NATCO PHARMA LIMITED, Chemical Division

RISK ASSESSMENT REPORT
Chapter 7 of EIA Report Volume-I

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7.0 Introduction

Hazard is an intrinsic property of a chemical substance at a given point and at given plant of certain phenomenon that can have an adverse effect on the human life and health, on the environment or on anything else you consider important. Hazard is anything (e.g. condition, situation, practice, behavior) that has the potential to cause harm, including injury, disease, death, environmental, property and equipment damage and Risk is the likelihood, or possibility, that harm (injury, illness, death, damage etc.) may occur from exposure to a hazard.

The principal objective of the risk assessment study is to identify and quantify the major hazards and the risk associated with various operations of the proposed project, which may lead to emergency consequences (disasters) affecting the public safety and health. Based on this information, an emergency preparedness plan will be prepared to mitigate the consequences. The approach involves hazards identification, hazards assessment and evaluation, developing Disaster Management Plan (DMP).

Risk analysis: provides a relative measure of the likelihood and severity of various possible hazardous events by critically examining the plant storages, process and operating units, deal with different materials in their production, some of which are hazardous in nature i.e. flammable, explosive, toxic and corrosive. Fire, explosion, toxic release or combinations of these are the hazards associated with industrial plants using hazardous chemicals. Risk Assessment has now been developed to improve upon the integrity, reliability and safety of the plant.

Scope of study: Hazard Identification and analysis, evaluation of risks due to the Maximum Credible Accident (MCA) analysis, consequence analysis and preparation of DMP by

evaluation of risks due to fire and explosion, atmospheric release of Toxic dispersion. Based on this information, an emergency preparedness plan will be prepared to mitigate the consequences.

7.1 Hazard identification

Identification of hazards is of primary significance in the analysis, quantification and cost effective control of accidents involving chemical handling and process thereof. A classical definition of hazards states that hazard is in fact the characteristics of system/ plant/ process that present potential for the accident. Hence, all the components of a system/ plant/ process need to be thoroughly examined/studied to assess their potential for initiating or propagating an unplanned events/sequence of events, which can be termed as an accident.

Estimation of probability of unexpected event and its consequences form the basis of quantification of risk in terms of damage to property, environment and personnel. Therefore, the type, quantity, location and condition of release of toxic or flammable substances have to be identified in order to estimate its damaging effects, the area involved, and the possible precautionary measures required to be taken.

Once a hazard is identified, it is necessary to evaluate it in terms of the risk it presents to the employees and the neighbouring community. In principle, both probability and consequences are considered.

The following two methods for hazards identification have been employed in the study:

- Identification of major hazardous units based on Manufacture, Storage and Imports of Hazardous chemicals Rules, 1989 of Government of India and amended rules1994 & 2000 and
- Identification of Fire-Explosion and Toxicity Index (FE&TI)

7.1.1 Identification of Major Hazard Installations based on GOI Rules, 1989 as amended in 1994 & 2000

By studying accidents occurred in Indian industries in over a few decades, a specific legislation covering major hazard activities has been enforced by Government of India in1989 in conjunction with Environment Protection Act, 1986. This is referred here as GOI rules1989. For the purpose of identifying major hazard installations the rules employ certain criteria based on toxic, flammable and explosive properties of chemicals.

Indicative Criteria for Identification of Toxic, Flammable & Explosive Chemicals (GOI Rules, 1989) & Amended rules 1994 & 2000

(a) Toxic Chemicals:

Chemicals having the following values of acute toxicity and which owing to their physical and chemical properties are capable of producing major accident hazards:

Sl. No.	Toxicity	Oral toxicity LD50(mg/kg)	Dermal toxicity LD50 (mg/kg)	Inhalation toxicity LC50 (mg/l)
1.	Extremely toxic	> 5	< 40	< 0.5
2.	Highly toxic	>5–50	>40-200	< 0.5-2.0
3.	Toxic	>50-200	>200-1000	>2-10

(b) Flammable Chemicals:

(i) Flammable gases: Gases which are at 20˚C and at standard pressure of 101.3 KPa are:-

1. Ignitable when in a mixture of 13% or less by volume with air ,or
2. Have a flammable range with air of at least 12 percentage points regardless of the lower flammable limits.

Note: The flammability shall be determined by tests or by calculation in accordance with methods adopted by International Standards Organization (ISO)-10156 of 1990 or by Bureau of Indian Standards (1446 of 1985).

(ii) **Extremely flammable liquids**: Chemicals which have flash point lower than or equal to 23˚C and boiling point less than 35˚C

(iii) **Very highly flammable liquids**: Chemicals which have a flash point lower than or equal to 23˚C and initial boiling point higher than 35˚C.

(iv) **Highly flammable liquids**: Chemicals which have a flash point lower than or equal to 60˚C but higher than 23˚C.

(v) **Flammable liquids**: Chemicals which have a flash point higher than 60˚C but lower than 90˚C.

(c) Explosives: Explosive means a solid or liquid or pyrotechnic substance (or a mixture of substances) or an article:

i. Which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings

ii. Which is designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as the result of non-detonative self-sustaining exothermic chemical reaction

7.1.2 Applicability of Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 & subsequent amendments

A systematic analysis of the chemicals and the quantities of storage of chemicals has been carried out to determine threshold quantities as notified by GOI Rules, 1989 and the applicable rules are identified. The description of applicable rules is summarized in **Table 7.1.**

Table 7.1: Description of applicable provisions of GOI rules'1989 as amended in 1994 & 2000

Applicable Rules	Description
4	**Identify Major accident** Take adequate steps to prevent major accidents, Provide information to persons working onsite Impart training, provide equipment and antidotes
5	Notification of major accidents to concerned authority, If any major accident occurs occupier to inform Concerned authority as listed in SC-5 and submit report as per the format in SC-6 (applies after commencing of the activity)
7	Notification of site to competent authority
8	Updating of site notification following changes in threshold quantity
9	Transitional provision for the existing activity
10	Preparation of safety reports for commencement of activity
11	Updating of safety reports based on modification
12	Provision of further information on safety reports to the authority
13	Preparation of on-site emergency plan by the occupier
14	Preparation of off-site emergency plan by the occupier
15	Information to be given to persons liable to be effected by a major accident
17	Collection, development and dissemination of information on hazardous Chemicals employed by the occupier
Occupier will develop information in the form of safety data sheet as specified in SC-9. Every container of the hazardous chemical will be labeled with name of the manufacturer or importer of the hazardous chemical.	

From the above table it can be inferred that there would be Hazardous chemicals stored at the proposed site, which would attract the GOI rules 4,5,7-9 and 13-15,as the quantity likely to be stored at site lies above the stipulated threshold quantities.

7.1.3 Storage Facilities of Hazardous Chemicals

The storage capacities, daily consumption, type of storage and physical status of each hazardous chemical proposed to be used for manufacturing various products are given in **Table 7.2**. The project proponent deals with different materials in their production, some of which are hazardous in nature i.e. flammable, explosive, toxic and corrosive. Fire,

explosion, toxic release or combinations of these are the hazards associated with industrial plants using hazardous chemicals. Chemicals consumed in this plant are in solid, liquid and gaseous form and observed that some of these chemicals are hazardous in nature. The Hazard analysis is required for these chemicals. The information on Material safety data sheet (MSDS) for all the identified hazardous chemicals is presented in **(Volume II of EIA report pages # 658-731).**

Table 7.2: List of Hazardous Chemicals, Consumption, Maximum Storage, Type of Storage and Nature of Material

Sl. No.	Name of the Material	Consumption (kg/day)	Maximum Storage Capacity	Maximum Package	No. of Packings	Storage Type	Nature of the Material
i)	**Ware Houses**				Nos.		
1.	1,4 – Dioxane	1390	3150 liters	210 Liters	15	MS drums	Flammable & Toxic
2.	Acrylo Nitrile	3400	6880 Kg	160 Kg	43	MS Drums	Flammable &Toxic
3.	Benzyl chloride	508	5060 Kg	220 Kg	23	HDPE Drums	Toxic
4.	Ethyl Alcohol	2900	6000 liters	250 Liters	24	HDPE Drums	IA Flammable
5.	n-Butanol	2100	4200 Kg	200 Kg	21	HDPE Drums	IC Flammable
6.	Tri Ethyl Amine	164.5	1015 Kg	145 Kg	7	MS Drums	Toxic & IB Flammable
7.	Thionyl chloride	2955	9000 Kg	300 Kg	30	GI drums	Toxic
8.	Aceto Nitrile	3600	5600 Kg	160 Kg	35	MS drums	Toxic & IB Flammable
9.	Dimethyl sulfoxide	2200	5750 Kg	230 Kg	25	HDPE drums	Toxic & Flammable
10.	MIBK	20	330 Kg	165 Kg	2	MS drums	Toxic & IB Flammable
11.	Bromine	390	1512 Kg	18 kg	84	Bottles in crates	Toxic
12.	1,2-Dimethoxyethane	500	1000 Liters	200 Liters	5	MS Drums	Flammable
13.	1-Pentanol	10	210 Liters	210 Liters	1	MS Drums	Flammable
14.	2-Methyl Tetrahydrofuran	1100	3000lts	200Lts	15	MS Drums	Flammable
15.	Anisole	1000	2000 Kg	200 Kg	10	HDPE drums	Combustible
16.	Bromoform	200	700 Kg	100 Kg	7	MS drums	Noncombustible
17.	Diisopropyl ether	320	1050kg	150kg	7	MS drums	Flammable
18.	Dimethoxy ethane	160	600kg	150kg	4	MS drums	Flammable & Toxic
19.	Dimethylacetamide	700	1800 Kg	200 Kg	9	HDPE drums	Combustible

