	3000	38	112
Diethylene Triamine	3130	2	8
Dimethyl Formamide	3383	15	45
1,1-Dimethylhydrazine	3391	1.5	3
Dimethyl Sulfate	3456	2	10
Dinitro Aniline	3487	1	7
Dinitro Benzene	3500	-	3
Dinitro Toluene	3565	-	3
Dioxane (Diethylene Dioxide)	3584	125	450
Epichlorohydrin	3794	7.5	28
Ethanolamine (moneothanolamine)	3831	6	12
Ethyl Acetate	3859	400	1400
Ethyl Acrylate	3866	38	150
Ethyl Alcohol (Ethanol)	3870	1000	1900
Ethyl Benzene	3897	125	544
Ethyl Chloride	3939	1000	2600
Ethyl Ether	3970	400	1212
Ethylene	4116	Asphyxiant	
Ethylene Dichloride (1,2 Dichloroethane)	4126	62	250
Ethylene Oxide	4135	75	135
Fluorine	4247	2	4
Formaldehyde	4283	2	3
para-Formaldehyde	4285	10	12
Formic Acid	4296	10	18
Hydrazine	4753	2	2.6
Hydrochloric Acid (Hydrogen Chloride)	4788	5	7
Hydrocyanic Acid (Hydrogen Cyanide)	4803	15	16
Hydrofluoric Acid (Hydrogen Fluroide)	4806	6	4
Hydrogen Peroxide	4814	2	2.8
Hydrogen Sulfide	4817	15	22
Kerosene	5116	500	3200
Lead Nitrate	5194	-	0.3
Lead Oxides	5197	-	0.2
Malathion	5460	-	20
Maleic Anhydride	5462	.75	3
Mercaptans	5499	15	15-30
Mesityl Oxide	5581	38	150
Methyl Acetate	5615	250	762
Methyl Acrylate	5623	15	52
Methyl Alcohol (Methanol)	5628	250	328
Methyl Amines	5633	15	18
Methyl Bromide	5675	22	90
Methyl isoButyl Ketone	5692	100	411
Methyl Chloride	5711	125	260
Methyl Chloroform	5715	350	1900
Methyl Ethyl Ketone (2-Butanone)	5760	250	738
Methyl Formate	5770	125	312
Methyl Hydrazine	5797	0.2	0.35

SUBSTANCE	CODE	Excursion TLV (max. conc. permitted for short time) ppm	mg/m^3
Methylene Chloride (Dichloromethane)	5957	500	1740
Napthalene	6022	15	75
Nitric Acid	6236	4	10
Nitroaniline	6271	2	12
Nitro Benzol (Nitro Benzene)	6299	2	10
Nitrochlorobenzene	6350	0.5	3
Nitroethane	6386	125	388
Nitrotoluene	6498	7.5	42
Nitrogen Tetroxide	6534	5	18(Liquid) 9(Gas)
Parathion	6757	.025	0.3
Pentaborane	6771	0.015	0.03
Perchloroethylene	6814	125	838
Phenol (Carbolic Acid)	6850	7.5	28
Phosgene (Carbonyl Chloride)	7003	0.3	1.2
Phosphoric Acid	7017	0.75	3
Phosphoric Anhydride (Phosphorus Pentoxide)	7019	1	5.8
Phosphorus, Red	7023	Non toxic	
Phosphorus, White (Yellow)	7024	-	0.3
Phosphorus Oxychloride	7049	0.5	3
Phosphorus PentaSulfide	7053	-	3
Phosphorus Trichloride	7067	1	6
Phthalic Anhydride	7079	3	18
Potassium Cyanide	7219	-	5
Propane	7360	Asphyxiant	
Propionaldehyde	7371	200	476
isoPropyl Alcohol	7391	500	1225
isoPropyl Amine	7394	7.5	18
Propylene	7481	4000	6900
Propylene Oxide	7490	125	300
Pyridine	7516	7.5	22
Silver Nitrate	7858	-	0.01
Sodium Chlorite	7925	-	0.74
Sodium Dichromate	7934	-	0.3
Sodium Hydroxide	7950	-	4
Sodium Potassium Alloys	8005	-	2
Styrene (Monomer) (Phenylethylene)	8157	125	525
Sulfur Chlorides	8199	2(Monochloride)	12
Sulfur Dioxide	8025	7.5	19
Sulfuric Acid, Fuming (oleum)	8213	0.75	3
Sulfuric Acid	8214	0.75	3
Tetraethyl Lead	8335	0.03	0.45
Tetra Hydrofuran	8344	250	738
Toluene (Toluol)	8629	125	469
Toluene DiisoCyanate	8631	0.02	0.14
Toluidine	8664	7.5	33
Trichloroethylene	8824	125	669
Turpentine (oil)	9068	125	695
Vinyl Acetate	9197	15	45
Vinyl Chloride (Chloroethylene)	9206	250	962
Xylene	9231	125	544
Zinc Chlorate	9323	-	1

