7 RISK ASSEMENT AND SAFETY MEASURES

7.1 Risk Assessment

The inherent property of material used in the process and the processes themselves pose the potential hazard in any chemical industries and a comprehensive risk assessment is needed for effective management of risk, which needs to be identified, assessed and eliminated or controlled. Prevention of human and property losses is integral to the operation and management of chemical process plants. This may be achieved through the selection of a technology that is inherently safe. Alternatively safety of plant design and/or operation can be audited by the application of hazard identification and risk analysis techniques, and adopting measures suggested by the risk analysis.

7.2 Objective, Philosophy & Methodology of Risk Assessment

The main objective of risk assessment study to carry out risk analysis studies for industries, planning and management of industrial prototype hazard. Risk Assessment study of the proposed unit is carried out serve the following objectives;

- Identification of safety areas
- Identification of hazard sources
- Generation of accidental release scenarios for escape of hazardous materials from the facility
- Identification of vulnerable units with recourse to hazard indices
- Estimation of damage distances for the accidental release scenarios with recourse to
- Maximum Credible Accident (MCA) analysis
- Suggest risk mitigation measures based on engineering judgement, reliability and risk analysis approaches
- up gradation of DMP

The main objective of the Risk Assessment study is to determine possible damage due to major hazards having damage potential to life and property. The secondary objective is to identify major risk in manufacture of chemicals, storage of chemicals and provide control though assessment. To prepare onsite, offsite, disaster management plan for control of hazards.

7.2.1 Philosophy

The main philosophy of risk assessment is to find out the real cause of accident and then based on it to suggest appropriate remedial measures to prevent its recurrence.

To find out unsafe action negligence, omission or personal fault.

7.2.2 Methodology

Risk analysis is carried out by following of sequential steps described as follow:

A. Hazard Identification

Identifying sources of process accidents involving release of hazardous material in the atmosphere and the various ways (that is scenarios) they could occur.

B. Consequence Assessment

Estimating the probable zone of impact of accidents as well as the scale and/or probability of damages with respect to human beings and plant equipment and other structures.

C. Accident Frequency Assessment

Computation of the average likelihood of accidents.

D. Risk Estimation

Combining accident consequence and frequency to obtain risk distribution to find out the quantitative Risk Assessment by using software (ALOHA) as follow.

- Identify Vulnerable Zone for toxic dispersion,
- Pool fire,
- Tank on fire (Thermal Radiation),
- Flash Fire,
- Explosion over pressure (Vapor Cloud Explosion)

7.3 Hazard Identification

Hazard is the characteristic of any system or process which has the potential for accident. Identification of hazards, in presence of any hazardous chemicals generating units within the project facility is of primary significance in the analysis. For hazard identification total quantity of raw material and products to be stored within premises after expansion is taken into consideration.

Typical methods for hazard identification employed are:

- Identification of major hazardous units based on Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 of Government of India (as amended in 2000)
- Identification of hazardous units and segments of plants and storage units based on relative ranking technique, viz. Fire-Explosion and Toxicity Index (FE&TI).

7.3.1 Details of Chemicals To Be Handled

In the unit, risk will be involved in storage, handling and transportation of various chemicals those will be handled in the form of raw materials and products. Details of the raw materials and products with storage are given in .

Table 7-1: Details of the Raw Materials and Products with Storage

Sr. No.	Name of Product	Batch Details		Capacity per (MT/Month)	Physical Form	Mode of Storage	No. of Units	Transportation	Capacity of storage (Tonne)
		Size (Kg)	Nos.						
1	Pentoxyfylline	411	25	10	Solid (Crystal)	25 kg Drum	400	By road	12
2	Pregabaline	250	8	2	Solid (Crystal)	25 kg Drum	80	By road	2.5
3	Topiramate	330	6	2	Solid (Crystal)	25 kg Drum	80	By road	2.5
4	Carvidilol	55	37	2	Solid (Crystal)	25 kg Drum	80	By road	2.5

Sr. No.	Name of Raw Material	Qty. (Kg/batch)	Requirement (kg)		Used in	Physical Form	Mode of Storage	Capacity of storage unit (kg)	No. of Units	Total Storage Capacity (kg)	Storage Inventory (Days)
			Per Month	Per Day							
1	Theobromine	270	6750	270	Pentoxyfylline	Solid	bag	25	150	3750	14
2	6 Chloro 2 hexanone	202	5050	202		Liquid	barrel	300	20	6000	30
3	Pottasium Carbonate	207	5175	207		Solid	bag	50	28	1400	7
4	Dimethyl fomamide	800	20000	800		Liquid	MS Tank with inside SS Coating	9440	1	9440	12
5	Isoveraldehyde	344	2752	110.08	Pregabaline	Liquid	barrel	200	10	2000	18
6	Ethyl cyano acetate	452	3616	144.64		Liquid	barrel	200	15	3000	21
7	Di-n-propyl amine	29.1	232.8	9.312		Liquid	barrel	200	10	2000	215

Sr. No.	Name of Raw Material	Qty. (Kg/batch)	Requirement (kg)		Used in	Physical Form	Mode of Storage	Capacity of storage unit (kg)	No. of Units	Total Storage Capacity (kg)	Storage Inventory (Days)
			Per Month	Per Day							
8	n-hexane	516	4128	165.12		Liquid	MS Tank with inside SS Coating	6550	1	6550	40
9	DIETHYL MELONATE	618.7	4949.6	197.984		Liquid	barrel	200	25	5000	25
10	UREA	225	1800	72		Solid	bag	50	36	1800	25
11	CHLOROFORM	2400	19200	768		Liquid	drum	200	5	1000	1
12	R-(+)-(α)-PHENYL ETHYL AMINE	200	1600	64		Liquid	barrel	200	10	2000	31
13	HYDROCHLORIC ACID	117.8	942.4	37.696		Liquid	barrel	200	10	2000	53
14	LIQ. BROMINE	245	1960	78.4		Liquid	bottle	2	10	20	0
15	D-PYRANOSE FRUCTOSE	180	1080	43.2	Topiramate	Solid	bag	50	25	1250	29
16	ACETONE	427	2562	102.48		Liquid	barrel	200	15	3000	29
17	SULFURIC ACID	98	588	23.52		Liquid	container	92	10	920	39
18	SULPHURYL CHLORIDE	135	810	32.4		Liquid	barrel	50	20	1000	31
19	AMMONIA	17	102	4.08		Gas	cylinder	50	10	500	123
20	PYRIDINE	80	480	19.2		Liquid	barrel	50	10	500	26
21	SODIUM BICARBONATE	168	1008	40.32		Solid	bag	50	20	1000	25
22	TOLUENE	740	4440	177.6		Liquid	barrel	200	25	5000	28
23	4(Oxiranyl methoxy)- 9HCarbazol	32.5	1202.5	48.1	Carvidilol	Liquid	HDPE drum	50	25	1250	26
24	(2methoxyphenoxy)ethylamine	22.5	832.5	33.3		Liquid	HDPE	50	20	1000	30

Sr. No.	Name of Raw Material	Qty. (Kg/batch)	Requirement (kg)		Used in	Physical Form	Mode of Storage	Capacity of storage unit (kg)	No. of Units	Total Storage Capacity (kg)	Storage Inventory (Days)
			Per Month	Per Day							
							drum				
25	Activated carbon	7	259	10.36	Carvidilol	Solid	bag	50	10	500	37
		10	80	3.2	Pregabaline						
26	Ethyl acetate	413	15281	611.24	Carvidilol	Liquid	MS Tank with inside SS Coating	9020	1	9020	9
		1570	9420	376.8	Topiramate						
27	Methanol	770	19250	770	Pentoxyfylline	Liquid	barrel	200	50	10000	7
		61.2	489.6	19.584	Pregabaline						
		395	14615	584.6	Carvidilol						
28	SODIUM HYDROXIDE	183.1	1464.8	58.592	Pregabaline	Solid	bag	50	40	2000	26
		80	480	19.2	Topiramate						
		-	3	0.12	Scrubber to Incinerator						
29	Hyflow Bed	5.5	137.5	5.5	Pentoxyfylline	Solid	bag	50	10	500	77
		3	24	0.96	Pregabaline						
30	37% Sulphuric Acid	500	4000	160.0	Ammonia Srcubber for Pregabaline	Liquid	barrel	200	6	1200	8

Sr. No.	Name of Reactors	Capacity of Reactors	MOC of Reactors	No Reactors	Pressurized	Height	Diameter	Thickness
1	Pregabaline	5KL	Glass Line	1	1 KG	1700 MM	2200MM	6 MM
		4 KL	Glass Line	1	1 KG	1600 MM	2100 MM	6 MM
			SS-316	1	1KG	1600 MM	2100 MM	6 MM
2	Topiramate	3 KL	Glass Line	1	1 KG	1400 MM	2000 MM	6MM
			SS-316	1	1 KG	1400 MM	2000 MM	6 MM
3	Pentoxyfylline		SS-316	1	2 KG	1400 MM	2000 MM	6MM
		2 KL	Glass Line	1	1 KG	1200 MM	1900 MM	6 MM
4	Carvidilol		SS-316	1	2 KG	1200 MM	1900 MM	6 MM
		1.5 KL	Glass Line	1	1 KG	1100 MM	1600 MM	6 MM
			SS-316	1	1 KG	1100 MM	1600 MM	6 MM
		1 kl	ss-316	1	1 KG	1000 MM	1250 MM	6 MM

7.4 Identification of Hazardous Chemicals to be Handled After Expansion

Amongst the above described raw materials and products, some chemicals are falling into category of hazardous chemicals defined under Manufacture, Storage and Import of Hazardous Chemical Rules, 1989, amended 2000(MSIHC). List of chemical and physical properties of the same are given in ***Table 7-2***. [(Souce of data: NIOSH Pocket Guide to Chemical Hazards, 2004 published by the National Institute for Occupational Safety and Health (NIOSH)), MSDS attached as ***Annexure 5***. Note: All concentrations in parts per million (ppm) unless otherwise noted. "C" indicates Ceiling Limit.]

Table 7-2: Hazardous Chemicals Details

Sr. No.	Chemicals	TLV (ppm)	Toxicity Level			Flammable Limit					Chemical Class (As per MSIHC Rules)
			LD_{50} Oral mg/ Kg	LD_{50} Dermal mg/Kg	LC_{50} mg/l	LEL%	UEL%	FP ^{0}C	BP ^{0}C	Class (As per petroleum classification)	
1	N-Hexane*	TLV 50 IDLH 1100	15,800	>3300	42,600	-22 ^{0}C	1.1 %	7.5 %	63- 69	A	Flammable
2	Chloroform*	TLV 10 IDLH 500	695 mg/kg	-	47702 mg/m	None	None	None	61°C	B	Toxic
3	Hydrochloric Acid*	2C IDLH 50	2857 ug/kg	900 mg/kg	4701 ppm	None	None	None	108.58 C	B	Hazardous
5	Liq. Bromine*	TLV 0.1 STEL 0.2 IDLH 3	2600 mg/kg	-	750 ppm 1 hours	None	None	None	58.78	-	Highly toxic
7	Sulfuric Acid*	TLV 1mg/m^3 STEL: 3	2140 mg/kg	-	510 mg/m3	None	None	None	270°C	-	Corrosive

Sr. No.	Chemicals	TLV (ppm)	Toxicity Level			Flammable Limit					Chemical Class (As per MSIHC Rules)
			LD_{50} Oral mg/ Kg	LD_{50} Dermal mg/Kg	LC_{50} mg/l	LEL%	UEL%	FP ^{0}C	BP ^{0}C	Class (As per petroleum classification)	
9	Ammonia* (liquefied Compressed Gas)	TLV 25mg/m^3 STEL: 35 IDLH: 300	350 mg/kg	-	2000 ppm/4H	16%	25%	None	(-)33.35°C	-	Highly toxic
10	Pyridine*	TLV 1ppm IDLH: 1,000 ppm	891 mg/kg	-	28500 mg/m 1 hour	1.8%	12.4%	20°C	115.3°C	B	Toxic Flammable
11	Toluene*	50 IDLH: 500	636	N/A	440	1.1	7.1	16	110.6	A	Flammable, Toxic, Hazardous
12	Methanol*	200 STEL 250 IDLH 6,000	5628	15800	64000 ppm/ 4 hr	6	36.5	12 ^{0}C	64.5	A	Very high flammable
13	Sodium Hydroxide*	2 mg/m^3	N.A	N.A	N.A	N.A	N.A	N.A	1388	--	Hazardous

Sr. No.	Chemicals	TLV (ppm)	Toxicity Level			Flammable Limit					Chemical Class (As per MSIHC Rules)
			LD_{50} Oral mg/ Kg	LD_{50} Dermal mg/Kg	LC_{50} mg/l	LEL%	UEL%	FP ^{0}C	BP ^{0}C	Class (As per petroleum classification)	
14	Ethyl Acetate*	400 IDLH: 2000	5620 mg/kg	-	45000 mg/m	2.2%	9%	-4.4°C	77°C	--	Flammable
15	Dimethyl Fomamide	10 ppm	: 2,800 mg/kg	4,720 mg/kg	: 9.4 mg/l	2.2 %	15.2 %	58 °C	153 °C	--	Flammable
16	Acetone	TWA: 750 STEL: 1000	5800 mg/kg	-	50100 mg/m 8 hours	2.6%	12.8%	-20°C	56.2°C	--	Flammable

Note: CC: Close Cup; OC: Open Cup; N.A.: Not Available.

The Toxicity level of hazardous chemicals as per Manufacture, storage and import of Hazardous Chemical (Amendment) Rules, 2000 (MSIHC) is shown as below

Sr. No	Toxicity	Oral Toxicity LD_{50} (mg/Kg)	Dermal Toxicity LD_{50} (mg/Kg)	Inhalation Toxicity LD_{50} (mg/Kg)
1	Extremely Toxic	<5	<40	<0.5
2	Highly Toxic	>5- 50	>40-200	>0.5-2
3	Toxic	>50-200	>200-1000	>2-10

7.4.1 Hazard associated with the storage of hazardous chemical

Storage details of raw materials and products are given in table no. 7.1. It is noticeable from storage details that very less quantity of hazardous chemicals will stored within premises. Major storage will be for chemicals like N- Haxane, Dimethyl Formamide, Chloroform, Methanol, Ethyl Acetate in MS tank with inside SS coating. All other raw materials will be stored in HDPE drums in very small quantity. Two bottles of Liquid Bromine and two cylinders of Ammonia will stored within premises.

Area identified for possibility of Fire & Explosion Hazard:

- Methanol storage Tank
- N- Haxane Storage Tank
- Ethyl Acetate storage Tank
- Pyridine barrel/HDPE drum
- Toluene barrel/HDPE drum

Main Area identified for possibility of Toxic Gas Release:

- Toxic gas release from Ammonia Cylinders, Pipelines, valves
- Liq. Bromine storage & Process Reactors, pipelines, valves

7.5 Hazard Preventive Measures

Hazardous material may be present in a number of process systems or storage vessels. Major Accident could be a fire, explosion, release of energy/toxic emission arising from a sudden release of hazardous or toxic material form tank, storage vessel or pipeline of the facility. Hazardous activities within this plant as follow:

- A storage area of solvents
- Pipeline carrying hot oil from Thermic Fluid Heater
  - Above ground storage containing hazardous chemical as listed in ***Table 7-2.***

Table 7-3: Raw Material Storage Hazards and Controls

Sr. No.	Material stored & (Type of Hazard)	Quantity (Max)	Operating press/ temp	Hazard Rating Systems	Risk involved	Persons Affected
(1)	N-Hexane*	6.55 Ton (MS Tank with inside SS Coating)	Ambient	TLV:50 IDLH : 1100 NFPA Ratings: Health:1; Flammability:3; Instability: 0 Flash Point: 79.44^{0}C	• Dangerous when exposed to heat or flame as it is highly inflammable and • Forms an explosive mixture with air. It can lead to slight toxicity on inhalation of vapour • Pool Fire • BLEVE	Operators Maintenance Technicians Workers
	Control Measures: ➢ Dyke provision to storage area of tank ➢ Safety boards should be displayed on the tank ➢ Good ventilation must be provided.					

Sr. No.	Material stored & (Type of Hazard)	Quantity (Max)	Operating press/ temp	Hazard Rating Systems	Risk involved	Persons Affected
	➢ Safety shower should be provided in the vicinity of storage and handling area. If the area covered is wide, it should be ensured that shower is quickly and easily accessible to all persons concerned or more number of showers may be provided depending upon the need. ➢ A fire hydrant line should be provided near the area of storage/handling of hexane. ➢ Use water spray to keep fire-exposed containers cool. Wear a self-contained breathing apparatus (SCBA) to prevent contact with thermal decomposition products. ➢ Handling of Haxane with Safety glasses, hand gloves, gumboot ➢ Flameproof enclosures of electrical apparatus and fitting, electrical equipment to be used ➢ Provision of explosive meters/flammable vapour indicators should be made ➢ Earthing may be done according to IS : 30431966					
(2)	Methanol (Fire & Toxicity)	10 MT	Ambient	TLV – 200 PPM (8-hr TWA) STEL-250 PPM NFPA Ratings: Health: 1 Flammability: 3	• Highly Flammable • Toxic by inhalation • Toxic when contact with Skin • Toxic if swallowed • Danger of very serious irreversible effects. • Pool fire • BLEVE	Operators Maintenance Technicians
(3)	Toluene (Fire & Toxicity)	0.8 MT	Ambient	TLV – 200 PPM (8-hr TWA) STEL-500 PPM NFPA Ratings: Health: 2 Flammability: 3	• Flammable • Toxic by inhalation • Toxic when contact with Skin • Toxic if swallowed • Danger of very serious irreversible effects.	Operators Maintenance Technicians

Sr. No.	Material stored & (Type of Hazard)	Quantity (Max)	Operating press/ temp	Hazard Rating Systems	Risk involved	Persons Affected
	Control Measures: ➢ Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. ➢ In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents. ➢ Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location. ➢ Safety boards displayed on the tank. ➢ Good ventilation must be provided.					
(4)	Ethyl Acetate (Fire & Toxicity)	MT (MS Tank with inside SS Coating)	Ambient	TLV: 400 IDLH: 2000 Health: 1 Flammability: 3 Reactivity: 0	• Flammable • Toxic by inhalation • Toxic when contact with Skin • Toxic if swallowed • Pool Fire • BLEVE	Operators Maintenance Technicians
	➢ Dyke provision to storage area of tank ➢ Safety boards should be displayed on the tank ➢ Good ventilation must be provided. ➢ Safety shower should be provided in the vicinity of storage and handling area. If the area covered is wide, it should be ensured that shower is quickly and easily accessible to all persons concerned or more number of showers may be provided depending upon the need. ➢ A fire hydrant line should be provided near the area of storage/handling of hexane. ➢ Use water spray to keep fire-exposed containers cool. Wear a self-contained breathing apparatus (SCBA) to prevent contact with thermal decomposition products. ➢ Handling of Ethyl Acetate with Safety glasses, hand gloves, gumboot					

Sr. No.	Material stored & (Type of Hazard)	Quantity (Max)	Operating press/ temp	Hazard Rating Systems	Risk involved	Persons Affected
	➢ Flameproof enclosures of electrical apparatus and fitting, electrical equipment to be used ➢ Provision of explosive meters/flammable vapour indicators should be made ➢ Earthing may be done according to IS : 30431966					
(5)	Chloroform (drum)	200 Kg x 10	Ambient	TLV : 10 ppm IDLH : 50 ppm Health: 2 Flammability: 0 Reactivity:0	• Toxic by inhalation • Toxic when contact with Skin • Toxic if swallowed • Toxic gas dispersion • In presence of excess moisture, strong alkalis, sunlight and high temperatures Chloroform decomposes to highly toxic phosgene and hydrochloric acid.	Operators Maintenance Technicians
	➢ Chloroform are not compatible with mild steel storage and handling equipment. The use of stainless steel—lined mild steel, nickel clad steel, or stainless steel of the 300 series. ➢ Precautionary measures should be taken to ensure that moisture does not contaminate the solvent. To minimize evaporation losses, a completely sealed storage tank is recommended. ➢ Positive displacement rotary pumps are recommended for chloroform service. ➢ Submerged centrifugal pumps may be used in storage tanks designed for atmospheric service. ➢ Piping may be of steel or black iron, preferably with welded or flanged joints. ➢ Lubricant for threaded joints must be of a type resistant to chloroform, such as white lead, graphite and glycerine pastes or fluorocarbon tape. ➢ Dyke provision to storage area of tank ➢ Safety boards should be displayed on the tank					

Sr. No.	Material stored & (Type of Hazard)	Quantity (Max)	Operating press/ temp	Hazard Rating Systems	Risk involved	Persons Affected
	➢ Good ventilation must be provided.					
(6)	Liquid Bromine	540 Kg	Ambient	TLV : 0.1ppm STEL: 0.2ppm IDLH : 3ppm Health: 3 Flammability: 0 Reactivity:0	• Toxic by inhalation • Toxic when contact with Skin • Toxic if swallowed • Toxic liquid • Bromine itself will not burn but it is a strong oxidizer	Operators Maintenance Technicians
	➢ Bromine should be stored in a cool well ventilated area avoiding direct sunlight. The temperature of storage area should not go below—7°C to prevent freezing. ➢ Glass Bottles—Hermeticallysealed glass containers should be first cooled and then opened with extreme caution. ➢ Bromine should be stored away from other chemicals and organic chemicals. ➢ Bromine vapours from reaction vessels or storage tanks should be vented through an alkali absorber preferably kept under constant pressure. The vent line should be purged with dry air. ➢ Electrical fittings in area where bromine vapours are likely to be present should be able to withstand the corrosive effect and should be of vapour proof construction, wiring being in tight, rigid metal conduits. ➢ Safety showers and eyewash fountains should be immediately at hand where contact is at all likely.					