Sl. No.	Name of the Material	Consumption (kg/day)	Maximum Storage Capacity	Maximum Package	No. of Packings	Storage Type	Nature of the Material
i)	**Ware Houses**				Nos.		
20.	Dimethylformamide	17980	20900 Kg	190	110	HDPE drums	Combustible
21.	Ethylene Glycol	1500	2990 Kg	230 Kg	13	HDPE drums	Combustible
22.	Ethylenediamine	50	180 Kg	180 Kg	1	MS Drums	Flammable
23.	Heptane	210	540kg	180kg	3	MS Drums	Flammable
24.	Isopropyl Acetate	250	600 Kg	200 Kg	3	HDPE drums	Flammable
25.	Isopropyl ether	4700	5600 Kg	140 Kg	40	MS Drums	Flammable
26.	Methyl Ethyl Ketone	900	1600 Kg	160 Kg	10	MS Drums	Flammable
27.	Methyl tert-butyl ether	1500	3000 Kg	150 Kg	20	MS Drums	Flammable
28.	N,N-Diisopropylethylamine	20	90kg	3kg	30	MS tins	Flammable
29.	n-Heptane	2100	4000 liters	200 Liters	20	MS Drums	Flammable
30.	n-Hexane	540	3000 liters	200 liters	15	Drums	Flammable
31.	o-Xylene	17	200 Liters	25 Liters	8	MS Drums	
32.	Petroleum ether	30	400 Liters	200 Liters	2	MS Drums	Flammable
33.	Tetrahydrofuran	4600	7200 Kg	180 Kg	40	MS Drums	Flammable
34.	Trifluoroacetic acid	1100	2000 Kg	200 Kg	10	MS Drums	
35.	2-Aminopyridine	33	200	50kg	4	HDPE carboys	Combustible Solid
36.	2-Methoxyethanol	9	200 Kg	200 Kg	1	HDPE Drums	
37.	Acetic Anhydride	461.5	1200 Kg	30 Kg	40	HDPE Drums	Flammable & Corrosive
38.	Ammonia (20%) solution	652	2000 Liters	200 Liters	10	HDPE	
39.	Benzene	4.7	10kg	2.5kg	4	Glass bottles	Flammable
40.	Benzoyl Peroxide	7	50 Kg	25 Kg	2	HDPE	Combustible
41.	Chlorobenzene	1	5kg	2.5kg	2	Glass bottles	Flammable
42.	Copper Cyanide	6	98 Kg	49 Kg	2	MS Drums	Toxic
43.	Cyclopentadiene	12	100kg	50kg	2	HDPE carboys	Flammable
44.	Diethylamine	3	20 Liters	0.5 Liters	40	Bottles	Flammable
45.	Ethylene Oxide	3.8	70 Kg	35 Kg	2	Cylinder	

Sl. No.	Name of the Material	Consumption (kg/day)	Maximum Storage Capacity	Maximum Package	No. of Packings	Storage Type	Nature of the Material
i)	**Ware Houses**				Nos.		
46.	Formalin (37%)	28	200kg	50kg	4	HDPE carboys	Flammable
47.	Formic acid (85%)	50	300kg	25kg	12	HDPE carboys	Combustible
48.	Hydrobromic acid (48%)	1375.08	5000kg	250kg	20	HDPE Drums	Corrosive
49.	Hydrogen Chloride	68	12000	12kl tanker	1	PPFRP Tank	Corrosive
50.	Lithium aluminum hydride	2	40 Kg	10 Kg	4	MS Drums	Flammable & Corrosive
51.	Maleic Anhydride	276	750 Kg	25 Kg	30	PAPER	
52.	Monomethylamine (40%)	220	2000 Lts	200 Lts	10	Drums	
53.	N,N-Dimethylaniline	155	2000 Lts	200 Lts	10	Drums	Combustible
54.	*o*-Toluidine	99	2000 Kg	200 Kg	10	MS Drums	
55.	Phenol	55.5	200 liter	200 liters	1	MS Drum	
56.	Phosphorous Oxychloride	446.4	1000 Kg	50 Kg	20	HDPE	
57.	Phosphorous Trichloride	143	400 Kg	200 Kg	2	MS Drums	
58.	Phosphorus Pentachloride	20	200kg	50kg	4	HDPE Carboys	
59.	Piperdine	155.87	510 Kg	170 Kg	3	MS Drums	
60.	Sodium Cyanide	10	100 Kg	10 Kg	10	MS Drums	Toxic
61.	Titanium Chloride	67.6	600 Kg	300 Kg	2	GI Drums	

ii) Tank farm area:

Sl. No.	Name of the Material	Consumption (Kg/day)	Max. Capacity of tanks	Nature of the Material	Type of storage
	SOLVENTS				
1.	Acetic Acid	810	30 KL	Combustable & Corrosive	Horizontal Tank
2.	Acetone	460	19 KL	IB- Flammable	Horizontal Tanks
3.	Chloroform	30400	30 KL	Toxic	Horizontal Tank in tank farm
4.	Ethyl Acetate	40850	30 & 20 KL	IB Flammable	Horizontal Tank
5.	IPA	31700	30 & 20 KL	IB Flammable	Horizontal Tanks
6	Hexane	500	10 KL	IB Flammable	Horizontal Tanks
7	Cyclohexane	1850	30 KL	IB Flammable	Horizontal Tanks
8	Methanol	49800	100 & 30 KL	IB Flammable	Horizontal Tanks
9.	MDC	18520	30 KL	Toxic	Horizontal Tanks
10.	Toluene	20800	2 x 30 KL	IB Flammable	Horizontal Tanks
11.	Dimethylamine(40%)	366	20KL	--	Horizontal Tanks

FUEL					
12.	Diesel	60KL	2 x30 KL	II Combustable	Vertical tanks
ACIDS					
13.	Sulfuric acid	1823	12 KL	Toxic	Vertical tanks
14.	Hydrochloric Acid (35%)	2305.5	12 KL	Corrosive	Vertical tanks

Total No. of Tanks: 21 Tanks with 2 nos. of 30 KL Standby tanks
Total Quantity in Tanks: 469 KL Solvents, 60 KL diesel & 24 KL acids

Sl. No.	Name of the Material	Consumption (Kg/day)	Maximum Storage Capacity	Max. Capacity of Cylinder	Nos.	Nature of the Material	Type of storage
CYLINDERS							
1.	Hydrogen	112.3	350 Cumec	50	7	Flammable gas	Cylinder
2.	Chlorine	900 x 3	2700 Kg	900 Kg	3	Toxic	Cylinder / Tonnel
3.	Ammonia	15	500 Kg	50 kg	10	Toxic	Cylinder
4.	Ethylene Oxide	3.8	70 Kg	35	2	Flammable gas	Cylinder

7.1.4 Potential Hazards

Hazard is an event/incident that can lead to damage of equipment or injury to personnel. The following are the potential areas in existing / proposed project that can lead to major accidents.

- Solvents/ hazardous chemicals in tank form area.
- Solvent / Hazard chemical Storage (drums) in ware houses.
- Different Hazard cylinders at dedicated sites.
- Hazard handling and process area
- Coal storage and handling
- Electrical Hazards

There can be three kinds of major hazards:

- Leakage of Solvents tanks leading to pool Fire – Explosion and Fire hazard
- Toxic gas release Leak/ Rupture
- Spontaneous ignition of coal – Explosion and Fire hazard
- Electrical Hazards like flashover and short circuits

7.2 Hazard Analysis

Identification of hazards is an important step in Risk Assessment as it leads to the generation of accidental scenarios. Hazard identification involves the identification of

hazard prone chemicals in each process / operations unit as well as the location of the processes / operations in the plant and its storage. Once a hazard is identified, it is necessary to evaluate it in terms of the risk it presents to the employees and the neighbouring community. In principle, both probability and consequences will be considered.

Nature of the hazard most likely to accompany the hazardous material is its spill or release airborne toxic vapours / mists and fire/ explosion due to large storage or processes in its handling. On release, the hazardous substance can cause damage on a large scale. The extent of the damage is dependent upon the nature of the release, the physical state of the material and the micro-meteorological condition prevailing at the time of accident. As part of Risk Analysis, the damage distances are computed based on probable meteorological conditions.