FIGURE 2

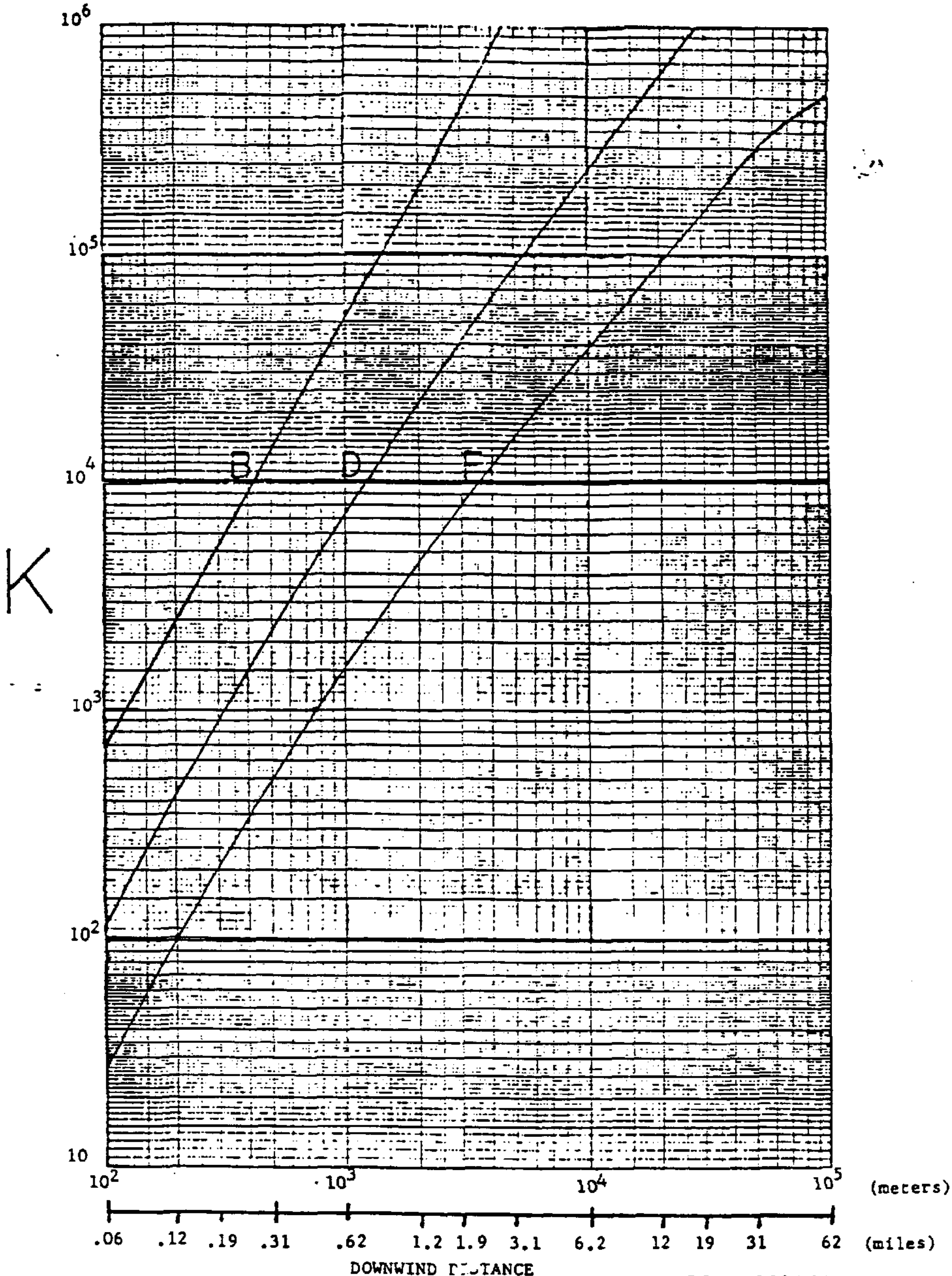


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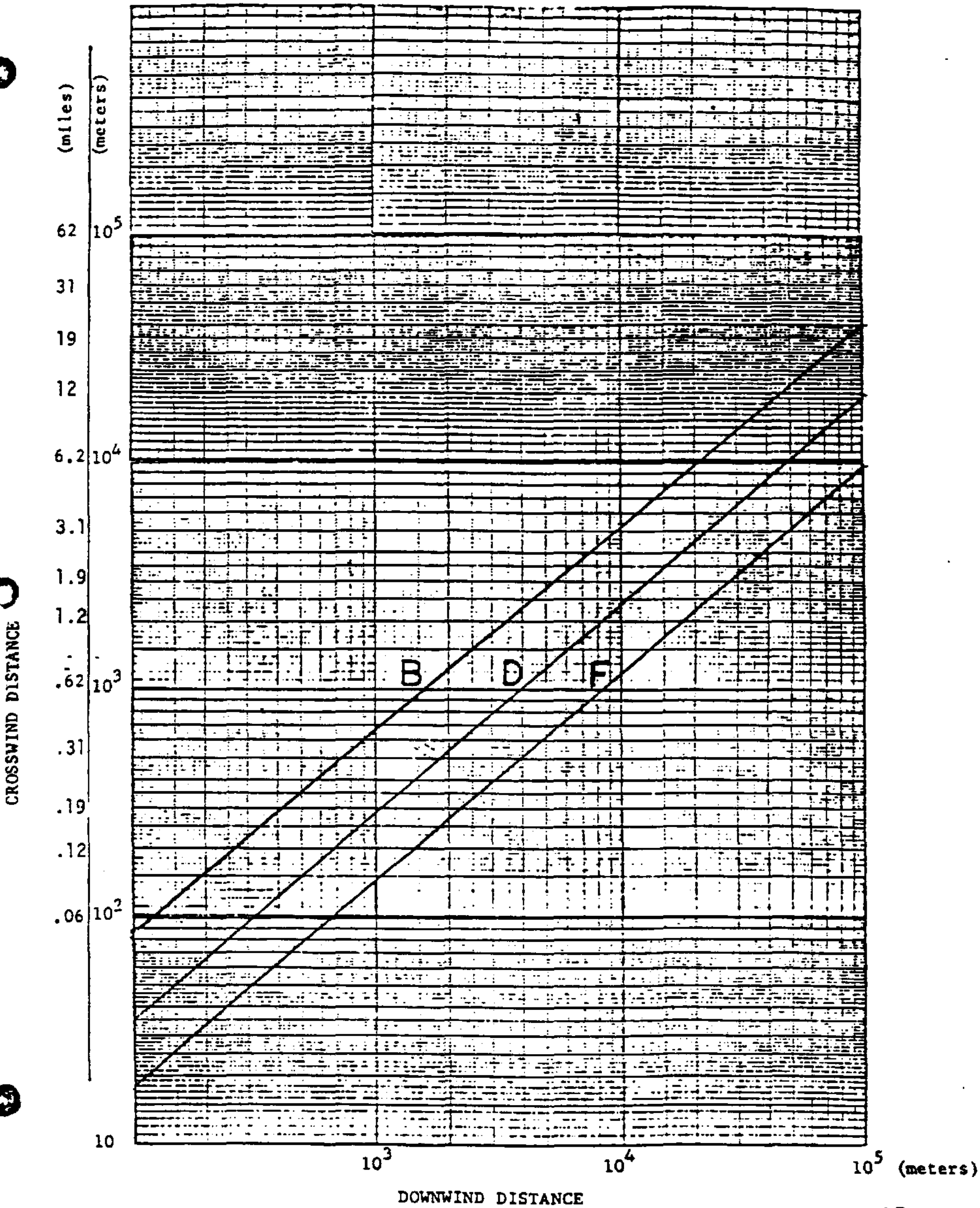
FIGURE 3



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c. If the wind travels upslope, gases that are significantly heavier than air may not be transported as far as the calculated downwind distance. The pattern of concentration would be foreshortened, and contamination in the valley would be heavier than expected.

d. This correction may be required for all the 15 gases on the priority list with the exception of ammonia and hydrogen cyanide. If the wind travels downslope, gases that are significantly lighter than air, chiefly ammonia and to a lesser extent hydrogen cyanide, would appear in lower concentrations downwind than expected.