Sr. No.	Material stored & (Type of Hazard)	Quantity (Max)	Operating press/ temp	Hazard Rating Systems	Risk involved	Persons Affected
(7)	Ammonia (Cylinders)	500 Kg (50 x 10)	Ambient	TLV : 25mg/m^3 STEL: 35 ppm IDLH: 300 ppm Health: 3 Flammability: 1 Reactivity:0	• Toxic by inhalation • Toxic when contact with Skin • Toxic if swallowed • Ammonia is capable of forming flammable mixtures with air within certain limits (16 to 25 percent by volume).	Operators Maintenance Technicians
	➢ Store in a fire resistant structure, away from steam pipes and heating devices. Storage should be dry and cool. Avoid mechanical damage or overheating of storage tanks and cylinders. ➢ Suitable safety device like pressure control relieving system must be there to avoid excess pressurization. Safety valved ammonia storage tanks are to be designed for fire conditions. ➢ Ventilation should be provided through the structure in such a manner that full advantage of natural ventilation may be obtained. ➢ Avoid pocketing of ammonia gas under floors, roofs, and similar structures. ➢ There should be provision of diagonally opposite emergency exits of each corner of the building and emergency push button at each exit which should sound alarm as part of warning system. Source of water should be available in vicinity for dealing with small spill and leaks. Fire hydrants should be located within 25 m of storage ➢ Store empty cylinders separate from filled cylinders and fasten an EMPTY tag on cylinders immediately upon emptying. Close valve, replace plug or nut on valve outlet, and secure valve protecting cap snugly.					

Sr. No.	Material stored & (Type of Hazard)	Quantity (Max)	Operating press/ temp	Hazard Rating Systems	Risk involved	Persons Affected
(8)	Acetone	600 Kg (Barrel) (200 x 3)	Ambient	TLV : 500ppm NFPA rating: Health: 1 Flammability: 3 Reactivity:0	• Acetone is highly flammable and its vapours form explosive mixtures with air. • Explosive concentration of acetone may be ignited at low energy levels of accumulated static charges. • Pool Fire • BLEVE	Operators Maintenance Technicians
	➢ All electrical motors, controls, switches, relays, lights, etc, shall be flameproof and should conform to the requirements of IS : 2148-1968* ➢ The safe method of emptying drums is by pump. Electrical pumps should have explosion-proof motors. If drums are emptied by gravity; the faucets shall be self-closing. Pressure shall never be used, especially with air. ➢ Before acetone drums are opened they shall be supported and grounded by fastening a screw clamp to the rim of the drums and connecting the clamp by a 6-mm extra flexible copper wire to any suitable and adequate earthing point. ➢ Drums shall be opened preferably with spark-resistant tools. Fittings shall never be struck with tools or other hard objects which may cause sparking. ➢ Acids or oxidizing materials shall not be stored in the same shed or nearby within the statutory safety distance.					
(9)	Hydrochloric Acid	2 Ton 200 Kg drum	Ambient	TLV : 500 ppm NFPA rating: Health: 1 Flammability: 3 Reactivity:0	• Non-flammable, but reacts with most metals with evolution of hydrogen which may cause fire nor explosion with air • Highly corrosive to most metals with evolution of	Operators Maintenance Technicians

Sr. No.	Material stored & (Type of Hazard)	Quantity (Max)	Operating press/ temp	Hazard Rating Systems	Risk involved	Persons Affected
					hydrogen gas, which is highly explosive when mixed with air	
	➢ Aqueous hydrochloric acid containers should be stored out of direct rays of the sun and away from sources of heat. Location of storage should be in the open, or in well-ventilated buildings or sheds. Ample, natural ventilation should be provided. ➢ Drums should be stored with the closures up to prevent leakage, securely blocked on skids, and on a properly drained and dry site. ➢ They should be stored out the direct rays of the sun and away from heat, oil, grease, and from all other potential sources of fire. Drums should be vented when received, and at least weekly thereafter, to relieve accumulated internal pressure. ➢ Electrical fixtures preferably should be of the vapour-proof type. All wiring should be in tight, rigid metal conduits, all protected with an acid-resisting coating. All electrical equipment should conform to the national electrical specifications wherever existing.					
(10)	Sulphuric Acid	500 Kg (50 x 10)	Ambient	TLV : 1 mg/m^3 NFPA rating: Health: 3 Flammability: 0 Reactivity:2	• Acid is non-flammable but in higher concentration may cause Ignition by contact with organic or combustible materials. • Likelihood of highly flammable hydrogen gas being generated inside a drum • Hydrogen gas will form explosive mixtures with air under certain conditions, smoking or open lights should not be permitted near	Operators Maintenance Technicians

Sr. No.	Material stored & (Type of Hazard)	Quantity (Max)	Operating press/ temp	Hazard Rating Systems	Risk involved	Persons Affected
					the open drums	
	➢ Drums should be stored with the plugs up. Storage period of acid in drums qhould be kept to a minimum. They should be vented once a week or earlier in hot weather to release hydrogen build-up. ➢ Floors of the storage area should be of acid resistant material and should have adequate slope for easy draining of any spilled acid. Before the acid is allowed to enter the main sewer, it should be collected in a catch pit, sufficiently diluted and suitably neutralized. Water should be freely available to dilute such spillage. ➢ Storage should be located in the open or in well ventilated buildings or sheds. Natural ventilation is sufficient. ➢ Electrical wiring should be made of acid-resistant insulation and encased in rigid metal or PVC conduits. Smoking shall be strictly prohibited where Sulphuric Acid is stored.					
11	Pyridine	Barrel (50 x 10) 500 Kg	Ambient	TLV 1ppm IDLH: 1,000 ppm NFPA ratting: Health: 3 Flammability: 3 Reactivity:0	• Severe fire hazard. • Vapor/air mixtures are explosive. The vapor is heavier than air. Vapors or gases may ignite at distant ignition sources and flash back.	
	➢ All electrical motors, controls, switches, relays, lights, etc, shall be flameproof and should conform to the requirements of IS : 2148-1968* ➢ The safe method of emptying drums is by pump. Electrical pumps should have explosion-proof motors. If drums are emptied by gravity; the faucets shall be self-closing. Pressure shall never be used, especially with air. ➢ Before Pyridine drums are opened they shall be supported and grounded by fastening a screw clamp to the rim of the drums and connecting the clamp by a 6-mm extra flexible copper wire to any suitable and adequate earthing point. ➢ Drums shall be opened preferably with spark-resistant tools. Fittings shall never be struck with tools or other hard objects which may cause sparking.					

Sr. No.	Material stored & (Type of Hazard)	Quantity (Max)	Operating press/ temp	Hazard Rating Systems	Risk involved	Persons Affected
	➢ Acids or oxidizing materials shall not be stored in the same shed or nearby within the statutory safety distance.					

7.6 Damage criteria

The storage and unloading at the storage facility may lead to fire and explosion hazards. The damage criteria due to an accidental release of any hydrocarbon arise from fire and explosion.

Tank fire would occur if the radiation intensity is high on the peripheral surface of the tank leading to increase in internal tank pressure. Pool fire would occur when the flammable liquid in the tank due to leakage gets ignited.

7.6.1 Fire damage

A flammable liquid in a pool will burn with a large turbulent diffusion flame. The radiations can also cause severe burns or fatalities of workers or firefighters located within a certain distance. Hence, it will be important to know beforehand the damage potential of a flammable liquid pool likely to be created due to leakage or catastrophic failure of a storage or process vessel. This will help to decide the location of other storage/process vessels, decide the type of protective clothing the workers/firefighters need, the duration of time for which they can be in the zone, the fire extinguishing measures needed and the protection methods needed for the nearby storage/process vessels.

The damage effect on equipment and people due to thermal radiation intensity whereas; the effect of incident radiation intensity and exposure time on lethality is given in ***Table 7-4.***

Table 7-4: Damage Due to Incident Radiation Intensities

S. No.	Incident Radiation (kW/m2)	Type of Damage Intensity	
		Damage to Equipment	Damage to People
1	37.5	Damage to process equipment	100% lethality in 1 min. 1% lethality in 10 sec.
2	25.0	Minimum energy required to ignite wood at indefinitely long exposure without a flame	50% Lethality in 1 min. Significant injury in 10 sec.
3	19.0	Maximum thermal radiation intensity allowed on thermally unprotected adjoining equipment	--
4	12.5	Minimum energy to ignite with a flame; melts plastic tubing	1% lethality in 1 min.
5	4.5	--	Causes pain if duration is longer than 20 sec, however blistering is un-likely (First degree
6	1.6	--	Causes no discomfort on long exposures
Source: Techniques for Assessing Industrial Hazards by World Bank.			

Table 7-5: Radiation Exposure and Lethality

Radiation Intensity (kW/m^2)	Exposure Time (seconds)	Lethality (%)	Degree of Burns
1.6	--	0	No Discomfort even after long exposure
4.5	20	0	1 st
4.5	50	0	1 st
8.0	20	0	1 st
8.0	50	<1	3 rd
8.0	60	<1	3 rd
12.0	20	<1	2 nd
12.0	50	8	3 rd
12.5	--	1	--
25.0	--	50	--
37.5	--	100	--

7.6.2 Damage due to Explosion

Explosion is a sudden and violent release of energy accompanied by the generation of pressure wave and a loud noise. The rate of energy release is very large and has potential to cause injury to the people, damage the plant and nearby property etc. The effect of over-pressure can directly result in deaths of those working in the immediate vicinity of the explosion. The pressure wave may be caused by a BLEVE (Boiling Liquid Expanding Vapour Cloud) or Vapour Cloud explosion.

A. BLEVE - fireball

BLEVE is sometimes referred to as a fireball. A BLEVE is a combination of fire and explosion with an intense radiant heat emission within a relatively short time interval. This phenomenon can occur as a result of overheating of a pressurized vessel by a primary fire. If a pressure vessel fails as a result of a weakening of its structure the contents are instantaneously released from the vessel as a turbulent mixture of liquid and gas expanding rapidly and dispersing in air as a cloud. When this cloud is ignited a fireball occurs causing enormous heat radiation intensity within a few seconds. This heat intensity is sufficient to cause severe skin burns and deaths at several hundred meters from the vessel, depending on the quantity of gas involved. A BLEVE can therefore be caused by a physical impact on a vessel or a tank, which is already overstressed.

B. Vapour Cloud Explosion

Explosion can be confined and unconfined vapour cloud explosions. Confined explosions are those, which occur within some sort of containment such as a vessel or pipeline. Explosions in buildings also come under this category. Explosions which occur in the open air are referred to as unconfined explosions and produce peak pressures of only a few kPa. The peak pressures of confined explosions are generally higher and may reach hundreds of kPa. ***Table***

7-6 tabulates the damage criteria as a result of peak over pressure of a pressure wave on structures and people.

Table 7-6: Damage Due To Peak over Pressure

Human Injury		Structural Damage	
Peak Over Pressure (bar)	Type of Damage	Peak Over Pressure (bar)	Type of Damage
5 - 8	100% lethality	0.3	Heavy (90% damage)
3.5 - 5	50% lethality	0.1	Repairable (10% damage)
2 - 3	Threshold lethality	0.03	Damage of Glass
1.33 - 2	Severe lung damage	0.01	Crack of Windows
1 - $1^{1/3}$	50% Eardrum rupture	-	-
Source: Marshall, V.C. (1977) ' How lethal are explosives and toxic			

C. Effect due to toxic gas release

Chlorine is a greenish-yellow, highly reactive halogen gas that has a pungent, suffocating odour. The vapour is heavier than air and will form a cloud in the vicinity of a spill. Like other halogens, chlorine exists in the diatomic state in nature. Chlorine is extremely reactive and rapidly combines with both inorganic and organic substances. Chlorine is an eye and respiratory tract irritant and, at high doses, has direct toxic effects on the lungs. The critical values of chlorine concentrations in air are given in ***Table 7-7.***

Table 7-7: Critical Concentrations for Ammonia

Criteria	Concentration
90% lethality (10 min exposure)	866 ppm
50% lethality (10 min exposure)	433 ppm
10% lethality (10 min exposure)	217 ppm
Immediate Damage to life and Health	25 ppm

7.6.3 Typical scenarios considered for MCA analysis

Based on the storage and properties of the chemicals to be used in plant some typical scenarios relevant for MCA analysis is given in the following Table.

Table 7-8: Scenarios Considered For MCA Analysis

Sr. No.	Chemical	Quantity MT	Jet Fire	Pool Fire	BLEVE	Explosion	Toxic Release
1	Failure of N- Haxane storage tanks (Connection leak))	10	--	*	-	-	-
2	Catastrophic Failure of N –Haxane Storage Tanks	10	--	*	-	-	-
3	Failure of Chloroform storage tanks (Connection leak))	10	-	*	-	-	*
4	Leakage of Chloroform Storage drum Tanks	200 Kg	-	*	-	-	*
5	Failure of ammonia cylinder	50 Kg	--	-	*	*	*
6	Failure of Ethyl Acetate storage tanks (Connection leak))	10	--	*	-	-	-
7	Catastrophic Failure of Ethyl Acetate Storage Tanks	10	--	*	-	*	-
8	Catastrophic Failure of Methanol drum	200 kg	--	*	-	-	-

Note:* Considered for MCA Analysis

Most likely scenario is leakage of Ammonia and forming toxic cloud during unloading operation and leakage of chloroform leading to explosion during filling operation.

A perusal of the above table indicates that major material storage is flammable liquid. Fires could occur due to presence of ignition source at or near the source of leak or could occur due to flashback upon ignition of the traveling vapour cloud. Tank fires may occur due to the following:

Ignition if rim seal leak leading to rim seal fire and escalating to full-fledged tank fire. Lighting is a major source of ignition of tank fires; and

Overflow from tank leading to spillage and its subsequent ignition, which flashes back to the tank leading to tank fire. The chance of overflow should be less unless operator has grossly erred. Spillage due to overflow may result in a dyke fire if ignition occurs after sufficiently long period.

For radiation calculations, pool fire may be important and the criteria of 4.5 kW/m^2 could be selected to judge acceptability of the scenarios. The assumptions for calculations are:

- It is not continuous exposure
- It is assumed that no fire detection and mitigation measures are initiated
- There is not enough time available for warning the public and initiating emergency

action

- Secondary fire at public road and building is not likely to happen
- Shielding effect of intervening trees or other structures has not been considered. No lethality is expected from this level of intensity although burn injury takes place depending on time of exposure

7.7 Consequence Analysis

Spill, dispersion, and subsequent fire effects calculations are performed using the ALOHA Software. ALOHA is an air dispersion model, which you can use as a tool for predicting the movement and dispersion of gases. It predicts pollutant concentrations downwind from the sources of a spill, taking into consideration the physical characteristics of the spilled material. ALOHA also accounts for some of the physical characteristics of the release site, weather conditions, and the circumstances of the release. Like many computer programs, it can solve problems rapidly and provide results in a graphic, easy to use format. This can be helpful during an emergency response or planning for such a response.

ALOHA provide output as amount of chemical discharged from the source as well as its concentration in air it takes into account different levels of concentrations for a specified chemical.

Software used for calculation- ALOHA (Areal locations of Hazardous atmospheres)

Aloha is a computer program designed especially for use by people responding to chemical accidents, as well as for emergency planning and training. ALOHA can predict the rates at which chemical vapors may escape into the atmosphere from broken gas pipes, leaking tanks and evaporating puddles. It can then predict how a hazardous gas cloud might disperse in the atmosphere after an accidental chemical release.

ALOHA provides output as amount of chemical discharged from the source as well as its concentration in air it takes in to account different levels of concentrations for a specified chemical. Different concentration levels are given below:

7.7.1 Toxic Release

For toxic release, there is several hazard classification systems in use. Some chemicals have not been classified in every system. ALOH determines its default toxic Level of Concern (LOC) values based on the following:

A. AEGLs

Acute Exposure Guideline Levels (AEGLs) are Toxic Levels of Concern (LOCs) that is used to predict the area where a toxic gas concentration might be high enough to harm people. The guidelines define three-tiered AEGLs as follows:

AEGL-1: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

AEGL-2: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

AEGL-3: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

ALOHA only includes AEGL values with an exposure period of 60 minutes.

B. ERPGs

The Emergency Response Planning Guidelines (ERPGs) are Toxic Levels of Concern (LOCs) that is used to predict the area where a toxic gas concentration might be high enough to harm people. The ERPGs are threetiered guidelines with one common denominator: a 1-hour contact duration.

Each guideline identifies the substance, its chemical and structural properties, animal toxicology data, human experience, existing exposure guidelines, the rationale behind the selected value, and a list of references.

ERPG 1: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor.

ERPG 2: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.

ERPG 3: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

The most important point to remember about the ERPGs is that they do not contain safety factors usually incorporated into exposure guidelines. Rather, they estimate how the general public would react to chemical exposure. Just below the ERPG-1, for example, most people would detect the chemical and may experience temporary mild effects. Just below the ERPG-3, on the other hand, it is estimated that the effects would be severe, although not life threatening. The ERPG should serve as a planning tool, not a standard to protect the public.

C. TEELs

There are three TEEL levels that are important for responders to consider:

TEEL-1: Maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing other than mild transient health effects or perceiving a clearly defined objectionable odor.