List of hazardous chemicals along with maximum storage facility, per day consumption Flash Ignition Point (FIP), Boiling Point (BP) along with IDLH, TLV, UEL and LEL values is presented in **Table 7.3**. Further material analysis are made as per National Fire Protection Agency (NFPA) rating along with material factor is presented in **Table 7.4.** Classification of Flammable / Combustible liquids and description of NFPA classification are presented in **Tables 7.5 and 7.6** respectively. Storage of hazard chemicals mainly solvents in respective tanks capacity of each 30 KL in tank form area, where as solvent methanol is storing in 30KL as well as in 100 KL underground horizontal tank. Apart from tank form area the hazard chemicals are stored in specified drums mostly in ware houses of I & II and gas cylinders at dedicated areas, details of storage of chemicals are depicted in plant layout **Fig.7.1**.

Table 7.3 : Hazardous materials properties, rating and TLV value - solvent storage yard

Sl. No.	Raw Material	Physical Status of Chemical	Rating	Melting Point (^oC)	Boiling Point (^oC)	Flash Point (^oC)	IDLH (ppm)	TLV Value (ppm)	LEL (%)	UEL (%)
1.	1,4-Dioxane	Liquid	2	11.8	101.1	18.3		20	2	22
2.	Acetic Acid	Liquid	3	17 ^oC	118.1 ^oC	39	50	10	4	19.9
3.	Acetone	Liquid	1	-95.35	56.5	-20	2500	1000	2.15	13
4.	Acetonitrile	Liquid	2	-46	81-82	2	500	20	4.4	16
5.	Acrylonitrile	Liquid	4	-84	77	-1.1	85	2	3	17
6.	Ammonia gas	Gas	3	-77.73	-33.34	Flammable gas		35	15	28
7.	Benzyl Chloride	Liquid	3	-43	179	67.2	10	1.1	14	1
8.	Bromine	Liquid	3	-22	106	N/A	3	0.05	N/A	N/A
9.	Chlorine Gas	Gas	3	-101	-34	N/A	10	0.5	N/A	N/A
10.	Chloroform	Liquid	2	-63.5	61.15	Non-Flammable	500	10	N/A	N/A

Sl. No.	Raw Material	Physical Status of Chemical	Rating	Melting Point (^oC)	Boiling Point (^oC)	Flash Point (^oC)	IDLH (ppm)	TLV Value (ppm)	LEL (%)	UEL (%)
11.	Cyclo-Hexane	Liquid	3	7.0	81	-18	1000	300	1.3	8.0
12.	Dimethyl sulfoxide	Liquid	-	18.5	189	flammable	-	-	2.6	42
13.	Ethanol	Liquid	2	-114	78.37	9	3300	1000	3.3	19
14.	Ethyl acetate	Liquid	2	-73	78.37	9	2000	400	2.0	11.5
15.	Hexane	Liquid	3	6.47	69	-23	1100	500	1.2	7.7
16.	Hydrogen	Gas	0	-259.2	-423	N/A	-	--	4	74
17.	Isopropyl Alcohol	Liquid	1	-89	82.5	11.7	2000	400	2	12.7
18.	Methanol	Liquid	1	-97	65	12	6000	200	6	36
19.	Methyl isobutyl ketone	Liquid	2	-84.7	117	14	300	50	1.2	8
20.	Methylene dichloride	Liquid	2	-96.7	39.6	14	2300	50	12	19
21.	n-Butanol	Liquid	1	-89.8	117.7	35	1400	20	1.45	11.25
22.	Sulfuric acid	Liquid	3	-35	270	N/A	14mg/m3	1 mg/m^3	N/A	N/A
23.	Thionyl Chloride	Liquid	3	-104.5	76	N/A	200	1	N/A	N/ A
24.	Toluene	Liquid	2	-95	110.6	4.4	500	25	1.1	7.1
25.	Triethylamine	Liquid	3	-115	89.7	-8.3	200	25	1.2	8
26.	Diesel	Liquid	-	-	171/ 371	38	-	-	0.6	7.5

Note: Chemical Listing and Documentation of Revised IDLH Values (as of 3/1/95)

Table 7.4 : Hazard Maximum Storage and NFPA Rating – Open storages

S. No.	Description	Physical Status of Chemical	Maximum storage (KL)	NFPA Rating			
				Nh-health	Nf-Fire	Nr-Reaction	Material Factor (MF)
1	Acetic Acid	Liquid	30	3	2	1	14
2	Acetone	Liquid	19	1	3	0	16
3	Acetonitrile	Liquid	160 kg x35	3	3	0	16
4	Acrylo nitrile	Liquid	160 L x 43	4	3	2	24
5	Ammonia	Gas	50 kg x 10	3	1	0	4
6	Benzyl Chloride	Liquid	220kgX23	2	2	1	14
7	Bromine	Liquid	18 kgx 84	3	0	0	1
8	Chlorine	Gas	900 kg x 3	4	0	0	1
9	Chloroform	Liquid	30	2	0	0	1
10	Diesel	Liquid	2 x 30	0	2	0	10
11	Dimethyl sulfoxide	Liquid	230 kgx 25	1	2	1	14
12	1,4 Dioxane	Liquid	210 L x 15	2	3	1	16
13	Ethyl Acetate	Liquid	30 & 20	4	3	0	16
14	Ethyl alcohol	liquid	250L x 24	0	3	0	16
15	Hexane	Liquid	10	2	3	0	10
16	Cyclo - Hexane	Liquid	30	1	3	0	16
17	Hydrogen	Gas	7 m^3 x 50	0	4	0	21
18	Isopropyl Alcohol	Liquid	30 + 20	1	3	0	16
19	Methanol	Liquid	100 + 30	1	3	0	16
20	Methylene chloride	Liquid	30	3	1	1	4
21	MIBK	Liquid	165 kg x 2	2	3	1	16
22	n- Butanol	Liquid	200kg x 21	1	3	0	16
23	Sulfuric acid	Liquid	12	3	0	1	24
24	Toluene	Liquid	2 x 30	2	3	0	16
25	Tri ethyl amine	Liquid	145kgx7	3	3	0	16
26	Thionyl chloride	Liquid	300kgx30	4	0	2	24

Table 7.5: Classification of Flammable/Combustible Liquids

Class IA flammable liquid	Flash Point below 22.78°C and Boiling Point below 37.78°C.
Class IB flammable liquid	Flash Point below 22.78°C and Boiling Point at or above 37.78°C.
Class IC flammable liquid	Flash Point at or above 22.78°C and below 37.78°C.
Class II combustible liquid	Flash Point at or above 37.78°C and below 60°C.
Class IIIA combustible liquid	Flash Point at or above 60°C and below 93.33°C.
Class IIIB combustible liquid	Flash Point at or above 93.33°C.

Table 7.6: Description of National Fire Protection Agency (NFPA) Classification

Rating Nh	Type of possible injury	Rating Nf	Susceptibility of material to burning	Rating Nr	Susceptibility to release of energy
4	Materials which on very short exposure could cause death or major residual injury even though prompt medical treatment is given	4	Materials which will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature or which are readily dispersed in air and which will burn readily	4	Materials which in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressure
3	Material which on short exposure could cause serious temporary or residual injury even though prompt medical treatment is given	3	Liquids and solids that can be ignited under almost all ambient temperature conditions	3	Materials which in themselves are capable of detonation of explosive reaction; but require a strong initiating source or which must be heated under confinement before explosively with water
2	Materials which on intense or continued exposure could cause temporary, incapacity or possible residual injury unless prompt medical treatment is given	2	Materials that must be moderately heated or exposed to relatively high ambient temperature before ignition can occur	2	Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Also materials which may react violently with water to form explosive mixture
1	Materials which on exposure would cause irritation but only minor residual injury even if no treatment is given	1	Materials that must be preheated before ignition can occur	1	Materials which in themselves are normally stable, but which can become unstable at elevated temperatures and pressure or which may react with water
0	Materials which on exposure under fire conditions would offer no hazard beyond 0 that of ordinary combustible material	0	Materials that will not burn	0	Materials which in themselves are normally stable, even under fire exposure conditions and which are not reactive with water

Nh- Health, Nf- Fire, Nr-Reaction

Fig. 7.1: Plant layout

7.2.1 Fire and Explosion Index

The Fire and Explosion Index (FEI) is useful in identification of areas in which the potential risk reaches a certain level. It estimates the global risk associated with a process unit and classifies the units according to their general level of risk. FEI cover aspects related to the intrinsic hazard of materials, the quantities handled and operating conditions. This factor gives index value for the area which could be affected by an accident, the damage to property within the area and working days lost due to accidents. The method for evaluation of FEI involves the determination of Unit Hazard Factor and the determination of Material Factor (MF). Fire and explosion index is then calculated as the product of Material Factor (MF) and Unit Hazard Factor.