12. Adjustments for fire: The fire hazard has not been considered in construction of the hazardous area. Many of these chemicals are highly flammable. In some cases ignition caused by a spark or open flame some distance downwind may flash back to the source, resulting in an initial explosion or fire of wide dimensions. Once in progress the fire tends to be concentrated at the source only, and the emanating cloud consists of combustion products that may or may not be toxic but are at least suffocating or highly irritating. Atmospheric dispersion models that treat this phenomenon generally consider the "stack effect" of the fire and the local atmospheric instability condition that rapidly develops near the source. However evacuation of people from an area farther than about 1 km from the fire is seldom required. The Emergency Action Center personnel can provide assistance in determining the hazardous area under such conditions.

13. Determine if additional support is required. Since your specific responsibilities are concerned with the contamination of the atmosphere, additional support required should be limited to such items as the need for more engineers or technicians, outside experts to determine the nature of the gas or chemicals involved, or meteorological support. You should appraise the overall situation. Determine if the general population is in danger, and if the local law enforcement of civil defense officials are performing their duties properly. If they are not, notify the Episode Unit of this fact.

14. If members of the press are present at the scene and ask to interview you, you should request that they speak to the individual in charge of controlling the incident. You should refrain from making comments to the press other than to inform them of the nature of the gas or chemical involved.

AIR POLLUTION INCIDENT RESPONSE SHEET

DATE: ______________ TIME NOTIFIED: ______________ ANS. SERVICE ☐

CALLER'S NAME: ______________ ORGANIZATION: ______________

CALL BACK NUMBER: ______________ LOCATION: ______________

CHEMICAL/MATERIAL INVOLVED: ______________

QUANTITY: ______________ CONTAINER TYPE: ______________

______________ NUMBER OF CONTAINERS: ______________

PROBLEM (include type of accident, time of accident, injuries, details):

____

____

____

____

____

LOCATION (give distance & location from nearest city, highway numbers, road names, populated or open area):

____

____

____

WEATHER (list significant weather such as rain, drizzle, snow, fog, etc. after comments):

SKY CONDITION: ______________ TEMPERATURE: ______________

WIND SPEED AND DIRECTION: ______________ COMMENTS: ______________

PERSONNEL AT SCENE: CIVIL DEFENSE ☐ ______________ POLICE ☐ ______________

FIRE ☐ ______________ AIR POLLUTION ☐ ______________

WATER POLLUTION ☐ ______________ OTHER ______________

PUBLIC WATER SUPPLIES ☐ ______________

CARRIER NAME AND TYPE: ______________

RAIL CAR NUMBER: ______________ TRUCK/TRAILER NUMBER: ______________

ORIGIN: ______________ DESTINATION: ______________

ENGINEER/EAC PERSONNEL FILING REPORT: ______________

ILLINOIS EPA EMERGENCY 24-HR. TELEPHONE NUMBER: (217) 525-3637

CHECKLIST

☐ Date ______________________.

☐ Engineer ____________________.

☐ Report to individual in charge (Name __________________________).

☐ Material(s) involved: ________________, ________________,
________________.

☐ Quantity of material involved: ________________.

☐ Quantity of material being released.
(source strength in gm/sec) ________________.

☐ If volatile liquid, vapor pressure from Table 1: ______________.

☐ Source strength (gm/sec) x % of spill rate = source strength
______________ x ______________ = ______________ (gm/sec).

☐ Windspeed ________________ (m/s).

☐ Wind direction ____________(degrees) ____________compass point.

☐ Temperature ________________°F.

☐ Net radiation class (Table 3): ______________________________.

☐ Stability category (Table 4): ______________________________.

☐ Excursion threshold value ______________ (ugm^{-3})

☐ Downwind hazardous area:

$$K = \frac{Q\ (gm/sec) \times 10^3}{windspeed\ (m/sec) \times ETLV\ (mg/m^3)}$$

$$K = \frac{(\qquad\qquad) \times 10^3}{(\qquad\qquad) \times (\qquad\qquad)} = \underline{\qquad\qquad\qquad}$$

☐ Downwind distance: __________________ mi (Figure 2).

☐ Crosswind distance:__________________mi (Figure 3).

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