TEEL-2: Maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.

TEEL-3: Maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing life threatening health effects.

D. IDLH

Immediately Dangerous to Life or Health (IDLH) level is a limit originally established for selecting respirators for use in workplaces by the National Institute for Occupational Safety and Health (NIOSH). A chemical's IDLH is an estimate of the maximum concentration in the air to which a healthy worker could be exposed without suffering permanent or escape-impairing health effects. We recommend that appropriate respirator (as per NIOSH) be kept handy/easily available.

The IDLH was not designed to be an exposure limit for the general population. It does not take into account the greater sensitivity of some people, such as children and the elderly.

Note: For AEGLs, ERPGs and TEELs, the rank number increase with the hazard level, so that AEGL-3 is more hazardous than AEGL-1. Typically, the "3" values are used for the most hazardous (red) threat zones because they represent the threshold concentration above which health effects may be life threatening.

7.7.2 ALOHA Software Modeling Input Details

A. Weather Data

- Average Wind Speed: 3 m/sec
- Average Ambient Temperature: 35^0C
- Average Humidity: 50%
- Atmosphere Stability Class: D

B. Chemical Properties

Chemical properties of each hazardous chemical stored within premises is given in ***Table 7-2.***

C. Storage Details

Storage quantity and type of storage of chemicals is given in ***Table 7-3.***

Table 7-9: Flammable, Toxic chemicals release and Consequence Analysis

Name of Chemical	Type of Impact		Flammable (Distance in meter)										
			Jet Fire			Pool Fire			Fire Ball (BLEVE)			Flash fire (Flammable Area of Vapor Cloud)	
	Radiation Intensity(kW/m^2)		37.5	25	12	37.5	25	12	37.5	25	12	UEL	LEL
	Fatalities		100%	50%	8%	100%	50%	8%	100%	50%	8%	-	-
	Wind Speed	Stability Class											
N – Haxane (10MT Tank)	3	B	-	-		23	31	49	98	124	184	48 meters	158 meters
	5	C	-	-		36	45	63	98	124	184	43 meters	160 meters
	4	D	-	-		33	43	61	102	128	189	32 meters	127 meters
Ethyl Acetate (10MT Tank)	3	B	-	-		18	24	39	69	93	144	21 meters	89 meters
	5	C	-	-		27	36	49	-	-	-	22 meters	36 meters
	4	D	-	-		25	33	48	72	97	149	23 meters	44 meters
Methanol (1 drum)	3	B	-	-		<10	<10	<10	22	29	46	-	-
	5	C	-	-		<10	<10	<10	22	29	46	-	-
	4	D	-	-		<10	<10	<10	23	30	47	-	-
Ammonia (50 Kg	3	B	10m	10m	10m	-	-	-	-	-	-	11 meters	30 meters

Name of Chemical	Type of Impact		Flammable (Distance in meter)										
			Jet Fire			Pool Fire			Fire Ball (BLEVE)			Flash fire (Flammable Area of Vapor Cloud)	
	Radiation Intensity(kW/m^2)		37.5	25	12	37.5	25	12	37.5	25	12	UEL	LEL
	Fatalities		100%	50%	8%	100%	50%	8%	100%	50%	8%	-	-
	Wind Speed	Stability Class											
cylinder)	5	C	10m	10m	10m	-	-	-	-	-	-	11 meters	29 meters
	4	D	10m	10m	10m	-	-	-	-	-	-	11 meters	30 meters
Pyridine (200 Kg Drum)	3	B	-	-	-	<10	<10	15	27	35	52	<10	<10
	5	C	-	-	-	10	12	16	27	35	52	<10	<10
	4	D	-	-	-	<10	11	16	28	36	53	<10	<10

Table 7-10: Toxic chemicals release and Consequence Analysis

Name of Chemical	Type of Impact		Toxic		
			AEGL(3)	AEGL(2)/ IDLH	AEGL(1)
	Wind Speed	Stability Class			
N-Haxane	3	B	--	--	--
	5	C	--	--	--
	4	D	27 meters --- (8600 ppm = AEGL-3 [60 min])	--	67 meters --- (2900 ppm = AEGL-2 [60 min])
Chloroform	3	B	<10meter (3200 ppm = AEGL-3 [60 min])	49 meters --- (64 ppm = AEGL-2 [60 min])	124 meters --- (10 ppm)
	5	C	<10 merter --- (3200 ppm = AEGL-3 [60 min])	59 meters --- (64 ppm = AEGL-2 [60 min])	153 meters --- (10 ppm)
	4	D	<10 merter --- (3200 ppm = AEGL-3 [60 min])	70 meters --- (64 ppm = AEGL-2 [60 min])	186 meters --- (10 ppm)
Ammonia	3	B	55 (1100 ppm = AEGL-3 [60 min])	105 (300 ppm = IDLH)	319 (30 ppm = AEGL-1 [60 min])
	5	C	58 (1100 ppm = AEGL-3 [60 min])	110 (300 ppm = IDLH)	350 (30 ppm = AEGL-1 [60 min])
	4	D	89 (1100 ppm = AEGL-3 [60 min])	171 (300 ppm = IDLH)	554 (30 ppm = AEGL-1 [60 min])
Pyridine (200 Kg Drum)	3	B	<10meter (1000 ppm = IDLH)	38 meters --- (19 ppm = PAC-2)	164 meters --- (1 ppm)
	5	C	<10meter (1000 ppm = IDLH)	47 meters --- (19 ppm = PAC-2)	213 meters --- (1 ppm)

Name of Chemical	Type of Impact		Toxic		
			AEGL(3)	AEGL(2)/ IDLH	AEGL(1)
	Wind Speed	Stability Class			
	4	D	<10meter	46 meters --- (19 ppm = PAC-2)	225 meters --- (1 ppm)
Bromine (270 Kg) Leakage Wrost case scenario	3	B	63 meters --- (8.5 ppm = AEGL-3 [60 min])	106 meters --- (3 ppm = IDLH)	900 meters --- (0.033 ppm = AEGL-1 [60 min])
	5	C	69 meters --- (8.5 ppm = AEGL-3 [60 min])	117 meters --- (3 ppm = IDLH)	1.1 kilometers --- (0.033 ppm = AEGL-1 [60 min])
	4	D	97 meters --- (8.5 ppm = AEGL-3 [60 min])	165 meters --- (3 ppm = IDLH)	1.8 kilometers --- (0.033 ppm = AEGL-1 [60 min])

7.7.3 Risk Countour

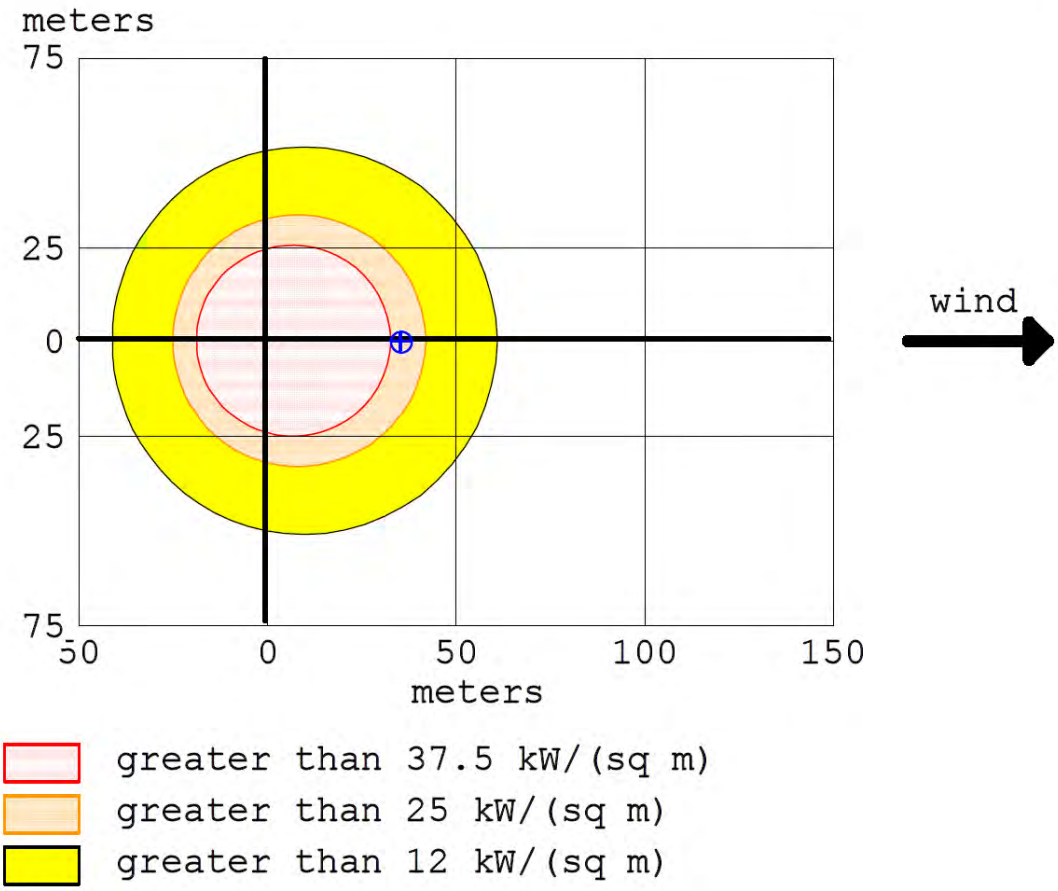
Thermal Radiation Threat Zone ALOHA® 5.4.6

```
Time: September 2, 2016  1620 hours ST (using computer's clock)

Chemical Name: N-HEXANE

Wind: 4 meters/second from WNW at 3 meters

THREAT ZONE:
  Threat Modeled: Thermal radiation from pool fire
  Red    : 33 meters --- (37.5 kW/(sq m))
  Orange: 43 meters --- (25 kW/(sq m))
  Yellow: 61 meters --- (12 kW/(sq m))
```



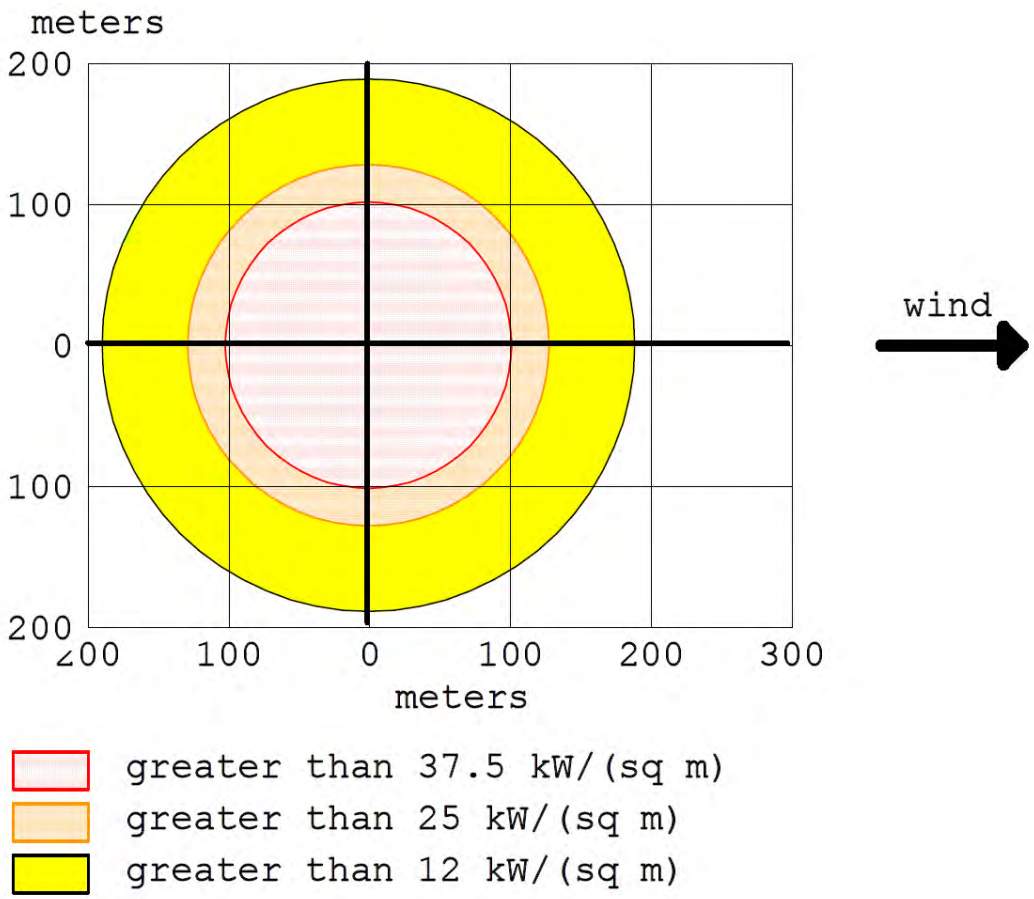
Thermal Radiation Threat Zone **ALOHA® 5.4.6**

```
Time: September 2, 2016  1717 hours ST (using computer's clock)

Chemical Name: N-HEXANE

Wind: 4 meters/second from WNW at 3 meters

THREAT ZONE:
  Threat Modeled: Thermal radiation from fireball
  Red    : 102 meters --- (37.5 kW/(sq m))
  Orange: 128 meters --- (25 kW/(sq m))
  Yellow: 189 meters --- (12 kW/(sq m))
```



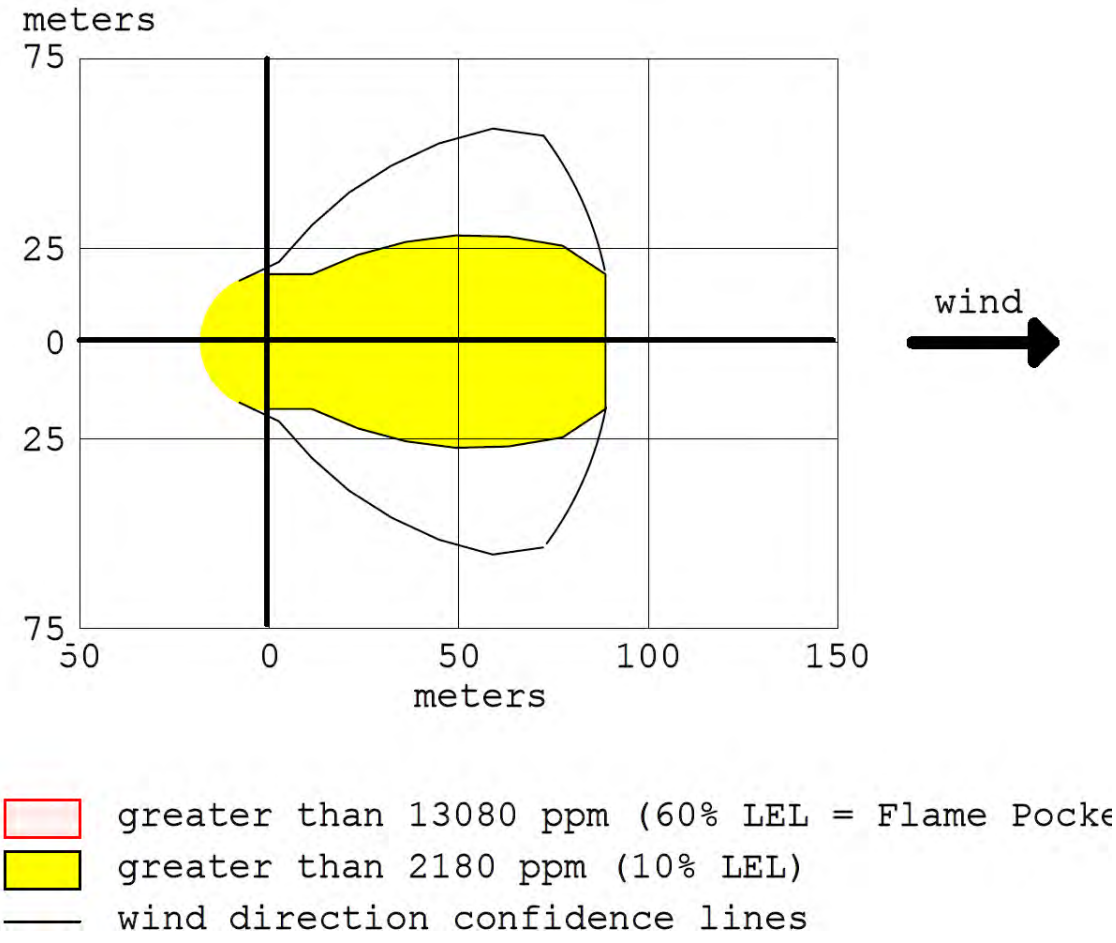
Flammable Threat Zone ALOHA® 5.4.6

```
Time: September 3, 2016  1057 hours ST (using computer's clock)

Chemical Name: ETHYL ACETATE

Wind: 3 meters/second from WNW at 3 meters

THREAT ZONE:
  Threat Modeled: Flammable Area of Vapor Cloud
  Model Run: Heavy Gas
  Red    : 21 meters --- (13080 ppm = 60% LEL = Flame Pockets)
  Note: Threat zone was not drawn because effects of near-field patchiness
    make dispersion predictions less reliable for short distances.
  Yellow: 89 meters --- (2180 ppm = 10% LEL)
```



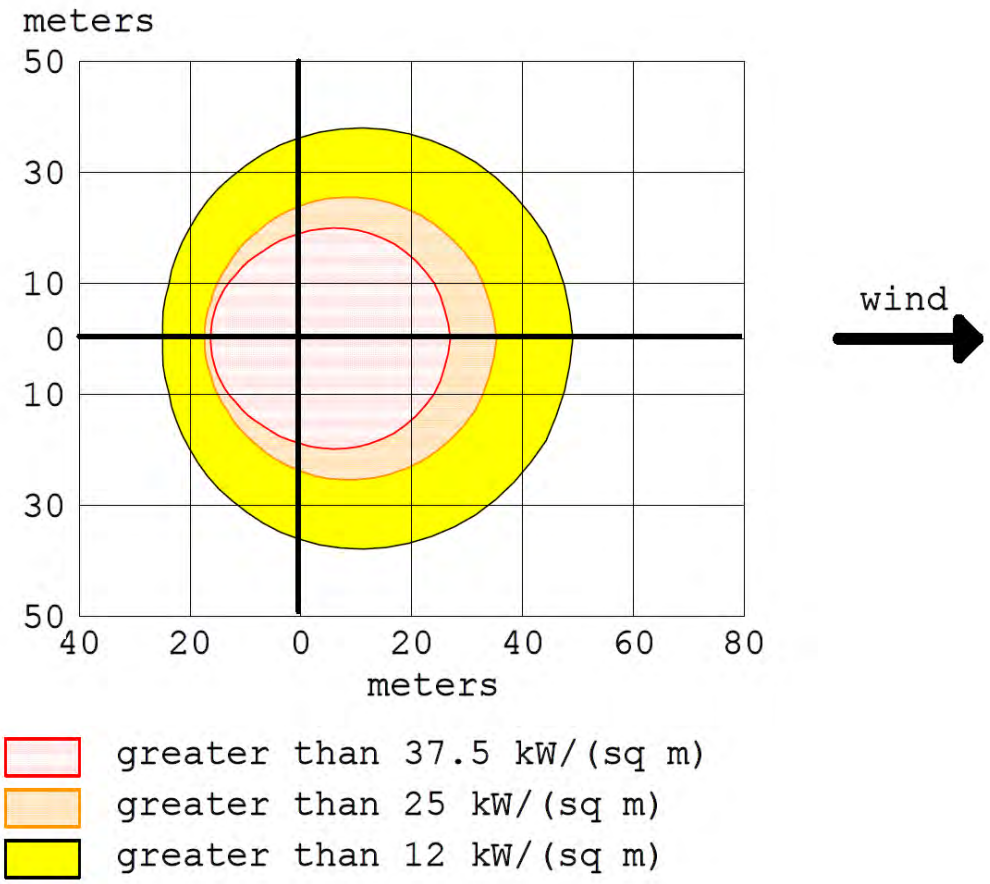
Thermal Radiation Threat Zone ALOHA® 5.4.6

```
Time: September 3, 2016  1115 hours ST (using computer's clock)

Chemical Name: ETHYL ACETATE

Wind: 5 meters/second from WNW at 3 meters

THREAT ZONE:
  Threat Modeled: Thermal radiation from pool fire
  Red    : 27 meters --- (37.5 kW/(sq m))
  Orange: 36 meters --- (25 kW/(sq m))
  Yellow: 49 meters --- (12 kW/(sq m))
```