The Unit Hazard Factor is obtained by multiplication of General Process Hazard (GPH) factor and Special Process Hazard (SPH) factor. The GPH factor is computed according to presence of exothermic reactions and loading & unloading operations. The penalties due to each of these reactions / operations are summed up to compute GPH factor. Similarly, SPH factor can be evaluated for the operations close to flammable range or pressures different from atmospheric pressures. Penalties of these operations for both factors can be obtained from Dow's FEI index form.

Material Factor for a given chemical is evaluated from NFPA indices of danger, health, flammability and reactivity data. It can be directly obtained from Dow's Fire and Explosion Index Hazard classification Guide of American Institute of Chemical Engineers, New York. The Material Factor for a given substance in the process unit gives intrinsic potential to release energy in case of fire or an explosion.

FEI Range	Degree of Hazard
0 – 60	Light
61 – 96	Moderate
97 – 127	Intermediate
128 – 158	Heavy
159 and Above	Severe

7.3 MCA Analysis

As part of Environmental Impact Assessment / Environmental Management Plan (EIA/EMP), the risk due to the Maximum Credible Accident (MCA) scenario has been quantitatively assessed. MCA stands for an accident with maximum damage distance, which is believed to be probable. In practice the selection of accident scenarios for MCA analysis is carried out on the basis of engineering judgement and expertise in the field of risk analysis especially in accident analysis.

The MCA analysis involves ordering and ranking of various sections in terms of potential vulnerability. The data requirements for MCA analysis are:

- Operating manual
- Flow diagram and P&I diagrams
- Detailed design parameters
- Physical and chemical properties of all the chemicals
- Detailed plant layout area

MCA analysis encompasses defined techniques to identify the hazards and compute the consequent effects in terms of damage distances due to heat radiation, toxic releases, vapour cloud explosion etc. A list of probable or potential accidents of the major units in the arising due to use, storage and handling of the hazardous materials are examined to establish their credibility. Depending upon the effective hazardous attributes and their impact on the event, the maximum effect on the surrounding environment and the respective damage caused can be assessed.

7.3.1 Event Tree Analysis

The accident scenarios of hazard chemicals can be divided into the following categories.

- Flammable gases
- Liquefied gas or boiling liquid release under pressure
- Non boiling liquid release
- Toxic gas release

Different consequences of accidental release of hazard due to undesirable conditions of failure are possible depending on type of event such as continuous or instantaneous releases in gas/ vapour / liquid. Event Tree Analysis for rupture and leak scenarios for continuous/ instantaneous release of gas/liquid and for delayed or immediate ignition or toxic cloud. Typical flow chart of accidental release of hazardous chemicals is presented in **Fig. 7.2**.

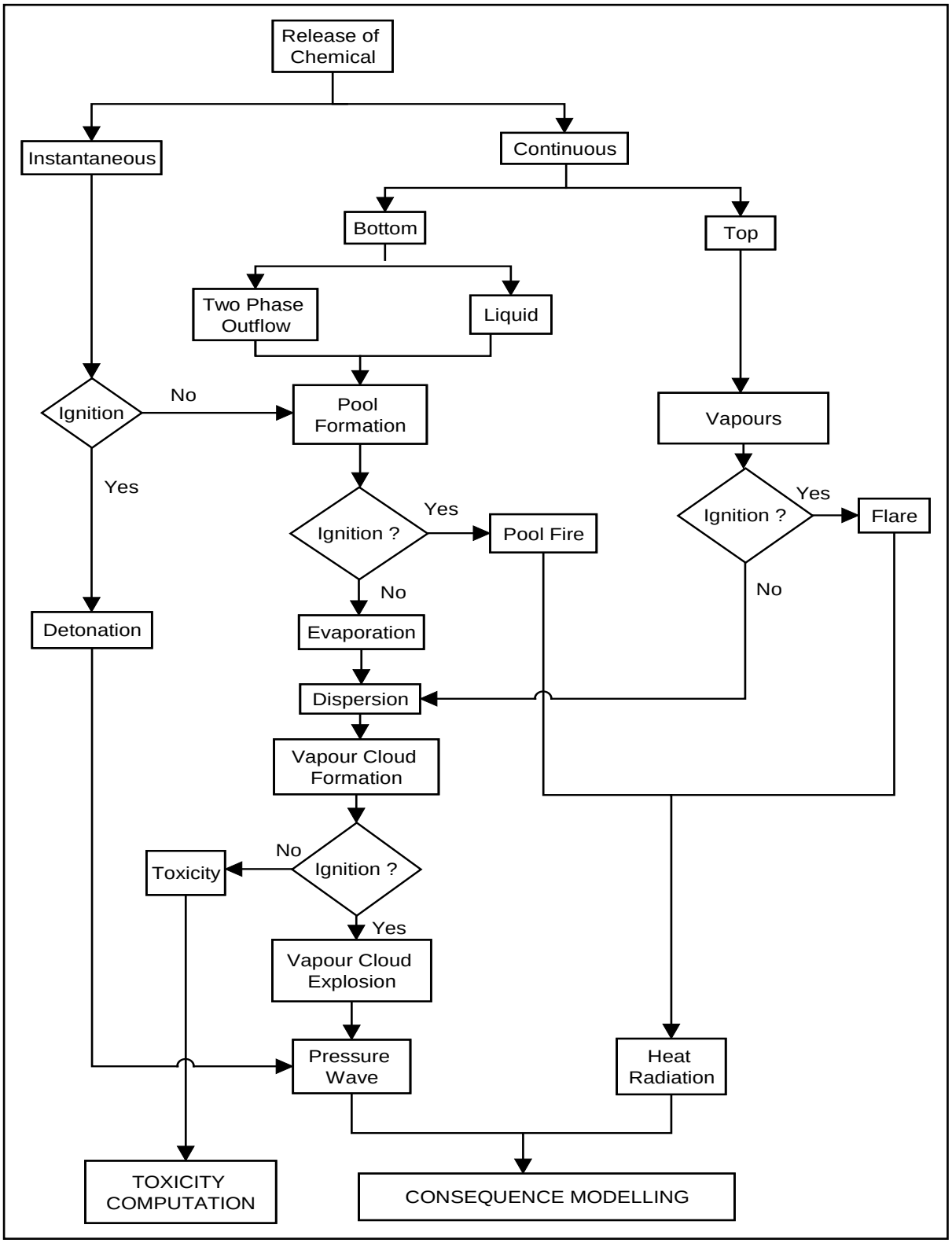


Fig. 7.2: Typical Flow Chart of Accidental Release of Hazardous Chemicals

7.3.2 Methodology of modeling exercise

Source Model: Source models represent the material release process. They provide useful information for determining the consequences of an accident including the rate of material release, the total quantity released and the physical state of the material. The source models that are used repeatedly are:

- Flow of liquid through a hole in a tank/ pipe
- Flow of vapour through holes in a tank/pipe
- Flow of vapour through pipes
- Flowing liquids
- Liquid pool evaporation or boiling

The purpose of source model is to determine:

- The form of material released is solid/ liquid/ vapour
- The total quantity of material released
- The rate at which it is released

Dispersion Model

Dispersion model describes the transportation of air borne toxic material away from the accident site and in to the surrounding areas. After the release, the airborne toxic substances are carried away by the wind in a characteristic plume or a puff. The maximum concentration of toxic material occurs at the point of release. The concentration at downwind is less due to turbulent mixing and dispersion of toxic substances with air. A number of parameters that affect the atmospheric dispersion of toxic material are Wind speed, atmospheric stability, general conditions such as buildings, water bodies and trees, height of release and initial movement of the material released.

Fire and Explosion Scenarios

Flammable substances on release may cause Jet fire and less likely unconfined vapour cloud explosion causing possible damage to the surrounding area. The extent of damage depends upon the nature of the release. The release of flammable materials and subsequent ignition result in heat radiation wave or vapour cloud depending upon the flammability and its physical state. Damage distances due to release of hazardous materials depend on atmospheric stability and wind speed. It is important to visualize the consequence of the release of such substances and the damage caused to the surrounding areas.

- First, before the ignition, a cloud of sufficient size must have been formed. Normally ignition delays of few minutes are considered the most probable for generating the vapour cloud explosions
- Second a sufficient amount of the cloud must be within the flammable range of the material to cause extensive overpressure.
- Third, the flame speed determines the blast effects of the vapour cloud explosions, which can vary greatly.

Combustible materials within their flammable limits of (UEL and LEL) may ignite and burn if exposed to an ignition source of sufficient energy. On process plants, this normally occurs as a result of a leakage or spillage depending on the physical properties of the material and the operating parameters. The event Classification of fire and explosion scenarios is described in **Table 7.7**.