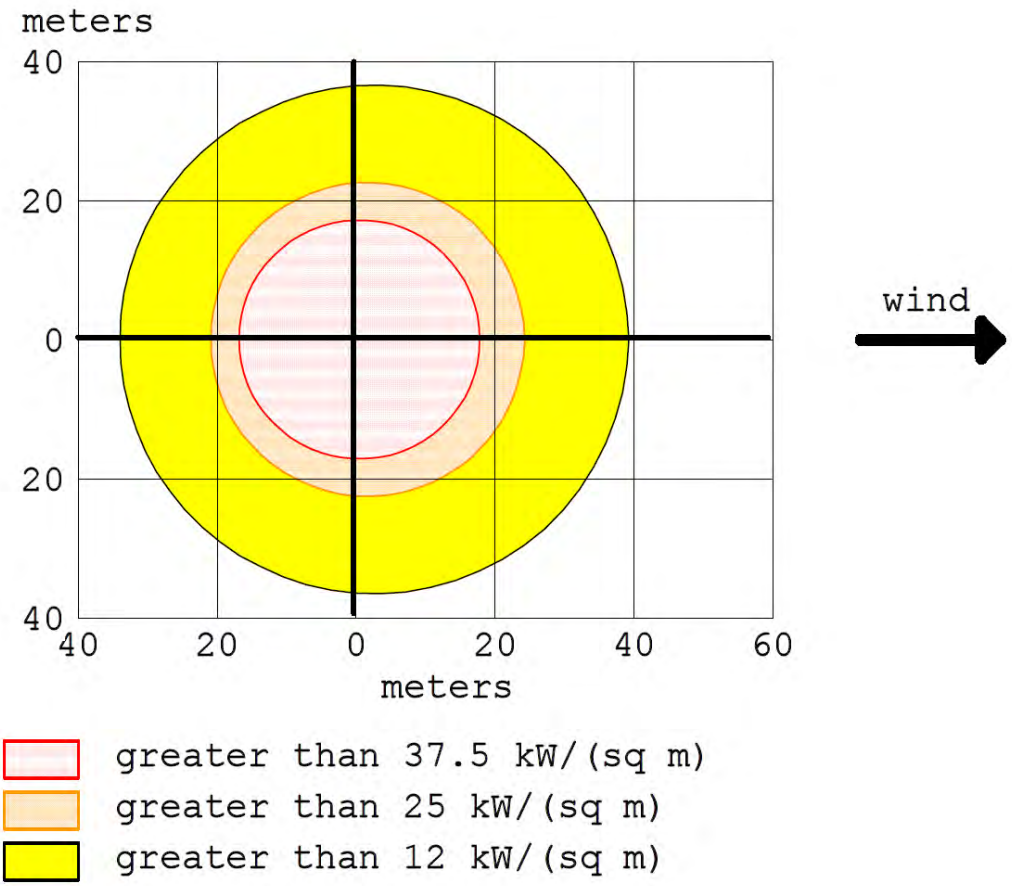
Thermal Radiation Threat Zone ALOHA® 5.4.6

```
Time: September 3, 2016  1119 hours ST (using computer's clock)

Chemical Name: ETHYL ACETATE

Wind: 3 meters/second from WNW at 3 meters

THREAT ZONE:
  Threat Modeled: Thermal radiation from pool fire
  Red    : 18 meters --- (37.5 kW/(sq m))
  Orange: 24 meters --- (25 kW/(sq m))
  Yellow: 39 meters --- (12 kW/(sq m))
```



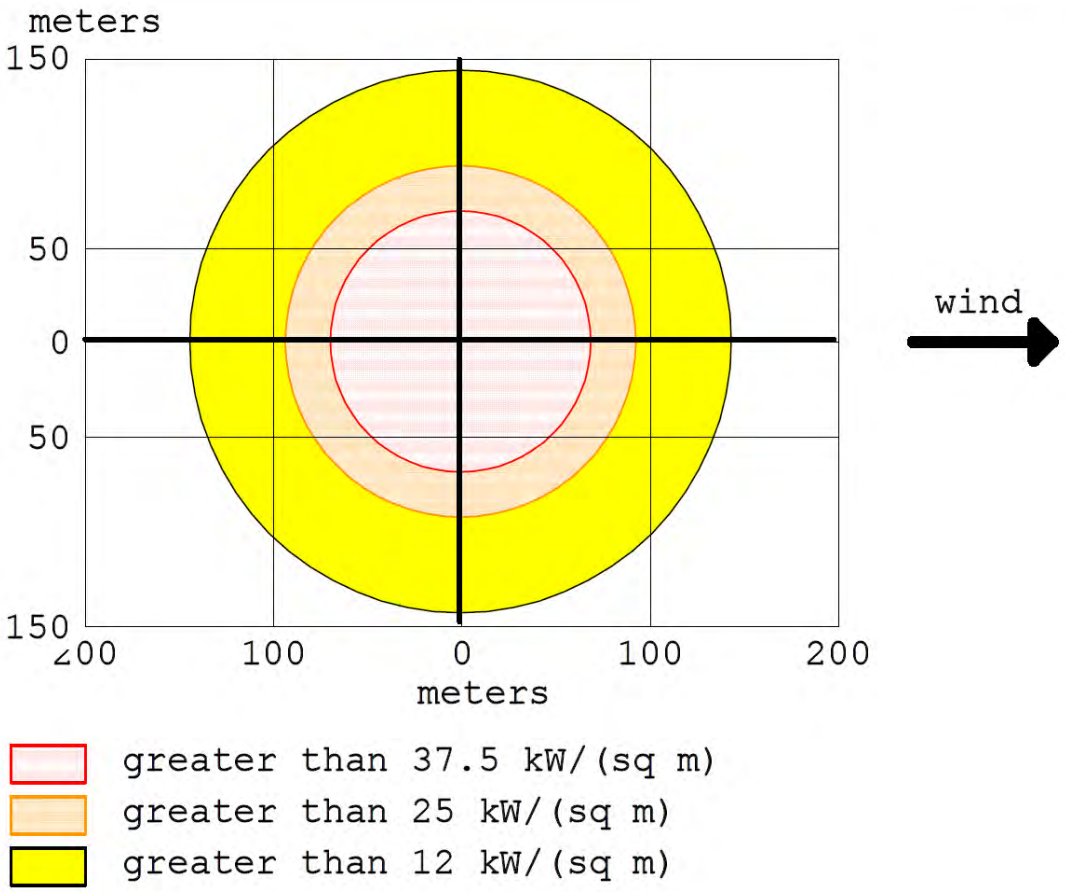
Thermal Radiation Threat Zone **ALOHA® 5.4.6**

```
Time: September 3, 2016  1119 hours ST (using computer's clock)

Chemical Name: ETHYL ACETATE

Wind: 3 meters/second from WNW at 3 meters

THREAT ZONE:
  Threat Modeled: Thermal radiation from fireball
  Red    : 69 meters --- (37.5 kW/(sq m))
  Orange: 93 meters --- (25 kW/(sq m))
  Yellow: 144 meters --- (12 kW/(sq m))
```



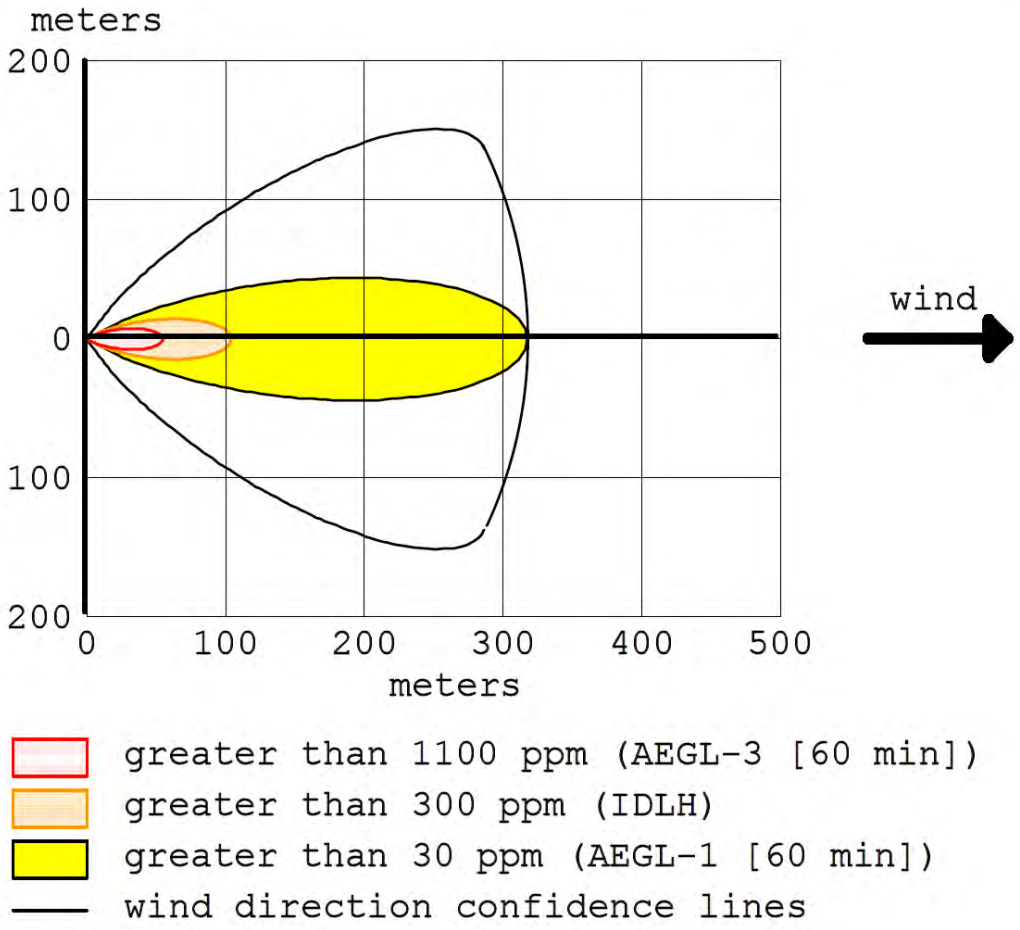
Toxic Threat Zone **ALOHA® 5.4.6**

```
Time: September 2, 2016  1735 hours ST (user specified)

Chemical Name: AMMONIA

Wind: 3 meters/second from WNW at 3 meters

THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red    : 55 meters --- (1100 ppm = AEGL-3 [60 min])
  Orange: 105 meters --- (300 ppm = IDLH)
  Yellow: 319 meters --- (30 ppm = AEGL-1 [60 min])
```



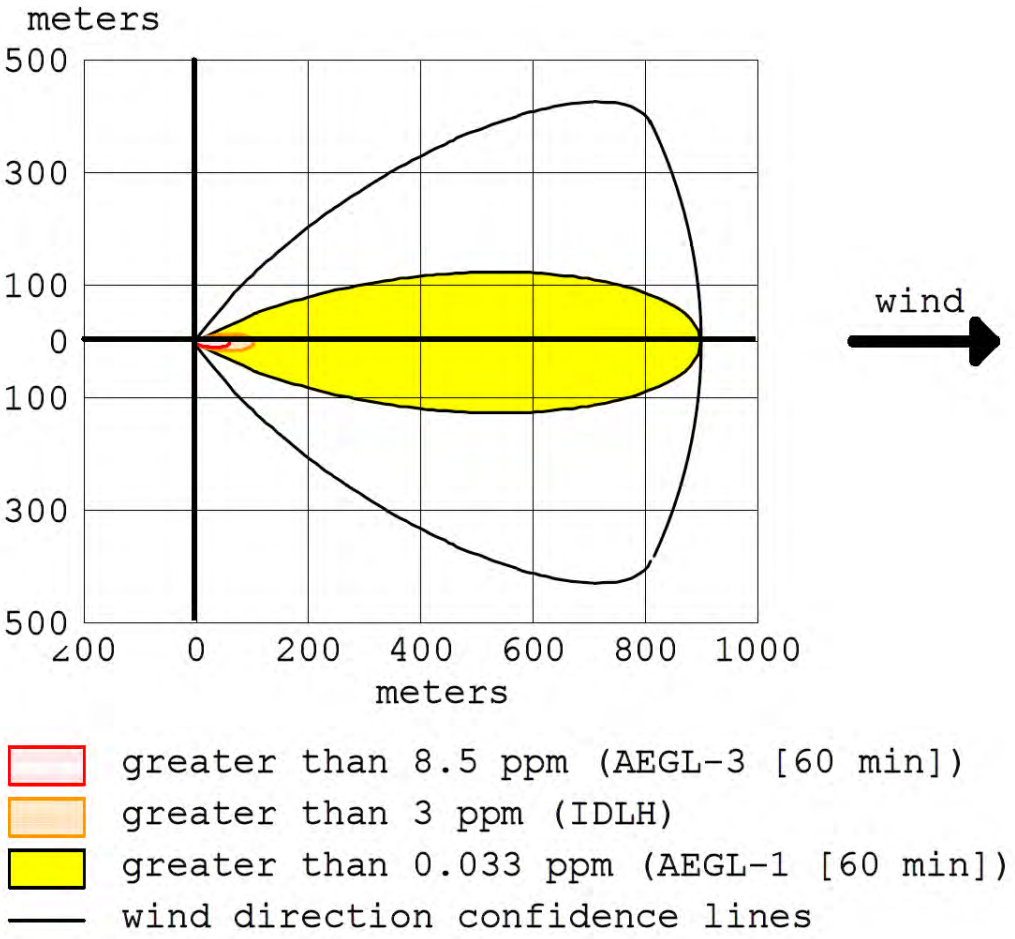
Toxic Threat Zone ALOHA® 5.4.6

```
Time: September 2, 2016  1735 hours ST (user specified)

Chemical Name: BROMINE

Wind: 3 meters/second from WNW at 3 meters

THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red    : 63 meters --- (8.5 ppm = AEGL-3 [60 min])
  Orange: 106 meters --- (3 ppm = IDLH)
  Yellow: 900 meters --- (0.033 ppm = AEGL-1 [60 min])
```



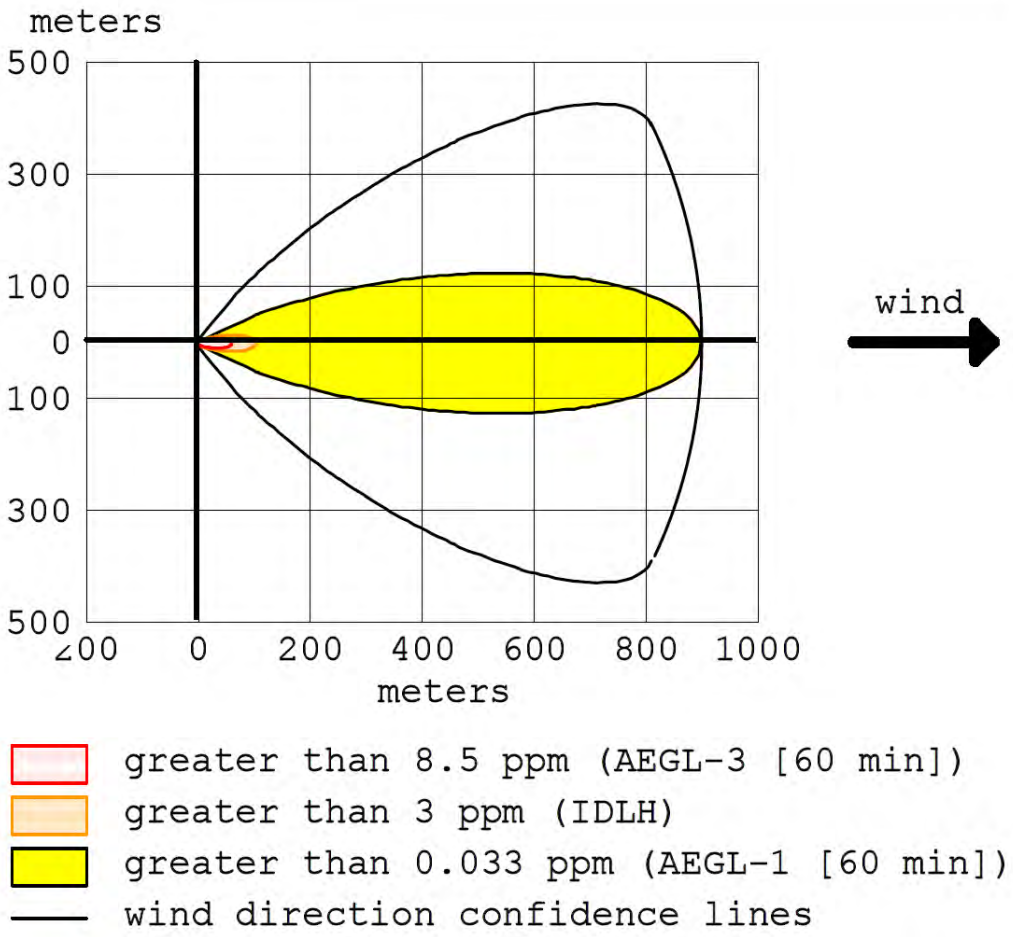
Toxic Threat Zone ALOHA® 5.4.6

```
Time: September 2, 2016  1735 hours ST (user specified)

Chemical Name: BROMINE

Wind: 3 meters/second from WNW at 3 meters

THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red    : 63 meters --- (8.5 ppm = AEGL-3 [60 min])
  Orange: 106 meters --- (3 ppm = IDLH)
  Yellow: 900 meters --- (0.033 ppm = AEGL-1 [60 min])
```