Table 7.7: Event Classification

Type of Event	Explanation
BLEVE	Boiling Liquid Evaporating Vapor Explosion; may happen due to catastrophic failure of refrigerated or pressurized gases or liquids stored above their boiling points, followed by early ignition of the same, typically leading to a fire ball
Explosion	A release of large amount of energy that form a blast wave
Fireball	The burning of a flammable gas cloud on being immediately ignited at the edge before forming a flammable/explosive mixture.
Flash Fire	A flammable gas release gets ignited at the farthest edge resulting in flash-back fire
Jet Fire	A jet fire occurs when flammable gas releases from the pipeline (or hole) and the released gas ignites immediately. Damage distance depends on the operating pressure and the diameter of the hole or opening flow rate.
Pool Fire	Pool fire is a turbulent diffusion fire burning above a horizontal pool of vaporizing hydrocarbon fuel where the fuel has zero or low initial momentum
Vapor Cloud Explosion	Explosion resulting from vapor clouds formed from flashing liquids or non-flashing liquids and gases

Models for the Calculation of Heat load and Shock Waves

If a flammable gas or liquid is released, damage resulting from heat radiation or explosion may occur on ignition. Models used in this study for the effects in the event of

immediate ignition (torch and pool fire) and the ignition of a gas cloud. These models calculate the heat radiation or peak overpressure as a function of the distance from the torch, the ignited pool or gas cloud. The physical significance of the various heat loads is presented in **Table 7.8**.

Table 7.8: Various Physical Effects Due to Heat Radiation

Flux / Intensity (KW / m²)	Thermal Effects
49	3rd degree burns Severe burns due to fire ball zone
37.5	100% lethality Severe burns, 80% or more leading to 100% fatality
25	50% lethality Severe burns due to explosion of gas, within lower and upper limit leading to 50% fatality
12.5	1% lethality Burns and injuries due to exposure to thermal radiation
4.5	First degree burns Blistering and first degree burns due to exposure to thermal radiation
1.6	No perceptible discomfort

Boiling Liquid Expanding Vapour Explosion (**BLEVE)**: If the liquid is stored under pressure at a temperature above its boiling point, the initial physical explosion that breaks the receptacle produces a sudden decompression giving rise to a massive evaporation of the saturated liquid. This is known as BLEVE. These explosions are of great destructive power due to the high increase in pressure caused by the sudden incorporation of liquid into the gas phase. The ignition of BLEVE produces a mass of gases at high temperature known as 'fireball' with significant thermal effects. Historically, BLEVEs have been produced with some frequency and have almost caused human casualties.

Model for Pressure Wave

A pressure wave can be caused by gas cloud explosion. The following damage criteria are assumed as a result of the peak overpressure of a pressure wave: 0.03 bar over pressure wave is taken as the limit for the occurrence of wounds as a result of flying fragments of glass. Physical significance of various pressure waves is depicted in **Table 7.9.** Methodology (Yellow book) and Software applied for the study TNO and also EPA based one).

Table 7.9: Over Pressure Effect of Explosion

Sl. No.	Press (psig)	Damage
1	0.03	Occasional breaking of large glass windows already under strain
2	0.1	Breakage of small windows under strain
3	0.3	" Safe distance " (probability 0.95 no serious damage beyond this value); projectile limit; some damage to house ceiling; 10% window glass broken
4	1.0	Partial demolition of houses, made uninhabitable
5	1-2	Corrugated asbestos shattered; corrugated steel and aluminum panels, fastenings fail followed by buckling wood panels (standard housing) fastening fail, panels blown in
6	1.3	Steel frame of clad building slightly distorted
7	3.0	Heavy machines (3000lb) in industrial building suffered little damage; steel frame building distorted and pulled away from foundations
8	5.0	Wooden utility pollen
9	7.0	Loaded train vapour over turned
10	10.0	Probable

7.4 Consequence of MCA Analysis

Based on the hazard identification and nature of hazard occurrence, MCA scenario is short listed below.

- Pool fire due to rupture / leakage and accumulation
- Fire/ explosion of flammable gas / vapour
- Dispersion of Toxic gas

Pool Fire/ Vapour cloud explosion

This scenario was visualized by considering leak and catastrophic rupture of combustible liquids of horizontal tanks such as acetic acid and diesel. For flammable liquid storage tanks (methanol and toluene etc.), various heat radiation levels are analyzed for neutral stability class and selected wind velocity. The damage distances due to leak and catastrophic rupture of storage tank for heat radiation of 37.5, 12.5 and 4.5 KW/m² are presented in **Table 7.10**. Pressure wave's values are also calculated for vapour cloud

explosion and reported for damage distance due to over pressure 0.3, 0.1 and 0.03 bar in **Table 7.10**.

Table.10: Consequences of MCA Analysis – Storages

***(Catastrophic Damage distances in meters)* (Pool Fire/ Fir Ball/ VCE)**

Hazard Material	Pool Fire/ Fir Ball/ VCE	Heat Radiation (KW/m^2)- Meters			Over Pressure (bar) - Meters		
		37.5	**12.5**	**4.5**	**0.3**	**0.1**	**0.03**
Cyclo Hexane 30 Kl	Pool Fire	3.2	5.7	11.2	-	-	-
	VCE / BLEVE	17	29	44	18	22	7.3
Acetic Acid 30 Kl	Pool Fire	-	-	<10	-	-	-
	VCE / BLEVE	-	-	<10	-	10	25
Ethyl Acetate 30 Kl	Pool Fire 5.0 Meter Dia	2.5	3.4	7.7	-	-	-
	VCE / BLEVE	-	201	345	396	444	665
Diesel 2x30 Kl	Pool Fire	-	-	<10	-	-	-
Hexane 10 Kl	Pool Fire 192 Kg/min	-	14	25	-	-	-
	F.B Dia 156 m.	-	334	557	551	611	900
Acetone 19 Kl	Pool Fire 6.2 m Dia	-	<10	17	-	-	-
	Tank (Leak)	<10	17	32	<10	11	25
	VCE / BLEVE	-	-	-	434	486	743
Iso Propyl Alcohol 30 Kl (Tank)	Pool Fire 6.2 m dia	-	<10	15	-	-	-
	VCE/ BLEVE (Tank)	120	268	453	529	557	829
Methanol 100 Kl (underground)							
	VCE / Radiation Leak of Tank	-	<10	15	-	28	46
Methanol 30 Kl Tank	Pool fire 6.2 m dia	-	<10	15	-	-	-
	VCE/ BLEVE	91	212	367	Within LOC	309	395
Toluene 2x30 Kl	Pool Fire 6.2 m Dia	3.4	5.3	10.1	-	-	-
	Leak of Tank (VCE)	17	27	44	13	55	93
	BLEVE	130	315	526	621	633	983
1, 4 Dioxane 210 L. x15 WH-I	VCE / BLEVE	27	54	92	39	50	111

Hazard Material	Pool Fire/ Fir Ball/ VCE	Heat Radiation (KW/m^2)- Meters			Over Pressure (bar) - Meters		
		37.5	12.5	4.5	0.3	0.1	0.03
Acrylo nitrile MS Drums-WH-I 43X160 Kg	VCE / BLEVE	-	55	92	51	61	103
Ethanol 250 L x 24 (HDPE Drums) WH-I	VCE / BLEVE	-	20	33	-	11	23
MIBK 165 kg x 2	VCE / VLEVE	31	58	97	63	77	116
Dimethyl Sulfoxide 230 Kg x 25 HDPE Drums (WH-I)	VCE / BLEVE	40	51	87	30	43	97
Hydrogen 50 Kg Cylinder	VCE / BLEVE	12	20	33	13	28	77
n-Butanol 200 Kg x 21 MS Drums WH-I	Usually within Flammable Limit	30	57	95	68	79	125

Most of the flammable liquids such as Acetone, Hexane, Cyclo hexane, IPA, Methanol, Toluene and Ethyl Acetate including combustible material acetic acid and diesel are storing in tank form area. Apart from these other Toxic chemicals Methylene chloride and Chloroform also are storing in tank form area in horizontal tanks, whereas Sulfuric acid tank capacity of 12 KL is located near to the ware house-IV. Other hazard chemicals are storing in specified MS, GI and HDPE drums of different capacity varying from 50 to 200 liters in Ware houses I and II. The materials storing are flammable, combustible, toxic and corrosive in nature, whereas toxic Bromine (l) of 2.5 lit bottles in crates is storing in Ware house-I. The drum capacity is considered as source strength to estimate for effect of heat radiation and over pressure. In this plant three types of gas cylinders are using, where in two are toxic in nature and one is flammable, which are stored at dedicated areas such as ammonia, Chlorine and Hydrogen. For identified most hazard flammable liquids/ gases distance of radiation and pressure wave effects are reported in **Table 7.10** including combustible liquids Acetic acid and Diesel and Flammable gas Hydrogen.