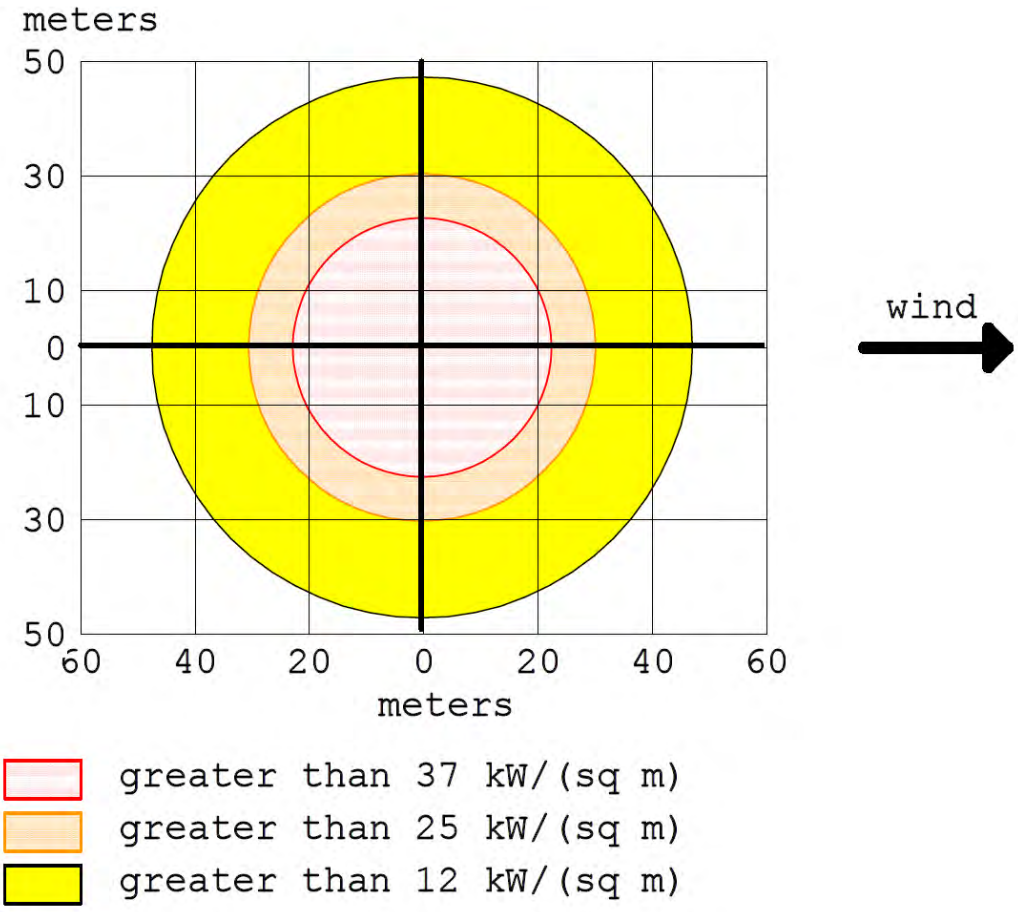
Thermal Radiation Threat Zone ALOHA® 5.4.6

```
Time: September 3, 2016  1135 hours ST (using computer's clock)

Chemical Name: METHANOL

Wind: 4 meters/second from WNW at 3 meters

THREAT ZONE:
  Threat Modeled: Thermal radiation from fireball
  Red    : 23 meters --- (37 kW/(sq m))
  Orange: 30 meters --- (25 kW/(sq m))
  Yellow: 47 meters --- (12 kW/(sq m))
```



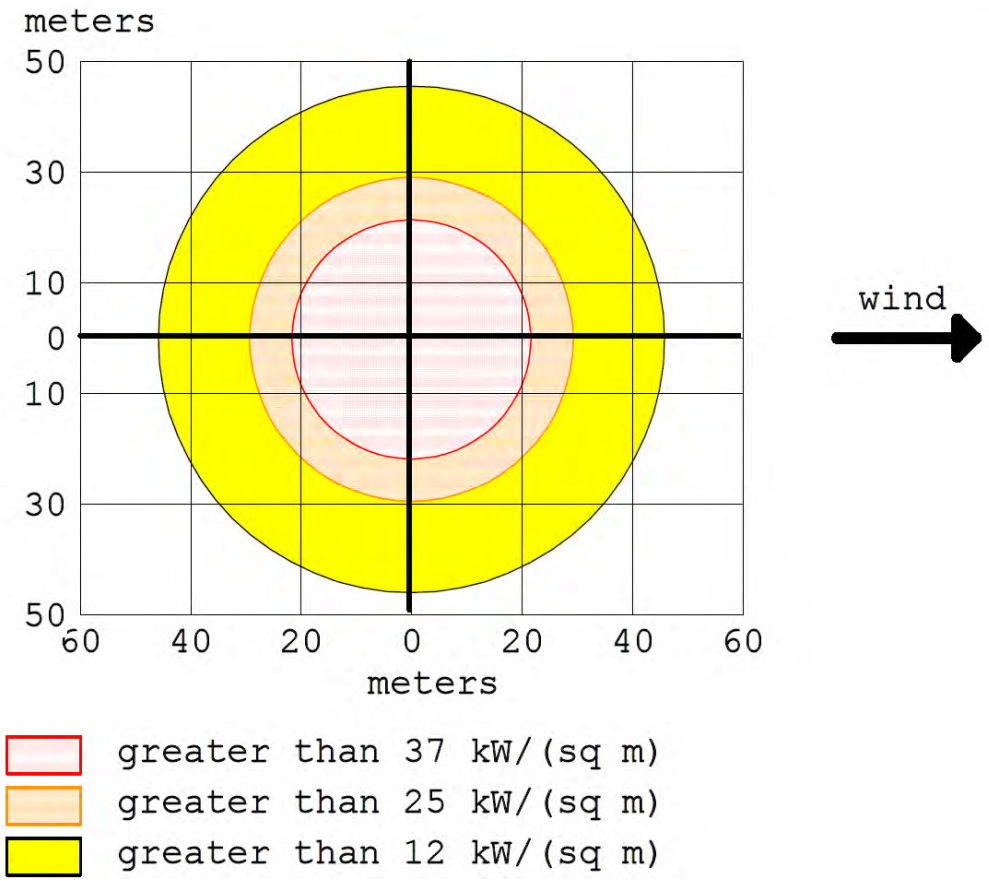
Thermal Radiation Threat Zone ALOHA® 5.4.6

```
Time: September 3, 2016  1132 hours ST (using computer's clock)

Chemical Name: METHANOL

Wind: 3 meters/second from WNW at 3 meters

THREAT ZONE:
  Threat Modeled: Thermal radiation from fireball
  Red    : 22 meters --- (37 kW/(sq m))
  Orange: 29 meters --- (25 kW/(sq m))
  Yellow: 46 meters --- (12 kW/(sq m))
```



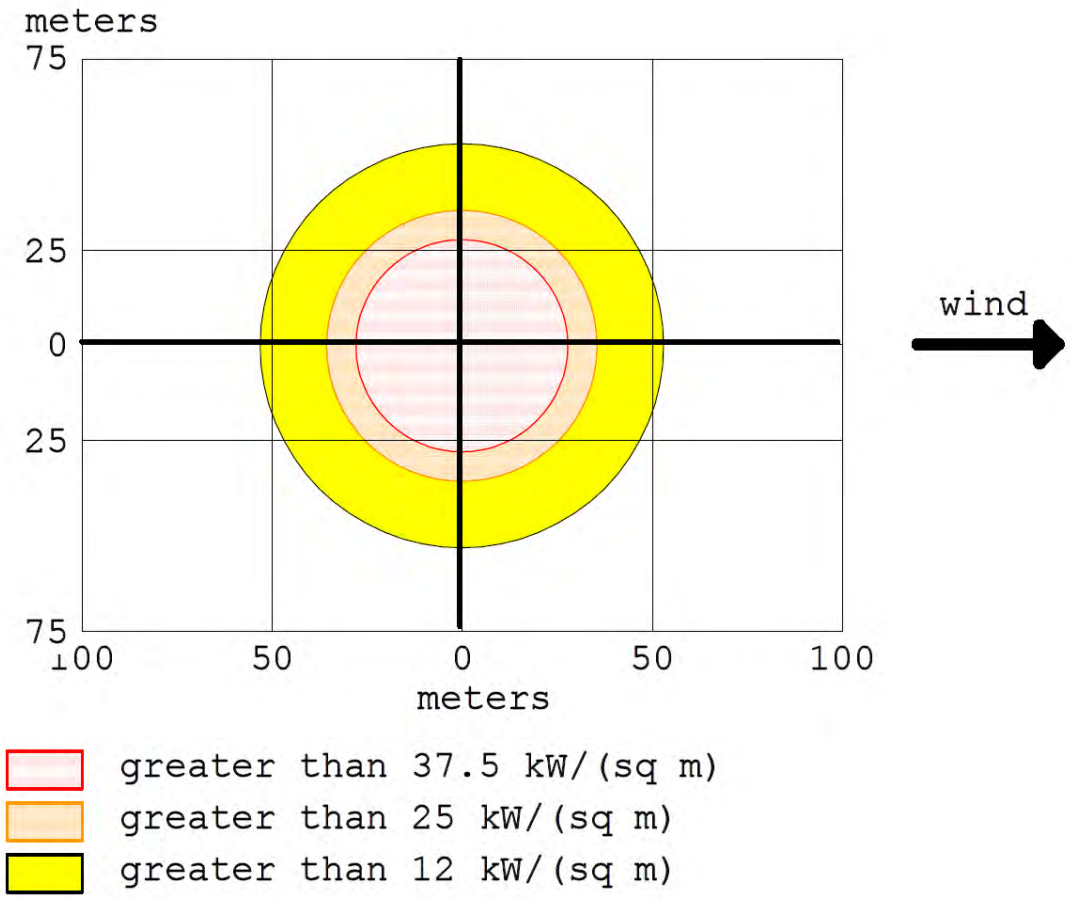
Thermal Radiation Threat Zone ALOHA® 5.4.6

```
Time: September 2, 2016  1735 hours ST (user specified)

Chemical Name: PYRIDINE

Wind: 4 meters/second from WNW at 3 meters

THREAT ZONE:
  Threat Modeled: Thermal radiation from fireball
  Red    : 28 meters --- (37.5 kW/(sq m))
  Orange: 36 meters --- (25 kW/(sq m))
  Yellow: 53 meters --- (12 kW/(sq m))
```



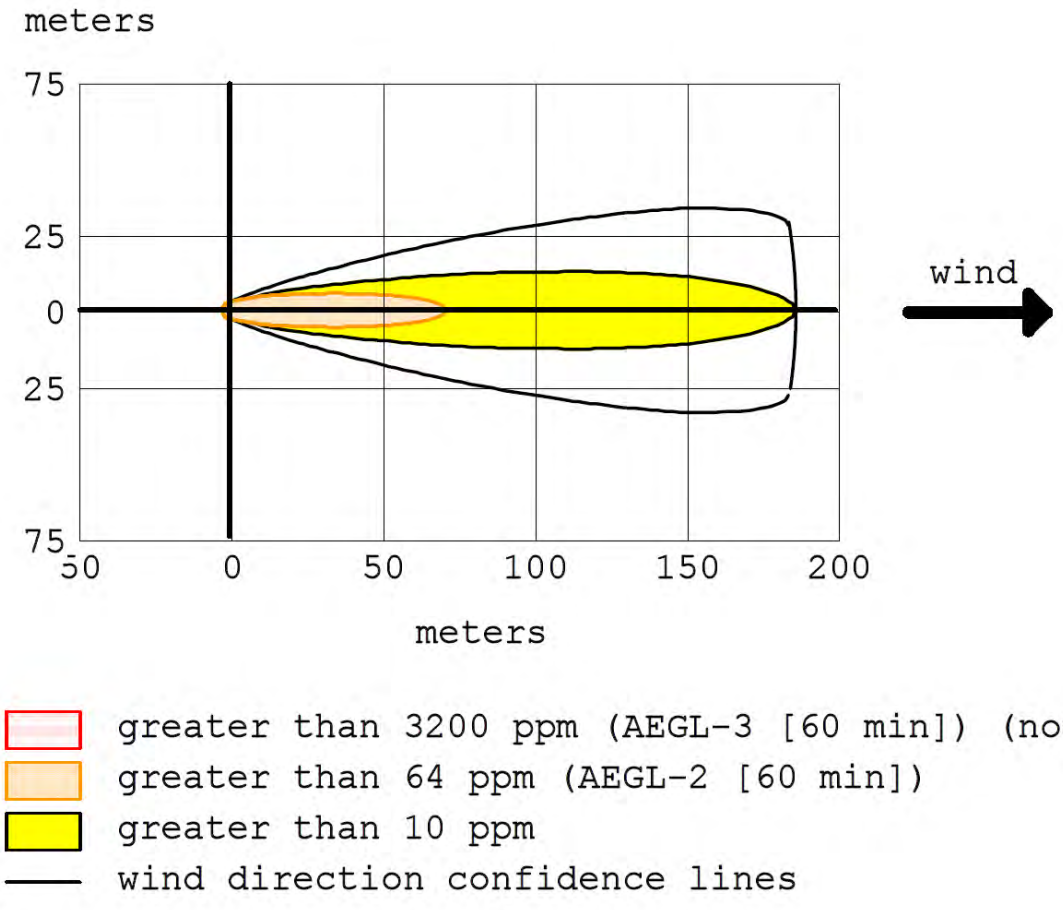
Toxic Threat Zone ALOHA® 5.4.6

```
Time: September 6, 2016  1742 hours ST (using computer's clock)

Chemical Name: CHLOROFORM
  Carcinogenic risk - see CAMEO Chemicals

Wind: 4 meters/second from WNW at 3 meters

THREAT ZONE:
  Model Run: Gaussian
  Red    : less than 10 meters(10.9 yards) --- (3200 ppm = AEGL-3 [60 min])
  Note: Threat zone was not drawn because effects of near-field patchiness
     make dispersion predictions less reliable for short distances.
  Orange: 70 meters --- (64 ppm = AEGL-2 [60 min])
  Yellow: 186 meters --- (10 ppm)
```



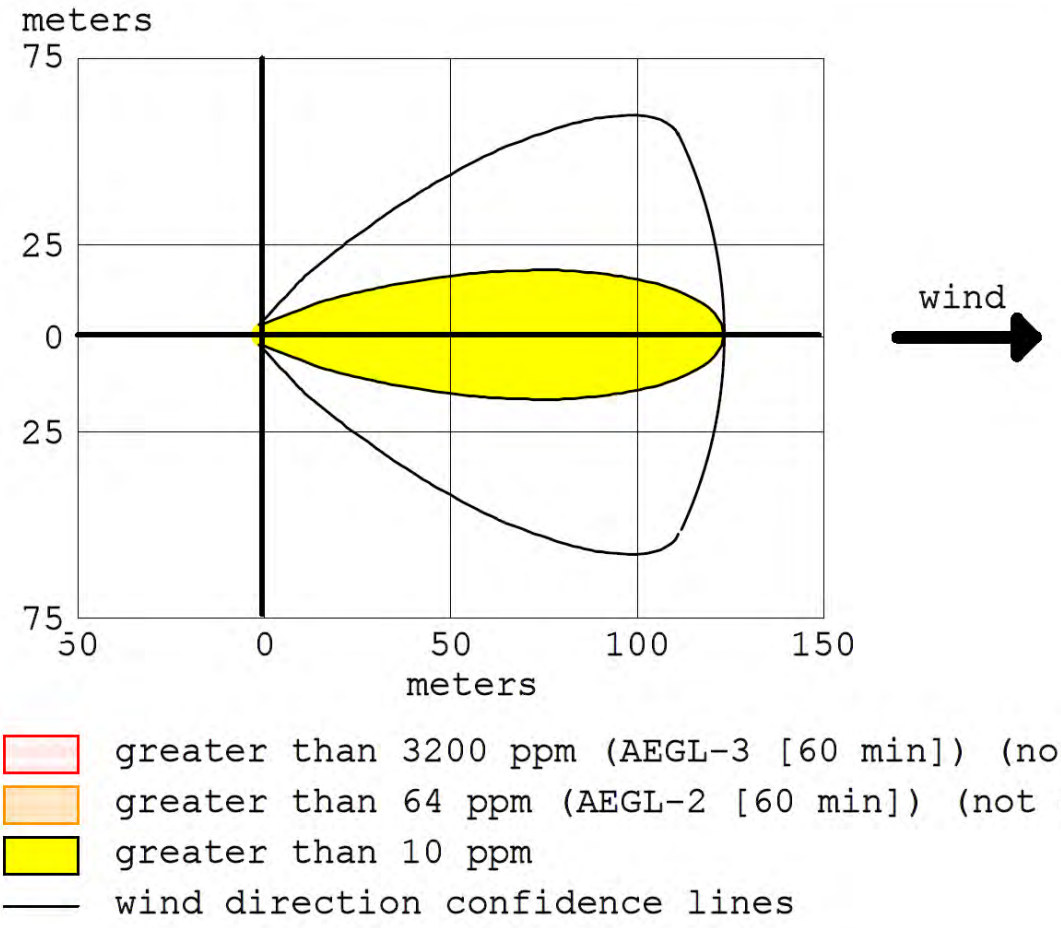
Toxic Threat Zone ALOHA® 5.4.6

```
Time: September 6, 2016  1745 hours ST (using computer's clock)

Chemical Name: CHLOROFORM
  Carcinogenic risk - see CAMEO Chemicals

Wind: 3 meters/second from WNW at 3 meters

THREAT ZONE:
  Model Run: Gaussian
  Red    : less than 10 meters(10.9 yards) --- (3200 ppm = AEGL-3 [60 min])
  Note: Threat zone was not drawn because effects of near-field patchiness
     make dispersion predictions less reliable for short distances.
  Orange: 49 meters --- (64 ppm = AEGL-2 [60 min])
  Note: Threat zone was not drawn because effects of near-field patchiness
     make dispersion predictions less reliable for short distances.
  Yellow: 124 meters --- (10 ppm)
```



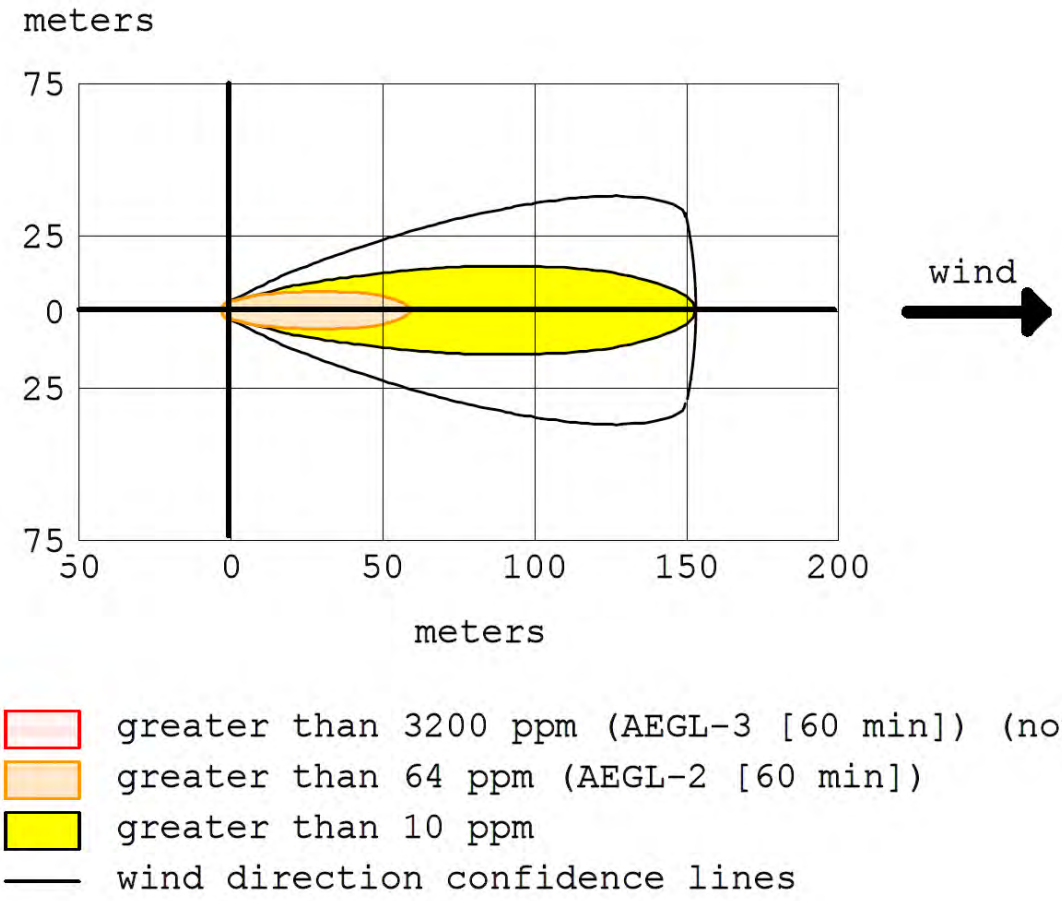
Toxic Threat Zone ALOHA® 5.4.6

```
Time: September 6, 2016  1746 hours ST (using computer's clock)

Chemical Name: CHLOROFORM
  Carcinogenic risk - see CAMEO Chemicals

Wind: 5 meters/second from WNW at 3 meters

THREAT ZONE:
  Model Run: Gaussian
  Red    : less than 10 meters(10.9 yards) --- (3200 ppm = AEGL-3 [60 min])
  Note: Threat zone was not drawn because effects of near-field patchiness
     make dispersion predictions less reliable for short distances.
  Orange: 59 meters --- (64 ppm = AEGL-2 [60 min])
  Yellow: 153 meters --- (10 ppm)
```



7.7.4 Process hazards and controls

Table 7-11: Process Hazards and Controls

Name of hazardous process and operation	Material in the process / operation	Type of hazard possible toxic gas release / fire / explosion / run away reaction / rupture, etc.	Control measured provided
Boiler	Hot Steam Fuel	Fire/explosion	
Reactor Vessel	Ammonia Chloroform Pyridine	Exothermic Run-away reaction Release of Heat and Flammable gases Fire, Toxic gas release and Explosion	• Raw Materials quantity must be controlled either volumetrically or gravimetrically. • Process control devices must be installed includes the use of sensors, alarms, trips and other control systems that either take automatic action or allow for manual intervention to prevent the conditions for uncontrolled reaction occurring. • High Temperature indicator valve and alarm system must be provided • Auto cutoff system must be provided after reaching of predetermined maximum safe temperature. • Pressure gauge is must provided. • Safety Control valve is must be provided. • The Vessel Emergency Relief vent should discharge to a suitably designed catch pot or should be so positioned that people working in the area and members of the public will not be in danger if the contents of the vessel are discharged. • Use skilled worker • Proper selection of MOC • Mechanical seal in all pumps and reactors

Name of hazardous process and operation	Material in the process / operation	Type of hazard possible toxic gas release / fire / explosion / run away reaction / rupture, etc.	Control measured provided
			• Transportation of finished product from vessel to storage tank through

7.7.5 General hazards and controls

Table 7-12: General Hazards and Controls

Type of Emergency	Identification of Area	Possible Causes	Possible Results	Preventive/control Measures
Fire	Tank farm area	Fire due to Bottom nozzle failure Damage of storage tank Pump discharge nozzle failure Unloading road tanker hose rupture	Major fire in the tank farm, it may spread all over the company and surrounding area May cause fatalities	• Licensed and isolated storage tank farm. • Flame proof fittings. • Earthling while unloading. • Spark arrestor at main gate. • Dip pipes on the tank for unloading. • Provision of dyke. • Earthling of tanks and pumps.\ • Get approval from an explosive department for plan approval, equipment layout & emergency control measures. • No electrical junction box close to storage materials. • Hot work permit system followed for hot working in the ware house.
Toxic Gas Release	Tank Farm Area and Reaction Vessel area	Cylinder blast Rupture of discharge valve Rupture of gas cylinder body	Major gas exposure in the company and /or surrounding area of the	• Storage Tank stored under shed and good ventilated area. • Procured by license holder party.

Type of Emergency	Identification of Area	Possible Causes	Possible Results	Preventive/control Measures
		Bursting of pipelines	company which resulting in irritation to respiratory track eyes and suffocation. More inhalation results in fatalities.	• Fitted with valve protection cap. • Valve opened with special key. • Loading/unloading done safely. • Trained persons for Material Handling in Tank Farm and Storage Tank area. • Periodic hydraulic testing through competent person by supplier • Painted according to its color code.
Explosion	All Material handling areas	Vapor explosion due to contact of spark to accumulated flammable vapor in confined area	Improper discharge of static charge Use of non FLP equipment for solvent handling Metal to metal impact Electrical short circuit Open flame	• Flameproof electric installation areas & use spark less tools • Isolated storage of Flammable material drums • Hot work permit for hot working in the plant • Earthling for human static charge • Good ventilated area for Flammable material storage
Material handling	In Plant	Flammable, eye irritating & body accident	Fire and health Hazards	• Trained employee • Required PPE and Fire • Protective equipment Provided • Good engineering practice • Separate storage are with dyke valve system provided
Methanol, Acetone, Toluene	Storage and other Operation Area	Spillage, Leakage and overflow,	Fire Hazard	• Required Fire Extinguisher Provided • Flame Proof Electrical Fitting • Proper Earthling arrangement • Fire Hydrant System with Jockey Pump

Type of Emergency	Identification of Area	Possible Causes	Possible Results	Preventive/control Measures
				• Gas Detector

7.7.6 Safe Practice for Handling, Storage, Transportation and Unloading of Hazardous Chemicals

For Storage/Handling:

- Separate from strong oxidant. & Keep it in well ventilated room.
- Dyke wall shall be provided to all above ground storage tank.
- Fire hydrant system shall be installed.
- Safety shower and eye washer shall be installed near storage area.
- Flame proof light fitting shall be provided at flammable storage area.
- Proper selection of MOC for chemicals storage tank.
- Sprinkler system shall be installed at flammable material storage area
- Earthing/bonding shall be provided for static charges.
- Flame arrestor shall be provided on flammable material storage tank vent.
- Level gauge and level measurement instrument shall be provided on material storage tank.
- Lightening arrestor on all chimney and building shall be provided.
- Hazardous material should be stored away from the plant and safe distance shall be maintained.
- Safety permit system shall be followed for loading, unloading of hazardous chemical.
- Fencing, caution note, hazardous identification board should be provided.
- Only authorized person shall be permitted in storage tank area and register will be maintained.

For Transportation & Unloading:

- Solvent shall be received by road tanker and stored in above ground storage tank in separated bulk storage area.
- Loading and unloading procedure shall be prepared for material received through road tanker.
- Earthing/bonding shall be provided for static charges.
- Flexible steel hose shall be used for unloading from the road tanker.
- Flame proof electric motor shall be used during loading/unloading.
- NRV shall be provided on pump discharge line.
- Fixed pipeline with pumps shall be provided for transfer to vessel.
- TREM CARD will be provided to all transporters and shall be trained for transportation Emergency of hazardous chemicals.
- Personal Protective Equipment (safety goggles, hand gloves, apron, masks, gum boots etc.) shall be provided.

For Storage/Handling of Bromine:

- All handlers should be aware of the potential hazards of bromine and of appropriate First aid measures.
- Exhaust hoods and ventilation should be adequate to maintain the concentration of bromine vapour in the work area below 0.1 ppm. Air analyses will be necessary for proper control.
- Safety showers and eyewash fountains should be immediately at hand where contact is at all likely.
- Bromine, in any breakable package or line, should be kept at as low a level as

possible above protection pans.

- Storage and operations should be over drip pans draining to a sump.
- Sumps should be sufficiently large to prevent general contamination in case of spills and shall be ventilated to prevent escape of vapours into inhabited areas.
- Hypo solution, lime water slurry, or soda ash solution may be poured over a liquid bromine spill on the floor. The bromine and neutralizer should be washed to the sump or sewer with a cold water hose. (Hypo solutions prepared by dissolving 220 g of technical sodium thiosulphate in a litre of water and adding 100 g of soda ash. The solution will remain stable for four to six weeks.)
- At all times ventilation should be sufficient to keep exposure at or below the threshold limit of one tenth (0.1) ppm, which is considered safe for repeated eight hour exposures.
- Air Analyzer indicating ppm level should be installed within storage area and around reactors.
- Working areas, storage rooms and unloading areas should be well equipped with safety showers, readily accessible and plainly marked. Eye washing fountains or running tap water, such as a bubbler drinking fountain or a hose should be available for eye irrigation.
- The location of such equipment should be inspected and tested at fixed intervals to make sure that it is in good working condition at all times.

For Storage/Handling of Ammonia:

- Cylinders should never be subjected to rough handling or to abnormal mechanical shock, such as dropping and bumping.
- Do not use rope slings for unloading. When handling by crane or derrick, a suitable platform, cradle or boat should be used. Do not use hooks, tongs or similar fastening devices.
- Do not use electric magnets for unloading or handling.
- Avoid dragging or sliding cylinders. It is safer to move the bottle type cylinders even short distances by using a suitable truck rather than by tilting or rolling them on their bottom edges.
- Use a rack or chain to hold cylinders in place when hooked up for discharging.
- Do not remove valve protection until ready to withdraw ammonia from the cylinder.

Emptying of Cylinders Ammonia:

- The tube type cylinder is normally used in the horizontal position. Two general types of valves are supplied. Depending on which type is involved, either the valve outlet or the valve stem is at an angle with the longitudinal axis of the cylinder. It is the position of this valve outlet or stem which determines whether liquid or gaseous ammonia will be discharged from the cylinder.
- When the valve outlet or stem is on top. The dippipe on the inside of the cylinder is under the liquid, and therefore, liquid anhydrous ammonia will be discharged. To discharge gaseous ammonia, the cylinder is turned so that the valve outlet or stem points downward. Follow instructions of ammonia manufacturer concerned.
- The bottle type or vertical cylinder will discharge ammonia as a gas when placed in an upright or vertical position. Due to liquid ammonia expansion, a bottle type cylinder may, under certain elevated temperature conditions, discharge a small amount of liquid when the valve is opened, and it is recommended that bottle type cylinders be allowed to reach room temperature before the valve is opened. To discharge liquid anhydrous ammonia, this type of cylinder shall be placed in horizontal position with the valve outlet pointed up.

- The rate at which gaseous ammonia may be discharged from either type cylinder depends upon the temperature of the surrounding atmosphere and the surface area of the liquid ammonia.
- When the cylinder is empty, disconnect it, insert the valve plug and replace the cylinder protective cap.
- If a bottle type cylinder has frozen during discharge, never use a pry under the valve end to loosen the cylinder. Use water to loosen the cylinder or wait for it to thaw out.
- Store empty cylinders separate from filled cylinders and fasten an EMPTY tag on cylinders immediately upon emptying. Close valve, replace plug or nut on valve outlet, and secure valve protecting cap snugly.

For Storage/Handling of Chloroform:

- Wear safety goggles, self contained breathing apparatus, air line mask, hand gloves.
- For exposure range >50 to <500 ppm respiratory equipment should be of supplied air, constant flow pressure demand, full face type and for exposure range of 500 ppm and above selfcontained breathing apparatus, pressure demand, full face type respiratory equipment should be used.
- Trucks are usually equipped with pumps driven by a power takeoff. They are essentially selfunloading with operations performed by the truck driver. It is customary to unload by means of rotary or centrifugal pump connected to the bottom outlet of the car by means of a flexible connection. Since the liquid is volatile, it is necessary to ensure adequate net positive suction head for the pump to prevent flashing the pump intake and loss of capacity.
- Positive displacement rotary pumps are recommended for chloroform service. Submerged centrifugal pumps may be used in storage tanks designed for atmospheric service. Externally mounted flooded suction centrifugal pumps may be used if care is taken to provide adequate suction head.
- In case of spill or leak of small quantity, absor the material by pouring sand or earth.
- However, in case of major (large) quantity spill or leak, dispose off the materials by atomizing in a combustion chamber.

7.7.7 Occupational Health Surveillance Programme

Health surveillance is the monitoring of a person's health to identify changes in health status due to occupational exposure to a hazardous substance. It includes biological monitoring.

Ideally, the avoidance of work-related diseases should be achieved by the prevention or controlling exposures to hazardous substances in the workplace. Where a process cannot be designed or maintained to eliminate the risk of exposure, it may be necessary for workers to undergo health surveillance.

A. Aims of Health Surveillance

1) Identify those at increased risk

Health surveillance is used to identify workers who have an increased risk of developing an occupational disease. For example, people who have existing skin, kidney, liver and eye disorders, heart problem; additionally smokers and pregnant women are at increased risk of being severely affected if exposed to Methanol.

2) Compliance with regulations

Health surveillance is sometimes required by laws and codes of practice (for example, a worker exposed to lead in battery manufacture or a spray-painted exposed to isocyanates in two-pack paints). Each state or territory has regulations containing a schedule of hazardous substances for which health surveillance is mandated.

3) Early detection

The major purpose of health surveillance is to detect adverse health effects at an early stage so that the worker may be protected from further injury, either by control of the process or by removal from exposure.

4) Evaluating effectiveness of control measures

Health surveillance is not a control measure in itself and should not be the sole means of determining whether control measures are effective. However, it can provide useful information on the effectiveness of safe working practices.

5) Epidemiology and disease

Health surveillance can be used to evaluate the health experiences of groups of workers exposed to specific hazardous agents or working within a particular industry.

Workers should be made aware that health surveillance is sometimes necessary to ensure their ongoing health. Health surveillance is often used in addition to workplace monitoring. Workplace monitoring will only indicate the potential for exposure of workers to a hazardous substance. It can never be an indication of the actual amount of substance absorbed or the effect on the body of absorbing the hazardous substance. When a toxic substance (such as an industrial chemical) is present in the environment, it contaminates air, water, food, or surfaces in contact with the skin: environmental monitoring evaluates the amount of toxic agent in these media.

As a result of absorption, distribution, metabolism, and excretion, a certain internal dose of the toxic agent (the net amount of a pollutant absorbed in or passed through the organism over a specific time interval) is effectively delivered to the body and becomes detectable in body fluids.

Subsequent interaction with a receptor in the critical organ (the organ which, under specific conditions of exposure, exhibits the first or the most important adverse effect) leads to biochemical and cellular events. Both the internal dose and the elicited biochemical and cellular effects may be measured through biological monitoring.

7.8 Occupational Health Programme

- The health & physical hazards caused due to toxic, irritant, corrosive, flammable materials. All chemicals are within Threshold Limit Value as per ACGIH.
- Monitoring of occupational hazards like noise, ventilation, chemical exposure etc. will be carried out regularly and its record will be maintained.
- Good housekeeping, use of PPE, Engineering controls, Enclosure processes, scrubber system, display of safety boards, SOP of loading / unloading, local exhaust

ventilation, safety shower etc. are important safety measures have taken to keep these chemicals within TLV.

- Appropriate personal protective equipment will be provided & ensure the usage of them.
- Workers will be trained on safe material handling of hazardous chemicals.
- Prepare & display the safe operating procedure for hazardous chemicals storage, handling & transporting or using.
- Periodical medical examination of the workers & Liver Function Testes will be done.
- Register (form no.37) for work place air monitoring will be done.
- Employee training and education will be carried out.
- Control the noise at source by substitution, isolation, segregation, barriers etc.
- Local Exhaust ventilation and scrubber should be installed where it is required to reduce fumes, vapors, temperature and heat stress.
- Insulate all hot equipment to reduce air temperature.
- Reduce the level of physical activity by sharing workload with other or by using mechanical means.

7.9 Chemicals which are Exposed to Workers Directly or Indirectly

Details of chemicals to which workers, operators will be exposed is given in ***Table 7-1*** and ***Table 7-2.*** Pre-employment medical checkup and periodically medical examination will be done. Liver function test will be done during pre-placement and periodical examination. In addition to the above, following safety equipment will be provided;

- Fire extinguishers at prominent places in the premises
- First aid kit
- Portable eye wash station, capable of supplying 15 minutes of water
- Emergency shower
- Ample supply of potable water for washing and drinking
- Emergency communication devices such as mobile phones and two way radios
- Vehicle suitable for emergency transport

7.10 Treatment of Workers affected by Acccidental Spillage of Chemicals

Hazards with Acute Exposure

- Contact with skin may cause severe burns or systemic poisoning.
- Systemic effects may occur from any route of exposure, especially after skin absorption.

Hazards with Chronic Exposure

- Repeated or prolonged exposure may harm the respiratory system. Can irritate and inflame the airways.
- Methanol affects the central nervous system, liver, and kidneys.
- Special Safety Precautions
- Prevent contact with skin by wearing neoprene gloves, lab coat, and resistant apron.
- Wear safety glasses or a face shield if splashing may occur.
- Store in a cool, dry, well-ventilated area, away from heated surfaces or ignition

sources.

- Skin contact requires immediate washing of the affected area with soap and water.
- Remove contaminated clothing and launder before wearing again.
- Procedure for treating workmen after skin contact.
- Skin contact requires immediate flushing of the contaminated area with soap and water at a sink or emergency shower for a good fifteen minutes. Remove contaminated clothing. In case of eye contact, promptly flush the eyes with copious amounts of water for 15 minutes (lifting upper and lower lids occasionally) and obtain medical attention. If methanol is ingested, obtain medical attention immediately. If large amounts of methanol are inhaled, move the person to fresh air and seek medical attention at once. It is recommended to provide the safety shower and eyewash station in plant.

7.10.1 Antidotes

A. Antidotes for Methanol

- Ethanol (30 % solution from inside, 5 % solution from outside i.e. by intravenous injection)
- Epicake syrup
- In case of acidosis give sodium bicarbonate
- In case of delirium give diazepam 10 mg by intravenous injection
- Folinic acid (leucovorin 1 mg/Kg iv, 4 hourly)

B. Antidotes for chloroform

- Activated Charcoal or Water

C. Antidotes for Toluene

- Skin is affected then wash with plenty of water. Administrative Oxygen or Shift to fresh air.
- Diazepam 0.1 mg/kg, bed rest.

7.10.2 Details of fire extinguishers

Unit will provide about 20 Nos. of fire extinguishers of DCP type at prominent places in the premises.

Sr. No.	Type	Capacity	Qty
1	DCP	5 kg	20
2	Foam Type	5 Kg	10
3	CO_2	10Kg	20

7.10.3 Minimization of the Manual Handling of Hazardous Substance

Whether moving materials manually or mechanically, employees should know and understand the potential hazards associated with the task at hand and how to control their work places to minimize the danger. Employers and employees should examine their workplaces to detect any unsafe or unhealthful conditions, practices, or equipment and take corrective action.

Provide flameproof electrical motor & transfer chemicals through the pipelines. Use specially designed pallets to hold, move raw materials, finished products through work areas. Minimize lifting of raw materials, heavy loads by using appropriate platforms, trolleys etc. Avoid the moving, manual handling of hazardous material.

7.11 Do's and Dont's

7.11.1 Handling of Chemicals

Do's	Dont's
• Know the hazards of the chemical before handling. • Know the antidotes for chemical, which you are handling. • Do keep material safety data sheet in locations where chemicals are being handled and study it. • Use appropriate personal protective equipment like gloves, aprons, and respirator; face shield etc. depending upon nature of the work. • Label every chemical that you use and tightly close the container. • Use eye wash fountain / safety shower in case of splash of chemicals in the eye or body for at least 15 minutes. • Segregate toxic, flammable chemicals and keep them under control. • In addition to draining and closing valves, lines should be blanked before taking up maintenance work. • Provide proper ventilation at the chemical handling area to limit their concentration within prescribed level.	• Do not store the chemicals that are incompatible with other chemicals. • Do not spill the chemicals. • Do not dispose chemical without neutralizing. • Do not keep large inventory of chemicals. • Do not allow empty containers of hazardous chemicals to be used by others. • Do not use compressed air for transferring chemicals. • Do not stand near chemical transfer pump while it is in operation with temporary hose connection. • Pouring of chemicals by hand or doing siphoning by mouth should never be adopted. • Chemicals drums should never be moved without protection. • Do not attempt to neutralize the acid / alkali on the skin. Use water only. • Do not use solvent for cleaning hands.