Flammable liquids: Analysis indicate that Confined pool fire of IB flammable liquids Acetone, Hexane, Cyclo hexane, Methanol, IPA, Ethyl acetate and Toluene heat radiation effect covers 7.7 to 25 m from center of pool, where in pool radius is 2.5 to 3.1 m and in all the cases heat radiation effect of 37.5 KW/m^2 within the pool only. In the case of

catastrophic rupture of storage tank with ignition radiation effect is 4.5 KW/m^2 up to maximum distance vary from 300 to 500 m and overpressure effect of 0.03 bar crosses plant boundary and it varies 395 to 980 m.

In the case of flammable liquids, which are stored in ware house - I mainly Dioxane, n-Butanol, Ethanol, Acetonitrile and MIBK due to leak/ rupture of drums with ignition radiation effect 4.5 KW/m2 covers a distance from 30 to 95 m, whereas damage distance of pressure wave VCE from 23 to 125 m. MCA analysis indicate that all the predicted values of damage distances are within in the plant mainly on-site area including lower and upper explosive limits. It is also indicated that effect of heat radiation is mainly at the site of incident, which is due to instantaneous release of material spread over unconfined area and by spark/ ignition thermal radiation and vapour cloud explosion occurs and causes effect on-site area.

Over pressure in ‘ psi ’ against damage distance and effect of heat radiation due to BLEVE for Methanol, n-Hexane and n-Butanol is shown in **Annexure XLII, XLIII and XLIV** along with respective heat radiation and pressure wave isopleths. It occurs only due to ignition/spark/ detonation of vapour cloud. However, it is observed that average concentration of exposure limit is less than LEL, hence vapour cloud explosion is unlikely occurs.

Flammable gas: Hydrogen is considered as **Class 2** flammable gas, respective cylinders are stored at dedicated area of capacity 7m3 each. Analysis indicate that heat radiation effect 4.5 KW/m2 covers a distance of 33 m and over pressure effect 0.03 bar up to 77 m in case of vapor cloud explosion.

Combustible liquids: Acetic acid & Diesel are combustible material, explosive limit values of diesel are low when compared with acetic acid and both are in tank form area. In case of instantaneous release of acetic acid explosive limits will be within plant boundary. In both the cases pool fire covers radiation effect of 4.5 KW/m2 less than 10 m from centre of pool as reported in **Table 7.10.**

For identified major Flammable liquids methanol and Toluene, tank leak for duration of 15 minutes also assessed for vapor cloud explosion and reported in **Table 7.10**. It indicates that radiation effect 4.5 KW/m2 is 44 m for toluene and 15 m for methanol and corresponding over pressure effect 96 m and 46 m respectively.

Toxic Release: The toxic hazard chemicals are using and also going to be used by proponent in their expansion programme are mainly Ammonia, Bromine, Chlorine, Thionyl chloride, Benzyl chloride, Methylene dichloride, Triethylamine and chloroform including sulfuric acid, which are selected on basis of IDLH and TLV value for the study. Some of the chemicals are flammable as well as toxic i.e. Acetonitrile, Acrylo nitrile, Dioxane and MIBK

are selected for toxic dispersion. Except Ammonia and Chlorine all are in liquid form and stored in Tank /Drums, whereas Ammonia and Chlorine gas cylinders are stored in specified areas. For the purpose of risk assessment study, consequences due to release of these toxic elements are analyzed for estimation of damage distances due to toxic releases. Consequences analyses for toxic release scenario are reported in **Table 7.11.**

Table.7.11: Consequence Analysis for Toxic Release Scenario

Scenario Considered	IDLH (ppm)	TLV (ppm)	Leak Size (mm)	Source Strength (kg/sec)	Weather	IDLH Distance (m)	TLV (m)
Ammonia Gas 50 Kg (Cylinder) 10 Nos.	300	50	Leak Leak 15 min	0.0124 0.056	2D 2D	45 97	110 251
			Instantaneous	0.833	2D	391	807
Bromine 2.5 l(18X84) WH-IV Crate. 18Kg	3	0.1	Leak	0.0007	2D	34	202
			Instantaneous	0.0417	2D	290	1200
Chlorine 900 Kg x 3 (Cylindrical)	10	3	Leak	0.25	2D	600	2500
			Instantaneous	15	2D	2600	6600
Chloroform 30 Kl Tank	500	10	Confined Pool	0.1407	2D	-	300
			Instantaneous	123	2D	175	3450
Methylene Chloride 30 Kl (Tank)	2300	50	Confined Pool	0.45	2D	-	200
			-	-	-	-	-
Sulphuric Acid 12 Kl (Tank)	15 mg/m^3	1 mg/m^3	Confined Pool	0.0502	2D	335	1810
Acetonitrile 160 Kg x 35 MS Drums (WH-II)	500	40	Leak	0.06	2D	42	157
			Instantaneous	3.60	2D	253	978
1,4 Dioxane 210 Lit x 15 MS Drums	500	100	Leak	0.06	2D	39	101
			Instantaneous	3.60	2D	281	602
MIBK 165 Kg x 2 MS Drums	300	20	Leak	0.046	2D	36	144
			Instantaneous	2.75	2D	298	918
Tri-ethyl Amine 145 kg x 7 MS Drums	200	25	Leak	0.040	2D	52	176
			Instantaneous	2.417	2D	348	906
Benzyl Chloride 220 Kg x 23 MS Drums	10	4	Leak	0.061	2D	213	773
			Instantaneous	3.667	2D	1200	2900
Acrylonitrile 160 Kg x 35 MS Drums	85	4.6	Leak (15 min)	0.044	2D	92	441
			Instantaneous	2.67	2D	661	1500
Thionyl Chloride 300 Kg x 30 (WH-IV)	14	1.0	Leak	0.083	2D	218	965
			Instantaneous	5.0	2D	1200	3300

A scenario was visualized by considering leak and release of chlorine from 900 kg cylinder. Due to instantaneous release of material spread over unconfined area causes, gas/ vapour travels towards wind ward direction. Consequence analysis indicate that IDLH concentration of chlorine gas 10 ppm covers a distances up to 2.6 km at wind ward side of plant for stability classes 2D conditions. The damage contour for chlorine is shown in **Annexure XLV.**

Apart from Chlorine, Thionyl chloride, Benzyl chloride, Triethyl amine, MIBK and Dioxane are also considered as toxic and heavy gas. In all these cases damage distances vary from 300m to 1200m, as individual storage capacity of chemical vary from 150 to 300 kg. In the case of ammonia 50 kg (g) cylinders are using in the plant, considering 50 kg ammonia gas as source strength for instantaneous release, effected distance of IDLH covers upto 391 m at down wind direction for short duration of exposure, whereas Bromine covers a distance of **290 m**, capacity of each bromine bottle is 2.5 kg, though it is highly toxic. The damage contour of Benzyl chloride and Ammonia are shown **in Annexure XLVI and XLVII respectively**. Other hazard chemicals (Chloroform and Methylene dichloride) are in tank form area and supposed to be toxic, and also predicted. The distance of exposure of IDLH level is reported in **Table 7.11**.

Sulphuric acid: There is a 12T capacity of storage tank within the plant premises at atmospheric condition. Under rupture of storage tank, it is in confined to respective pool and effect within the plant premises, Sulphuric acid fumes IDLH value (15mg/m^3) effect towards windward side and covers a distance of 335 m. Its consequences are on-site only even If any small/ large spill occurs. For the same specific precautionary measures are to be followed as per MSDS guidelines and the same are addressed in next section.

Handling of Hazardous Materials

- **Material hazards:** Coal is the major fuel for Boilers and High Speed Diesel (HSD) Oil for DG sets.
- **Process hazards** due to loss of containment during handling of hazardous materials or processes resulting in fire, explosion, etc.
- **Mechanical hazards** due to "mechanical" operations such as welding, maintenance, falling objects etc. - basically those NOT connected to hazardous materials.
- **Electrical hazards:** electrocution, high voltage levels, short circuiting, etc.

Out of these, the material and process hazards are the one with a much wider damage potential as compared to the mechanical and electrical hazards.

7.5 Risk mitigation measures

Consequence analysis indicate that the damage distances for fire and explosion situations and IDLH distances due to toxic release of hazardous chemicals fall well within the plant site as well as outside the boundary specially in the case of instantaneous release of Chlorine , Thionyl - chloride and Benzyl chloride storage only. Apart from these, other toxic chemicals are Ammonia, Bromine, Tri Ethyl Amine, Acrylonitrile, Acetonitrile, Methylene chloride, MIBK and Chloroform and for the same distance of effect are reported.

In the case of combustible and flammable liquid, effect of pool fire distance is on-site and its affected area up to maximum of 20 m from confined pool edge. Delayed ignition / spark of vapour cloud of the methanol, IPA, hexane, Cyclo-hexane and toluene solvent tanks over pressure effect crosses plant boundary including effect of radiation.

For the above by incorporating certain mitigation measures at source of release, the consequences to the members of public in and outside the plant can be further reduced.

The scope of the risk assessment studies covers the risk mitigation measures based on Maximum Credible Accident (MCA) Analysis, based on certain general and specific recommendations are suggested and listed in this chapter. In this regard, the recommended mitigation measures for natural disasters are also included.

7.5.1 General Risk Mitigation Measures

The industry has appropriate independent fire combat facility and personal protection system and also had a mutual aid with industries located in IDA, Kothur. On-site/ Off-site emergency plan with effective fire combat facility has been established. However further suitable mitigation measures with fire protective equipment is to be upgraded.

- Surrounding population needs to be aware of the safety precautions to be followed in case of any toxic release from proposed plant.
- Proposed buildings possibly made to withstand external blast waves and windows will be made of blast resistant glass with strong frame.
- Fire protection system will be in place in accordance with the requirements of NFPA standards. Design requirements and Safe Engineering practices will have full capability for early detection and suppression of fire
- Fire prevention and code enforcement is one of the major areas of responsibility for the fire service. The details of the fire-fighting systems and capabilities may be worked out with fire & safety personnel.

7.5.1.1 Fire Prevention and Protective Equipment

The present fire hydrant and emergency equipment's available at the industry is presented in **Table 7.12**. However, existing fire-fighting facility equipment will be upgraded as and when required. The following fire-fighting facility is to be checked, if not procured and maintain the same as in case of basic fire preventive measures.

Table 12 : Existing firefighting facility & protection equipment

S.no	Equipment	
1.	Water tank capacity	700 Lit
2.	Jockey Pump	10m3/hr
3.	Sub Mersible pump	40 m3/hr
4.	Power Driven Pump (Main)	273 m3/hr
5.	Diesel Generator pump	284m3/hr
6.	Single Hydrant	57 Nos
7.	Double Hydrant	5 Nos
8.	Water Monitor	5 Nos
9.	Fire Escape Hydrant	7 Nos
10.	Hose reel	37 Nos
11.	Fire extinguisher	412 Nos
12.	Fire extinguisher (spare)	20 Nos
13.	Deluge Valve with water sprinkler	11 nos for 57 tanks
14.	CI alarm valve with water sprinkler	3 Nos
15.	Foam monitor	5 Nos
16.	Water monitor	5 Nos
17.	Foam stock	4200 lts
18.	Fire Suit	4 Nos
19.	SCBA sets	7 Nos
20.	5x Foam gun	20 Nos
21.	Jet nozzles	57 Nos
22.	Revolving nozzles	1 Nos
23.	Water curtain nozzle	2 Nos
24.	Jet and spray nozzle	10 Nos
25.	Foam making nozzle	20 Nos
26.	Foam solution	4300 lit
27.	DCP Powder	600 kg
28.	SCBA sets	6 Nos
29.	Chemical Cartridge masks	66 No
30.	Normal fighting suits	6 No
31.	Life jackets	4 no
32.	Fall arrestor	10 n0
33.	Safety Net	12 no
34.	Grip Ladder	6 no
35.	PVC aprons	15 no
36.	No max fire suit	3 no
37.	Aluminized fire suit	01 no

- Water
- Water Tenders
- Foam Tenders
- Fire hydrant and monitor nozzle installation
- Dry powder extinguisher
- Water fog and sprinkler system
- Mobile Fire-fighting equipment
- DCP fire extinguishers
- CO_2 Fire extinguishers
- High expansion foam generator
- For large fire Dry chemical, CO_2 and alcohol resistant foam
- First aid appliances
- Fire extinguishers will be tested periodically and will be kept in operational mode
- Critical switches and alarm will be kept in-line
- Shut off / valves isolation will be easily approachable in emergencies
- Signboard for toxic or flammable hazard and no smoking signs and type of risk will be provided at various locations
- A wind direction pointer will also be provided at storage site, tanks and location of drums storage. So that in emergency the wind direction can be directly seen and downwind population cautioned accordingly specially when toxic gas release.
- The sufficient/adequate space in the storage areas such that to escape from fire and at the same time it will allow emergency procedures to be mobilized.
- Dykes are provided for most of the solvent storage tanks including Diesel tanks and same will be provided for proposed storage tanks. However for all the storage tanks of existing chemicals/ solvents wherever necessary it may be provided and keep safe distance between tanks to avoid domino effect in case of fire.
- The fire proofing materials will have adequate adhesion, strength and durability in the area.
- Seal all the waste in vapour tight plastic bags for eventual disposal or incineration.
- Use face shield, PVC gloves, and safety boots while handling and contaminated clothing has to be removed immediately.
- In case of accidental release, shut-off leaks without risk. Prevent spillage from entering drains or water sources.
- For small spills, take up with sand or other non-combustible material and placed into closed containers for later disposal.
- For large liquid spills, build dyke far ahead of the spill to contain the spilled material for reclamation or disposal as per environmental safety guidelines and

decontaminant the area.

- Cool containers/ drums with flooding quantity of water until well after fire is quit.
- Periodical mock drills will be conducted so as to check the alertness and efficiency of the DMP.
- In any case of large fire occurs**,** cool the tanks/ drums with flooding quantity of water until fire is quit.
- Breather valves with nitrogen blanketing system
- Public address system

7.5.1.2 Solvent Storage Tanks / Drums Handling Precautions

Storage tanks: There are several solvent storage tanks in tank form area as mentioned earlier and some of the solvents are also toxic i.e Methylene dichloride and chloroform. Solvents such as Methanol, Acetone, hexane, Butanol, toluene and Isopropyl alcohol if any will be transferred to the day tank situated at the production block with the help of mechanical seal pump through pipe lines from the tank, from day tank to reaction vessel unloading by gravity.

Drums: Most of the hazard Chemicals/ solvents are storing in ware house I & II such as Dioxane, Ethyl alcohol, Benzyl chloride, Thionyl chloride, MIBK and Dimethyl sulfoxide if any material in drums will be transferred to day tank area using Forklifts. In day tank area material will be transferred from respective drums (MS, GI, and HDPE) to the day tank situated at the production block with the help of AOD pump through pipe from the drums and from day tank to reaction vessel.

The storage and handling of hazardous chemicals in a chemical industry is inevitable, and they carry inherent characteristic risk to the employees due to the properties of chemicals such as toxicity & flammability. Accident due to fire and explosion by flammable substances are possible in process industry. The disastrous effect of fire, explosion and release of toxic fumes in storage and production area, is due to inappropriate design, improper storage, improper handling, poor maintenance or deficiencies in the operation of the plant. Chemical in any form can be stored, handled and used if their physical, chemical and hazardous properties are thoroughly understood and necessary precautions are taken. Chemicals are handled in standard containers like MS, HDPE, GI drums, PVC carbuoys, etc. All the chemicals are to be arranged and stored in accordance with their compatibility, dry, well ventilated, with flame proof electrical equipment's and lighting. All the chemicals are to be provided with identification labels.

Each chemical has its specific character. Hence, chemicals do not co-exist. They need their independent space, while storing. When two chemicals come in contact may generate heat, and gases by-product. Ambient temperature and moisture can trigger the reaction.

Halogenated compounds acquire aggravated properties. It is only wise to treat every chemical as toxic.

Chemicals are potential enough to destroy the flesh and the skin is ultrasensitive to chemicals. Chemicals on contact, the affected parts of the body will be washed thoroughly with plenty of water for at least 15 minutes, to dilute the aggressive nature of the chemical, as water is the only universal solvent and the best diluent. Then only further treatment is to be followed.

Eye wash/drench shower is to be provided at a strategic location for emergency purpose. Chemical safety data sheets and handling procedure, First aid measures are to be prepared and displayed for information and safety of the working personnel. The common safety data of the raw materials and solvents are given in **Table 7.13.**

Table 7.13: Safety data which are common to all raw materials and solvents

1. Fire Fighting Measures	
Extinguisher media	Water spray, dry chemical and carbon dioxide or foam as appropriate for surrounding fire and materials. In case of fire of water/air reactant chemicals like sodium boro hydride, water/foam shall not be used. Dry sand, dry chemical/lime may be used.
Special firefighting procedure	As with all fires, evacuate personnel to safe area. Fire fighters should use self-contained breathing apparatus and protective clothing.
Unusual fire and explosion hazard	This material is assumed to be combustible. As with all dry powders it is advisable to earth the mechanical equipment in contact with dry material to dissipate the potent buildup of static electricity.
Firefighting Procedures	As with all fires, evacuate personnel to a safe area. Fire fighters should use self-contained breathing apparatus and protective clothing.
2. Physical Hazards	
Hazardous Decomposition Products	When heated to decomposition, materials emit toxic fumes under fire conditions.
Hazardous Polymerization	Will not occur
3. Health Hazard Information	
Adverse Effects	Adverse effects may include dizziness, fainting, headache, and diarrhea, and nausea, loss of taste, dry cough, rash fever, joint pain, and unusual tiredness. Possible allergic reaction occurs to material if inhaled, ingested or in contact with skin.
Acute	Possible eye, skin, gastro-intestinal and/or respiratory tract irritation.
Chronic	Possible hyper sensitization
Inhalation	May cause irritation. Remove to fresh air.
Eyes	May cause irritation. Flush out with copious quantity of water by keep opening both eyelids of the affected eye/s. Obtain medical attention immediately.