7.11.2 Material Handling

Do's	Don'ts
• Use proper lifting tool and tackle having adequate capacity. • Only authorized persons should operate material handling equipments. • Each tool, tackle or equipment should have number and safe working load (SWL) marked on it. • Assess weight of the material, distance to be carried and hazards etc. before lifting the load. • Inspect and test all the lifting tools and tackles regularly as per Factory Rules.	• Do not use the equipment for the purpose other than its design intention. • Do not allow personnel to move underneath lifted load. • Do not load the equipment above its safe working load. • Do not use makeshift arrangements for lifting equipment without inspection and test. • Do not use defective tool and tackles. • Keep the tools & tackles free from adverse

Do's	Don'ts
• Wear Personal Protective Equipments while handling of material. • Wherever possible, mechanized material handling shall be adopted. • While lifting a load physically, keep the load as near as possible to the body with feet properly placed for body balance. • Bend knees, keep back straight, keep the load closed to the body and lift the load.	effect of atmosphere by applying suitable protective coating. • The angle between the legs of two leg sling should not exceed 90 degree. • Do not allow male and female adult to lift a load manually higher than 55 kgs and 30 kgs respectively. • Do not hold the load with tip of the fingers; grasp the load firmly with palm.

7.11.3 Fire Prevention

Do's	Don'ts
• Follow 'NO SMOKING' sign. • Deposit oily rags and waste combustible material in the identified containers and dispose them suitably. • Fire Hose used for any other purpose should be permanently marked and taken out of fire hydrant system. • Keep minimum inventory of flammable and combustible substances. • Take permission before breaking or removal of fire barrier and ensure subsequent relocation of fire barrier. • Check periodically the operability of fixed fire fighting system. • Attend any abnormality / deficiency with fire protection system promptly. • Provide earthling or bonding to prevent accumulation of static charges to tanks where flammable chemicals are stored / handled. • Use instruments that are intrinsically safe in explosive atmosphere.	• Do not leave flammable material like acetone, kerosene etc. used as cleaning agent at the work area. • Do not over tighten fire hydrant valves with F-lever. • Do not allow wild grass growth around storage of the gas cylinders and switchyard. • Do not obstruct accessibility to the fire related equipment. • Do not destroy the inspection tag provided with the fire equipment. • Do not misuse fire-fighting equipment other than intended purpose. • Do not store the flammable material in the open container. • Do not use instruments that are not intrinsically safe in the explosive atmosphere.

7.11.4 House Keeping

Do's	Don'ts
• Assign places for everything and maintain things at assigned places. • Clean the area after completion of work. • Use aisle space free for personnel and material movement. • Ensure adequate illumination and ventilation for the job. • Drop paper, plastic, glass, metal and bio-medical waste in a separate bin kept for this	• Do not leave combustible materials in the work area. • Do not smoke in the area of work. • Do not allow dust bin to overflow. • Do not generate extra waste. • Do not disturb the safety equipment from assigned location. • Do not block emergency switches and on/off switches of the equipment by storming of

Do's	Don'ts
purpose. • Know the location where emergency equipment such as first aid box, fire fighting equipment, SCBA, Stretchers are kept. • Arrest all types of spills such as chemical, water, oil, air / gas, steam etc. and clean up the area immediately. • Ensure exits are indicated / painted for use during emergency.	materials in front of work. • Do not leave cleaning agent like acetone, isopropyl alcohol, kerosene etc. at the work area after completion of work. • Do not block fire exit point by storing materials or by means. • Do not leave a spillage unattended.

7.12 Risk Reduction Measurement & Recommendation In View Of Safety Consideration

- Storage tank of Chloroform, N- Haxane, Ethyl Acetone, Ammonia should be installed away from the plant area.
- Wind indicator should be provided at the highest level of the plant to know the wind direction.
- Automatic sprinkler system for the flammable material tanks (over ground tanks only) may be provided as knock on effect in case of fire is possible.
- Containment dykes with proper sloping and collection sumps should be provided so that any spillages in the bulk storage and other handling areas shall not stagnate and shall be quickly lead away to a safe distance from the source of leakage. This reduces the risk of any major fire on the bulk storages and the risk to the environment shall be minimized/ eliminated.
- Inspection of the storage tanks as per prefixed inspection schedule for thickness measurement, joint and weld efficiency etc.
- Provision of flameproof electrical fittings / equipment's.
- Proper maintenance of earth pits.
- Strict compliance of security procedures like issue of identity badges for outsiders, gate passes system for vehicles, checking of spark arrestors fitted to the tank lorries etc.
- Strict enforcement of no smoking.
- Periodic training and refresher courses to train the staff in safety fire fighting.
- Employee training and education will be carried out.
- Structural fireproofing in the process area could be considered as a safety measure in the light of probable spill and fires in the area.
- Emergency drills should be carried out periodically to ensure preparedness must continue.
- Wind indicator should be provided at the highest level of the plant to know the wind direction.
- Many operations involve use of highly toxic/flammable materials and these needs to be documented as SOPs. These must be made and kept updated on priority.
- Extensive training on use of Self Contained Breathing apparatus (SCBAs) must be ensured for emergency control.
- Many of the raw materials used for resin are either toxic or flammable. It is therefore important to ensure that these materials are stored in closed, well ventilated totally safe areas. A fire alarm system (heat and smoke detection) should be provided for

the storage area where the material is stored as toxic fumes arise on combustion.

- Loose drums of waste materials, often solvent laden, must be removed from the working areas and close watch kept.
- Proper Earthing needs to be provided through plug type systems or through the agitators/liquid.
- Ventilation should be provided for any enclosed are where hydrocarbon or toxic vapors may accumulate. Several such areas were noticed- these may be surveyed and tackled accordingly.
- All personnel should be trained in handling emergency situations and should be apprised of their role in handling emergency situation and to ensure adequacy of the emergency procedures simulated exercise should be carried out. This was found wanting.
- Flame arrestor should be provided.
- Adequate number of caution boards highlighting the hazards of chemicals should be provided at critical locations.
- Monitoring of occupational hazards like noise, ventilation, chemical exposure etc. will be carried out regularly and its record will be maintained.
- Good housekeeping, use of PPE, Engineering controls, Enclosure processes, scrubber system, display of safety boards, SOP of loading / unloading, local exhaust ventilation, safety shower etc. are important safety measures have taken to keep these chemicals within TLV.
- Appropriate personal protective equipment will be provided & ensure the usage of them.
- Workers will be trained on safe material handling of hazardous chemicals.
- Prepare & display the safe operating procedure for hazardous chemicals storage, handling & transporting or using.
- Local Exhaust ventilation and scrubber should be installed where it is required to reduce fumes, vapors, temperature and heat stress.
- Reduce the level of physical activity by sharing workload with other or by using mechanical means.
- Following FIRE safety devices WILL BE PROVIDED to protect from any malfunctioning of plant equipments. Following fire protection systems will be provided.
- Water storage of adequate capacity to meet the requirements of water for firefighting purposes.
- Fire hydrants and automatic sprinkler system. Diesel driven pumps and headers to supply water to fire hydrant network.
- Adequate Portable fire extinguishers, sand bucket, wheeled fire & safety equipment should be provided at the required places.
- Equipment required for personal safety like blankets, gloves, apron, gum boots, face mask helmets, safety belts, first aid boxes etc. are provided. Proximity suits and self-contained breathing apparatus to be provided.

7.12.1 Health Arrangements will be provided to Workers Engage in Handling of Toxic Material.

- The health & physical hazards caused due to toxic, irritant, corrosive, flammable materials. All chemicals are within Threshold Limit Value as per ACGIH.
- Monitoring of occupational hazards like noise, ventilation, chemical exposure etc. will be carried out regularly and its record will be maintained.
- Pre-employment medical checkup and periodically medical examination will be done.

Medical Check-up of Employees will include Chest X rays, Audiometry, spirometry, Vision testing, ECG, during pre placement and periodic intervals.

- Liver function test will be done during pre-placement and periodical examination.

7.13 Disaster Management Plan

7.13.1 Disaster

An emergency is said to have arisen when operations in the plant are not able to cope up with a potential hazardous situation i.e. loss of control of an incident cause the plant to go beyond its normal operating conditions, thus creating danger. When such an emergency evolves chain of events affect the normal working within the factory area and/ or which may cause injuries, loss of life, substantial damage to property and environment both inside and outside the factory and a disaster is said to have occurred.

The various steps involves in the process of Disaster Management can be summarized as:

- Minimize Risk Occurrence (Prevention)
- Rapid Control (Emergency Response)
- Effectively Rehabilitate Damaged Areas (Restoration)

Disaster Management Plan is involved by careful scrutiny and interlinking of:

- Types and causes of disaster
- Technical know-how
- Resource availability

The various type of Disaster that may occur is

- Due to the fire and
- Major spillage from tank
- Hurricane, cyclone and other natural calumniates.

7.13.2 Objectives of the Plan

The plan will set into action immediately after a fire occurs inside the plant. However fire hazard will be restricted to fuel tank storage area only and hence to major disaster is envisage. The plan is developed to make best possible of unit,

- Rescue the victims and treat them suitable.
- Safe guard others (evacuating them to safer places).
- Contain the incident and control it with minimum damage.
- Identify the persons affected.
- Preserve relevant records and equipment needed as evidence incase on inquiry.
- Rehabilitate the affected areas.

A. Basis of Plan

Unit will prepare an onsite emergency plan. The basic guideline of the Plan is as given below:

- Informative broacher on emergency will be distributed to each staff member of the plant and telephone numbers of key personnel to be contacted during an emergency will be placed at all the operator placement point in the plan.

- Workers would be trained regularly on fire hazard drill, which will be organized once in a here mock drill from the safety and fire agency.
- The industry will provide the wall surrounding the methanol storage area.
- 24 hours vehicle for service and in-plant first aid emergency kit would be provided.

7.13.3 Post Disaster Analysis and Evaluation

When emergency is over, it is desirable to carry out a detailed analysis of the causes of the accident to evaluate the influence of various factors involved and to propose methods to eliminate them in future. Simultaneously, the adequacy of the disaster preparedness plan will be evaluated and any short comings will be rectified.

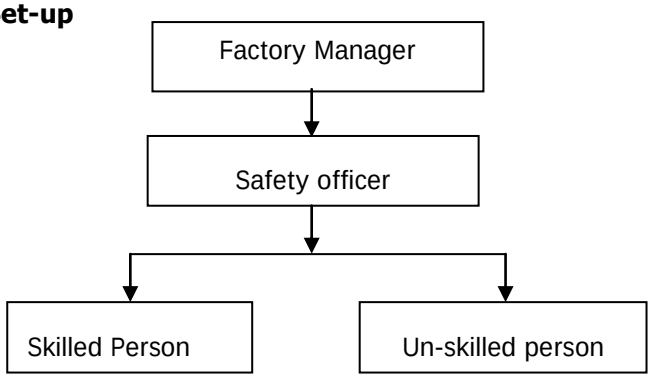
7.13.4 General Recommendations

- All non-routine work etc. should be carried out under a permit system.
- Adequate number of caution boards high lighting the hazards of chemicals to be handled, eye bath and emergency showers should be provided at critical location.
- Adequate number of absorbents should be placed at accessible locations in the tank farm area as well as in the pump house that would enable to contain spills immediately.
- Adequate color coding and labeling of the pipelines should be provided for easy identification of products proposed to be handled through them.
- The damage distance due to any failure could be reduced, by reducing the time required to stop the leak, which in turn would reduce the quantity of spillage. The response time could be reduced by installing /maintaining instruments, effective communication system, etc.
- It is recommended that rubber mats be provided in front of electrical panel of the entire plant with a view to prevent employees from receiving electric shocks.
- It is suggested that all type of fire extinguishers be placed at appropriate places for easy access in case of emergency.

7.13.5 The availability, organization, and utilization of resources for emergency

The organizational set-up necessary for chain of commands during emergency situation, which may arise in the premises. The system is described in following Subsections.

A. Organizational Set-up



Functions and Responsibilities of Factory Manager

- He shall be the main guiding person for direct emergency operations.

Safety officer

- The main responsibility of safety officer is safety management.
- The Safety management includes the implementation of prevention methods to avoid incident or accident and handling of emergency in case of accident.

Skilled person

- He shall be responsible for the operation and maintenance.

Skilled person

- He shall be arranging the safety equipment accordingly.
- He shall be followed the instruction of supervisor and officer.

7.13.6 Emergency Response Room (Safety officer room)

The place identified as Emergency Response Center will be considered as the Security Gate Office. The location of the Emergency Response Center may change in future as per convenience. The facilities available at the Emergency Response Center shall include:

- Internal Telephone
- External Telephone
- Manual Fire/Emergency Siren
- Siren Actuation Switch
- Important Address and Telephone Numbers
- Emergency Vehicles
- Confined Space Entry Procedure
- List of Antidote/actions to be taken in case of hazardous chemical/materials.
- Material Safety Data Sheets of chemicals
- A copy of On-Site Disaster Management Plan

All communications after General Shift working hours and on Sundays/ Holidays are to be routed through the Security Gate Office.

General Rules

- Follow sense of discipline and do not pain.
- Do not rush and endanger your personnel safety
- Use personnel protective equipment according to the situation
- Do not block any passages, which may hinder the movement of emergency vehicles.
- In case you have to shut down your plant operation, do it in an orderly manner as per standard operating procedures.
- In situation when you have to leave your work and evacuate to identify places out of operating areas, do it in an orderly manner.
- Follow instructions of the Safety officer.
- Understand the Disaster Management Plan well and take interest in practice mock drill.

7.13.7 Fire Fighting Facilities

A. Fire Buckets / Fire Extinguishers

Fire buckets and portable fire extinguishers will be provided in all the areas depending upon the specific needs of the area. Some spare equipment will also be maintained in the inventory at an identified fire & safety equipment store.

B. Fire Alarm Sirens

It shall be provided to alert all the employees inside the premises about the situation of an emergency.

C. Sand Buckets

5 nos. of sand buckets will be provided within the industrial premises in case of emergency fire.

D. Oxygen cylinder

12 no. of oxygen cylinder will be provided for emergency.

E. Safety Equipment

All types of personnel protective safety equipment required for handling the emergency are to be arranged in the M/s. Ever Shine Decor Pvt. Ltd. site. Some of the protective equipment is as follow:

- Canister/Cartridge type masks
- Dust Masks
- PVC suits, Aprons
- Safety showers/ Eye Wash fountains
- Other personnel protective appliances, like safety glasses, gumboots, helmets, hand gloves, face shields, safety belts, safety ladders, safety torches, blankets.

7.13.8 Other Key Personnel

All key personnel will wear red helmet for their identification and easy recognition. The responsibilities and duties of key personnel include.

A. Safety

The safety officer/ supervisor will carry out the following:

- To provide necessary equipment like firefighting equipment (FFE) and personal protective equipment (PPE).
- To accompany factory inspector during investigation of the emergency.
- To train workers/ supervisors in safety and safe operating procedures.
- To assist the site main controller, incident controller in preparing a brief report of the incident.

B. Assembly Points

- The assembly points for gathering non-essentials workers / persons will be fixed and

will be clearly marked as per the wind direction.

C. Fire Control Arrangement

Fire fighting trained personnel will be made available in all the shifts. The responsibilities and duties include:

- To fight the fire with available internal fire fighting equipment and to stop leakage of liquid etc.
- To provide personal protective equipment to the team.
- To cordon the area and inform incident controller or site main controller about the development of emergency.
- To train the persons (essential workers) to use personal protective equipment and fire-fighting equipment.

D. Medical Arrangement

The responsibilities and duties include:

- To provide first aid to the affected persons, and, if necessary, send them to hospitals for further treatment.
- To keep a list of blood groupings ready and update.

E. Transport Evacuation Arrangement

- For transportation of people, company's vehicles, cars, rickshaws etc. will be utilized.

7.13.9 On Site Emergency Plan

An emergency in the premises has the potential to cause serious injury or loss of lives or extensive damage to the property and/or environment and serious disruption both inside and outside the plant. In such cases sometimes outside agencies are required to call for help in handling the situation. The causative factors like plant/equipment failure, human error, earth quake, sabotage etc. will normally manifest in various forms viz. Fire, Explosion, Toxic release, structure collapse etc.

This OEP lays down the code of conduct of all personnel in the Plants and the procedures to be adopted by them in the event of an "Emergency". These procedures have been prepared taking into account the minimum strength of manpower available at all times in the premises. The individuals under the direction of the respective Team Leaders shall carry out the responsibilities assigned.

The emergency procedures outlined are suitable for round the clock coverage including holidays. These emergency procedures shall be followed as outlined in the OEP during general shifts as well.

The overall objectives of OEP are:

- To control the situation and if possible eliminate as quickly as possible.
- To avoid confusion/panic and to attend the emergency with clear-cut line of action.
- To minimize the loss of property to the plant as well as to our neighborhood.
- To safe guard the non-affected areas.
- To alert the neighborhood.
- To arrange head-count and rescue operations.

- Treatment of the injured.
- To safeguard others by timely evacuation.
- To prevent any cascade of emergencies.

A. Accident

An accident is an unplanned event, which has a probability of causing personal injury or property damage or both. It may result in physical harm (injury or disease) to person (s), damage to property, loss to the company, a near miss or any combination of the effect.

A Major accident is a sudden, unexpected, unplanned event, resulting from uncontrolled developments during and industrial activity, which causes or has a potential to cause

- Serious adverse effects immediate or delayed (death, injuries, poisoning or hospitalization) to a number of people inside the installations and/ or to persons outside the establishment.
- Significant damage may be caused to crops, plants or animals or significant contamination of land waters or air.
- An emergency intervention outside the establishment (evacuation of local population, stopping of local traffic).
- Any combination of above.

B. Emergency

An emergency is the situation, which has potential to cause a large-scale damage or destruction to life or property or Environment or combination of these within or outside the factory. Therefore it is essential to have a laid down procedure to meet emergency systematically. In any industry, emergency can arise at any moment and this depends on the type of:

- Structure
- Raw materials
- Machines
- Nearby Industries
- Location of the Industry etc.

C. Nature of Emergency

The "Emergency" specified in this plan will refer to occurrence of one or more of the following natural/manmade events.

- Fire
- Explosion
- Release of Toxic Gas/Vapour
- Spillage of flammable liquid /gas
- Deliberate Sabotage, Terrorism, Air Raid etc.
- Natural Calamities: - Lightening, Storm, Earthquake, Flood etc.
- Collapsing of structure
- Overturning of tanker containing flammable / toxic substances.

D. Medical Help

First Aid Boxes have been provided at various strategic locations. Requisite number employees are trained about First Aid, Liaison with nearest hospitals.

E. Communication System

- Alarm Raising for Emergency by blowing the sirens installed
- The siren will be used for raising the emergency alarm and also for all clear signals.
- Emergency Siren: The wailing alarm will be sounded intermittently at fixed interval of 30 seconds for a period of two minutes in case of emergency, such alarm will signify the employees that an emergency has occurred and that the emergency services should be put into operation.
- Incident Controller after assessing the situation will declare that emergency is over. Till the Incident Controller issues the declaration, all the leaders will adhere to the task and be present at the prescribed location.
- All clear signal will be sounded through continuous siren for 1 minute. Even after the emergency is over a skeleton staff of the Rescue/Evacuation Team will be available at the site of emergency for at least 30 minutes to ensure that the situation is absolutely free from danger.
- After the emergency is over, all the team leaders should meet at the Emergency Control Center and each team leader should submit a report to the Incident Controller about team performance and other details observed.
- In addition to the above systems, Internal telephones, P.A.System, Mobile telephones, Computer System etc. will be used for communication.
- If situation is beyond the control, the external agencies will be informed accordingly and asked for the help. Direct telephone, cell phone or messengers / runners may achieve this.

F. Assembly Point

In case of emergency some locations are considered as Assembly Points. Depending on the wind direction and location of emergency, Assembly Point will be declared. The employees should run across the wind direction and not against the wind direction.

Depending upon the location of the emergency the Incident Controller will fix the Assembly Point and Officer will announce the location of the Assembly Point. Employee's attendance, visitors and contractors workmen register will be made available at the Assembly Point for head count.

G. Emergency Control Center

Factory Manager Office will be declared as an Emergency control center. Emergency control center is facilities with:

- Address and Telephone numbers of the Factory Inspectorate, Gujarat Pollution Control Board, Police, Fire Brigade, Hospitals and OEP Team Members
- Plant layout-indicating storage of hazardous materials, layout of fire Hydrants/extinguishers, entrances/exits, roads etc.
- Portable P.A. System, Manual Siren, flood lights, Torches, Pickaxe, Saw, Nylon Ropes.
- Fire Blankets / Fire Proximity Suit, Breathing Apparatus, First Aid Box etc.
- List of employees with address, telephone number, blood group etc.

- Material Safety Data Sheets of all chemicals handled.

H. Wind Socks

Wind direction will be determined with the help of installed windsocks.

I. Mock Drill

Mock drills are carried out regularly to familiarize the staff with their roles, fire protection equipment/system installed in the plant and use of personnel protective equipment. Senior officials monitor this and shortcomings are thoroughly studied and necessary corrective measures are taken.

1) Procedures for Mock Drills

- Inform all the employees about mock drills and the signal to be given.
- Fix the date and location of the emergency for mock drills.
- Mock drills will be monitored by observers.
- Raise the siren for emergency.
- After hearing the siren the Incident Controller, Site Controller, Officers and Team Members should actuate the "On-site Emergency Plan".

2) Procedure on Noticing an Emergency

- If anybody notices any situation, which may lead to a disaster, should be immediately inform the Shift In-charge / site controller / Incident Controller / Fire & Safety Supervisor / Security.
- Take charge of the situation as Incident Controller.
- Rush to the site of emergency to get the correct picture and then to Emergency Control Center for speedy control over the situation by making an arrangement for raising the alarm.
- On arrival of Team members, he shall assign duties as required and activate the On-Site Emergency Plan.
- Ensure safety of the plant and the personnel in the plant. He will make an assessment of the emergency and decide on external assistance.
- Communicate and Coordinate among the Incidents Controller/ Site Controller/ Factory manager/ fire safety supervisor etc. and will be the final authority on all matters related with management of emergency such as:
  - Fire fighting.
  - Welfare and rescue operations.
  - Arrange for Civil/Mechanical/Electrical work during emergency.
  - Transport.

J. Incident Controller / Site Controller

Rush immediately to the scene of the fire/emergency, select and set out appropriate fire/emergency equipment. He will take the below mentioned actions at the earliest opportunity, if the fire/emergency is not controlled.

He will

- Call the security personnel from their residences for additional manpower if required.
- Regulate entry and exit of personal required for controlling the fire/emergency.

- Restrict exit of personal required for controlling the fire/emergency.
- Arrange for Personnel Protective Equipment required for the emergency.
- Call, the local Fire Brigade, Police in case of necessity in consultation with the Incident controller.
- Arrange transport facilities for removal of causalities to dispensary / hospital.
- Take responsibility of law and order.
- Keep detailed records of the incident and progress of operations to fight the emergency.

K. Factory Manager

He will rush to the Emergency Control Centre and collect the information from the Incident Controller. Further he will,

- Announce the location of the Assembly Point after getting information from Incident Controller / site controller.
- Take the list of persons to be communicated internally and externally.
- Maintain liaison with the press, government agencies i.e. Police, Fire Brigade etc. and the neighborhood regarding the emergency under instructions from Incident Controller.
- Courteously Receive officers from the State Government or neighbors to the Administration Block only and inform to Incident Controller that they can be taken care off.
- Take all the steps required for the welfare such as providing tea, snacks, emergency temporary Medical Center in consultation with the incident controller/site controller.
- Disclose all the necessary information in the plant and media so as to avoid rumors and Confusion.
- Also be responsible for the head counts at the Assembly Points.

L. Fire & Safety Supervisor/ Shift Incharge & Security

- Proceed to the scene; establish contact with firemen and incident controller to supplement efforts in fire fighting.
- Assist in searching casualties and help to remove them to the medical center.
- Organize outside assistance in fire fighting and rescue operations if required.
- Mobilize personal protective equipment and safety appliances and assist personnel handling emergency in using them.
- Keep and check on any new development of unsafe situation and report the same to Site Main Controller.
- Collect and preserve evidence to facilitate future inquiries.
- Effectively cordon off the emergency area and will prevent unauthorized people entering the scene.
- Permit the Fire tenders or Ambulance requisitioned by Incident Controller to the plant.
- Ensure that vehicles and trolleys are sent out of the plant premises.
- Ensure that all the employees are conducted out of plant and assembled at Assembly Point.
- Control Traffic Movement.
- Remove tankers, tanker drivers outside.
- Entry of unauthorized public to be prevented.

- Arrange for vehicles for shifting casualties and essential workers to safe assembly points.

M. Engineering/ Operation & Maintenance

- Ensure the safety of the remaining part of the plant.
- Take necessary steps for plant shutdown in consultation with the site controller.
- Ensure that an Operator is immediately available at the Water Pump House for fire fighting.
- Mobilize with necessary tools and tackles to handle any repair work on an emergency basis.

7.13.10 Locating the Plant in Open Area Instead Of Covered to be Reviewed in View of Safety Consideration

Storage tank of Chloroform, N- Haxane, Ethyl Acetate should be installed away from the plant area.

- Wind indicator should be provided at the highest level of the plant to know the wind direction.
- Automatic sprinkler system for the flammable material tanks (over ground tanks only) may be provided as knock on effect in case of fire is possible.
- Containment dykes with proper sloping and collection sumps should be provided so that any spillages in the bulk storage and other handling areas shall not stagnate and shall be quickly lead away to a safe distance from the source of leakage. This reduces the risk of any major fire on the bulk storages and the risk to the environment shall be minimized/ eliminated.
- Inspection of the storage tanks as per prefixed inspection schedule for thickness measurement, joint and weld efficiency etc.
- Provision of flameproof electrical fittings / equipment's.
- Comprehensive colour code scheme to identify different medium pipes.
- Proper maintenance of earth pits.
- Strict compliance of security procedures like issue of identity badges for outsiders, gate passes system for vehicles, checking of spark arrestors fitted to the tank lorries etc.
- Strict enforcement of no smoking.

7.13.11 Offsite Emergency Preparedness Plan

Offsite emergency plan would follow the onsite emergency plan. When the consequences of an emergency situation go beyond the plant boundaries, it becomes an offsite emergency.

Offsite emergency is essentially the responsibility of the public administration. However, the plant management will provide the public administration with the technical information relating to the nature, quantum and probable consequences on the neighboring population. The offsite plan in detail will be based on those events, which are most likely to occur, but other less likely events, which have severe consequence, will also be considered. Incidents which have very severe consequences yet have a small probability of occurrence would also be considered during the preparation of the plan. However, the key feature of a good offsite emergency plan is flexibility in its application to emergencies other than those specifically included in the formation of the plan.

The roles of the various parties who will be involved in the implementation of an offsite plan are described below. Depending on local arrangements, the responsibility for the offsite plan would either rest with the plant management or with the local authority. Either way, the plan would identify an emergency coordinating officer, who would take the overall command of the offsite activities. As with the onsite plan, an emergency control centre would be setup within which the emergency coordinating officer can operate.

An early decision will be required in many cases on the advice to be given to people living "within range" of the accident - in particular whether they should be evacuated or told to go indoors. In the latter case, the decision can regularly be reviewed in the event of an escalation of the incident. Consideration of evacuation may include the following factors: In the case of a major fire. Only houses close to the fire are likely to need evacuation, although a severe smoke hazard may require this to be reviewed periodically; and if a fire is escalating and in turn threatening a store of hazardous material, it might be necessary to evacuate people nearby, but only if there is time; if insufficient time exists, people should be advised to stay indoors and shield them from the fire. This later case particularly applies if the installation at risk could produce a fireball with very severe thermal radiation effects.

Although the plan will have sufficient flexibility built in to cover the consequences of the range of accidents identified for the onsite plan, it will cover in some detail the handling of the emergency to a particular distance from each major hazard works.

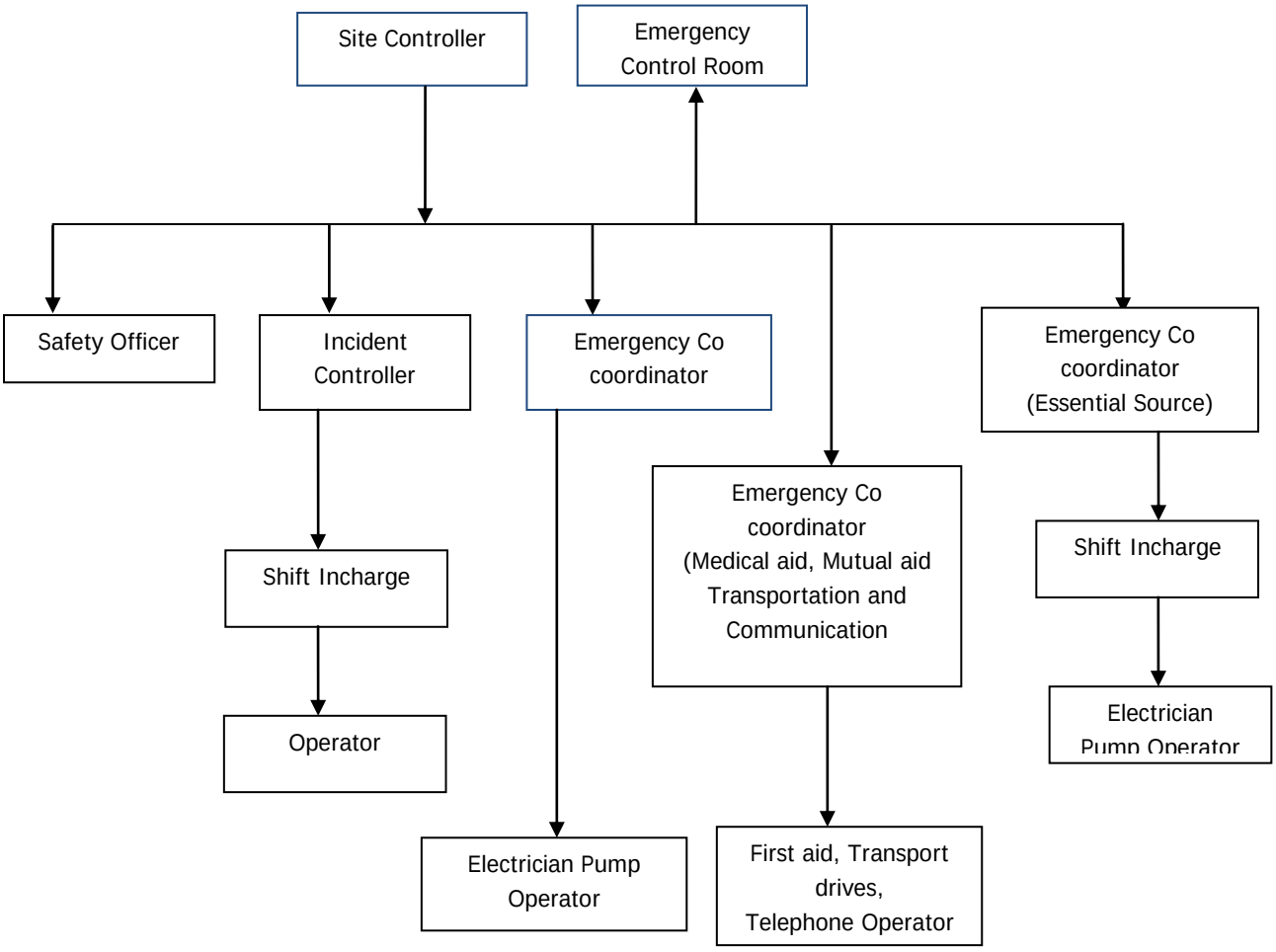


Figure 7-1: Off-Site Disaster Management Plan

A. Aspects Proposed to be considered in the Offsite Emergency Plan

The main aspects, which should be included in the emergency plan, are:

1) Organization

Detail of command structure, warning systems, and implementation procedures, emergency control centres. Names and appointments of incident controller, site main controller, their deputies and other key personnel.

2) Communications

Identification of personnel involved, communication center, call signs, network, list of telephone numbers.

3) Specialized Knowledge

Details of specialist bodies, firms and people upon whom it may be necessary to call e.g. those with specialized fuel knowledge, laboratories.

4) Voluntary Organizations

Details of organizers, telephone numbers, resources etc

5) Fuel Information

Details of the hazardous substances stored and a summary of the risk associated with them.

6) Meteorological Information

Arrangements for obtaining details of weather forecasts and weather conditions prevailing at that time

7) Humanitarian Arrangements

Transport, evacuation centres, emergency feeding, treatment of injured, first aid, ambulances and temporary mortuaries.

8) Public Information

Arrangements for (a) Dealing with the media press office; (b) Informing relatives

B. Assessment of Emergency Plan

Arrangements for:

Collecting information on the causes of the emergency; and Reviewing the efficiency and effectiveness of all aspects of the emergency plan.

1) Role of the Emergency Co-ordinating Officer

The various emergency services would be co-ordinated by an Emergency Coordinating Officer (ECO), who will be designated by the district collector. The ECO would liaison closely with the site main controller. Again depending on local arrangements, for very severe incidents with major or prolonged offsite consequences, the external control would be passed to a senior

local authority administrator or even an administrator appointed by the central or state government. The ECO will be equipped with address and phone numbers of important agencies.

2) Role of the Local Authority

The duty to prepare the offsite plan lies with the local authorities. The emergency planning officer (EPO) appointed should carry out his duty in preparing for a whole range of different emergencies within local authority area. The EPO should liaison with the plant, to obtain the information to provide the basis for the plan. This liaison should ensure that plan is continually kept up to date. It will be responsibility of the EPO to ensure that all those organizations which will be involved offsite in handling the emergency, know of their role and are able to accept it by having for example, sufficient staff and appropriate equipment to cover their particular responsibilities. Rehearsals for offsite plans should be organized by the EPO.

3) Role of Police

Formal duties of the police during an emergency include protecting life and property and Controlling traffic movements. Their functions should include controlling bystanders, evacuating the public, identifying the dead and dealing with casualties, and informing relatives of death or injury.

4) Role of Fire Authorities

The control of a fire should be normally the responsibility of the senior fire brigade officer who would take over the handling of the fire from the site incident controller on arrival at the site. The senior fire brigade officer should also have a similar responsibility for other events, such as explosions. Fire authorities in the region should be appraised about the location of all stores of flammable materials, water and foam supply points, and firefighting equipment. They should be involved in onsite emergency rehearsals both as participants and, on occasion, as observers of exercises involving only site personnel.

5) Role of Health Authorities

Health authorities, including doctors, surgeons, hospitals, ambulances and so on, should have a vital part to play following a major accident, and they should form an integral part of the emergency plan. For major fires, injuries should be the result of the effects of thermal radiation to a varying degree, and the knowledge and experience to handle this in all but extreme cases may be generally available in most hospitals.

Major off site incidents are likely to require medical equipment and facilities additional to those available locally, and a medical "mutual aid" scheme should exist to enable the Assistance of neighboring authorities to be obtained in the event of an emergency.

6) Role of Government Safety Authority

This will be the factory inspectorate available in the region. Inspectors are likely to satisfy themselves that the organization responsible for producing the offsite plan has made adequate arrangements for handling emergencies of all types including major emergencies.

They may wish to see well documented procedures and evidence of exercise undertaken to test the plan. In the event of an accident, local arrangements regarding the role of the factory inspector will apply. These may vary from keeping a watch, to a close involvement in advising on operations.

Table 7-13: Offsite Action Plan

Sr. No.	Action Required to be taken to Mitigate Disaster by Aid giving agency	Responsible Agencies for taking action	Equipments/Material facilities required at site to mitigate Emergency
A 1	Arrangements for evacuation/ rescue of persons from zone of influence to predetermined camps	Police Department	Self Breathing apparatus with spare cylinder Chemical gas mask with spare canister Vehicle with PA system Transportation for evacuation of people
2	Caution to public by announcement		
3	Traffic control by cordoning of the area		
4	Law & order		
5	Request to railway authority for keeping the nearest railway gate open & to stop the trains at the nearest railway station		
B	Control of fire	District Fire Brigade	Self breathing apparatus with spare cylinders Foam /water fire tenders Gas mask with spare canisters Lime water Neck to toe complete asbestos suit, PVC hand gloves, gumboots, safety goggles Mobile scrubbing system alongwith suction arrangement.
1	Scrubbing of the flashed off gas cloud with water curtain		
2	To rescue trapped persons		
3	If fire is big, keep surrounding area cool by spraying water		
4	Communication to State Electricity Board to continue or cut off electric supply		
5	Communication to water supply department for supplying water		
C	Medical facilities for affected persons (first aid and treatment)	Hospital and public health	Ambulance with onboard resuscitation unit, first aid, stretchers
D	Identification of concentration of gas in zone of influence	Pollution Control Board	Gas detector
E	Removal of debris and damaged structures	Municipal corporation	Provide bulldozers Provide cranes
F 1	Monitor the incoming and out going transports	Transport department	Provide traffic police at site Provide emergency shifting vehicles at site Provide stock of fuel for vehicles.
2	Arrange emergency shifting of affected persons and non affected person to specified area		
3	Arrange diesel/petrol for needed vehicles		

Sr. No.	Action Required to be taken to Mitigate Disaster by Aid giving agency	Responsible Agencies for taking action	Equipments/Material facilities required at site to mitigate Emergency
G 1	Give all information related to meteorological aspects for safe handling of affected area for living beings	Meteorological Department	Provide wind direction and velocity instruments with temperature measurements
2	Forecastimportant weather changes, if any		Mobile van for Meteorological parameter measurements
H 1	Representatives of all departments are in the local crisis group; therefore they are expected to render services available with them. Since it is a group of experts with authority, the mitigating measures can be implemented speedily. The representatives from locals are also there so that communication with local people is easy and quick.	Local Crises Group	Must have all resources at hand, specially disaster management plan and its implementation method. All relevant information related to hazardous industry shall available with crisis group Newspaper editor shall be a part of the group so that right and timely media release can be done
2	The district emergency or disaster control officer / collector shall be the president and he shall do mock drill etc so that action can be taken in right direction in time		
I 1	Collector shall be the President of District Crisis Group therefore all district infrastructure facilities are diverted to affected zone	District Crisis Group	All necessary facilities available at district can be made available at affected zone
2	All other functions as mentioned for local crisis group		Control of law and order situation