Skin	May cause irritation. Flush out with copious quantity of water.
Ingestion	May cause irritation. Flush out mouth with required quantity of water by gargling. Obtain medical attention immediately.
4. First Aid Measures	
Precautions to consider	Persons developing hypersensitive (anaphylactic) reactions must receive immediate attention; material may be irritating to mucous membranes and respiratory tract. When handling, avoid all contact and inhalation of dust, fumes, mists, and/or vapors associated with the material. Keep container tightly closed and use with adequate ventilation. Wash thoroughly after handling. Individuals working with chemicals should consider all chemicals to be potentially hazardous even if their individual nature may be uncharacterized or unknown.
Emergency and first aid procedures	Remove from exposure. Remove contaminated clothing. Person developing serious hypersensitive reactions must receive immediate medical attention. If a person is not breathing, give artificial respiration. If breathing is difficult, give oxygen. Obtain medical attention immediately.
5. Exposure Controls / Personal Protection	
Respiratory protection	Use the NIOSH approved respirator, if it is determined to be necessary by an industrial hygienic survey involving air monitoring. In the event of a respirator is not required, an approved dust mask will be used.
Ventilation	Recommended
Protective gloves	Rubber
Eye protection	Safety goggles/face shield
Other protective clothing	Appropriate laboratory apparels/Apron. Protect exposed skin.
6. Handling / Spill / Disposal Measures	
Handling	As a general rule, when handling the materials, avoid all contact and inhalation of dust, mists, and/or vapors associated with the material. Wash thoroughly with soap water after handling.
Storage	Store in airtight containers. This material should be handled and stored as per label instructions to ensure product integrity.
Gspill response	Wear approved respiratory protection, chemically compatible gloves and protective clothing. Wipe up spillage or collect spillage using a high efficiency vacuum cleaner. Avoid breathing dust. Place spillage in an appropriately labeled container for disposal. Wash out the spilled site thoroughly.

Measures to Avoid Evaporation

Keep chemical holding tank/ containers/ drums tightly closed. Keep away from, sparks, flame and sources of ignition. Avoid utilizing common shed for different hazard chemicals specially incompatible chemical in same shed, if not keep safe distance.

At present most of the Chemicals are receiving in HDPE, MS and GI drums /carboys are stored in a ware houses of I and II. The ware house floors are made of impervious and the room is well ventilated. MS/GI drums are stored on spill containment pallets. In case of any

leakage from the drum it will be collected in the tub space provided in the pallet itself as containment.

Drums are transferred from ware house to manufacturing area along with spill pallets by Forklifts. It is necessary to store drums in a cool, dry, well-ventilated area away from incompatible substances sufficient buffer space will be provided between containers/ drums, so that it can be isolated during leak/ spill and respective remedial measures can be undertaken to minimize the effect on-site area. If any chemical to be dispensed for part quantities, the dispensing operation will be done in the dispensing room with local exhaust ventilation system connected to scrubber.

Following contaminant procedure and safety systems is to be followed to minimize/ avoid release of hazard chemical and to control at source if leak/ spill of gas/ vapor/ liquid.

7.5.1.3 Spill containment procedure

Chemicals / Neutralizing	Acid (Corrosive)	Water Reactive	Caustics	Oxidizer	Reducer	Poison	Air Reactive	Flammable	Alkali Metals
Absorbing Agent	Polypropylene pad, Brooms & Sand	Polypropylene pad & Broom	Polypropylene pad, Broom & sand	Polypropylene pad & Brooms	Polypropylene pad & Brooms	Polypropylene pad & Brooms	Polypropylene pad & Brooms	Polypropylene pad, Brooms & sand	Dry sand /Mineral oil
Neutralizer	Sodium Bi Carbonate (or) Soda Ash	Sodium Bi Carbonate (or) Soda Ash & Special Dry Powder (TEC)	Weak Acid (5% Hydrochloric acid)	5% sodium thiosulphate solution & Powder	5% sodium hypo chlorite solution	5% sodium hypo chlorite solution	Sodium Bi Carbonate (or) Soda Ash & Mineral oil	Activate Charcoal	Nil
Decontaminator	Water and to be checked by pH paper	Water	Water and to be checked by pH paper	Water	Water	Solvent for water reactive and then with water	Water	Water	Mineral oil and then with water

1. In case of minor spill isolate the chemical/ material
2. Neutralize the spill with the chemical as mentioned below
3. Sweep the area
4. Decontaminate the area with suitable decontaminator as mentioned in the above table

It is also necessary every chemical industry to be maintained spill control kit with minimum of these items is to be followed and updated in regular interval.

1. Sorbent rolls

2. Sorbent brooms
3. Sorbent pads
4. Air tight goggles
5. Half face cartridge mask
6. Chemical resistant suit
7. Antistatic gloves
8. PVC gloves

7.5.1.4 Safety Systems and Personal Protective Equipment (PPE)

1. Designated areas with proper indication flammable/ toxic / explosive & safety signs
2. Double earthing systems
3. Flame arrestor to the vent
4. Flame proof transferring pumps
5. Handling precautions/SOP protocol
6. Pressure Gauges
7. Level indicators
8. Flame proof lighting to storage yard

Personal Protective Equipment (PPE) provides additional protection to workers exposed to workplace hazards in conjunction with other facility controls and safety systems. Selection of PPE will be based on the hazard and risk ranking and will be according to the criteria on performance and testing established. The generally recommended measures for use of PPEs in the work place are given in **Table 7.14.**

Table 7.14: Recommended Personal Protective Equipment's (PPEs)

Objective	Workplace Hazards	Suggested PPEs
Eye and face protection	Flying particles, molten metal, liquid chemicals, gases or vapors, light radiation.	Safety glasses with side-shields, Chemical splash glasses protective shades, Fiber glass resistant to most chemicals etc.
Head protection	Falling objects, inadequate height clearance, and overhead power cords.	Plastic helmets with top and side impact protection.
Hearing protection	Noise, ultra-sound.	Hearing protectors (ear plugs or ear muffs)
Foot protection	Failing or rolling objects, points objects. Corrosive or hot liquids.	Safety shoes and boots for protection against moving and failing objects, liquids and chemicals.
Hand protection	Hazardous materials, cuts, vibrations, extreme temperatures.	Gloves made of rubber, PVC coated gloves or synthetic material (Neoprene), leather, steel, insulation materials, etc.

Objective	Workplace Hazards	Suggested PPEs
Respiratory protection	Dust, fogs, fumes, mists, gases, smokes, vapors	Facemasks with appropriate filters for dust removal and air purification (chemical, mists, vapors and gases). Canisters for toxic gas Single or multi-gas personal monitors, if available.
	Oxygen deficiency	Portable or supplied air (fixed lines). Onsite rescue equipment.
Body / leg protection	Extreme temperatures, hazardous materials.	Fire Entry Suit; Insulating clothing, body suits, aprons etc. of appropriate materials Stud safety shoes, PVC knee boots

7.5.2 Specific Risk Mitigation Measures

Specific attention to be made during storage, transport and handling mode specially for combustible, flammable/ explosive and toxic material.

The major hazard situations in the unit are: The pool fire occurs due to:

- Possible rupture/ leak of storage tanks / drums
- Dispersion of liquid to confined or unconfined area
- Ignition of releasing liquid/ vapour

To prevent accident due to fire and explosion, it is necessary to know:

- The fire and explosion properties of the material
- The nature of fire and explosion process and
- The procedure to reduce fire and explosion

To avoid or reduce Vapour Cloud Explosion (VCE) to minimize dispersion of flammable vapour by operating water/ foam tenders and to avoid further dispersion by maintaining water/ foam curtain.

- Sudden release of large quantity of flammable vapour, typically this phenomenon occurs when a storage tank containing suspended and pressurized liquid ruptures
- Dispersion of vapour in nearby areas while mixing with air
- Ignition of the released vapour cloud

Vapor clouds are normally ignited at the edge as they drift and stop further spreading of the cloud in that direction causes Unconfined Vapour Cloud Explosion (UVCE).

Boiling Liquid Expanding Vapour Explosion (BLEVE) is caused by sudden failure of the container due to any cause. The primary cause is usually an external flame impinging on the shell of a vessel above the liquid level weakening' the container and leading to a sudden

shell rupture. A pressure relief valve does not protect against this mode of failure. BLEVE can occur due to any mechanism that results in the sudden failure of the container allowing a superheated liquid to flash typically increasing its volume over 200 times. This is sufficient to generate a pressure wave and fragments. If the released liquid is flammable a fireball may result. However vapour cloud explosion unlikely occur in M/s NATCO being released vapour cloud in most of the case below the LEL as per analysis.

The major incompatibilities is a guide to the storage and handling of chemicals and which combinations to eliminate accidents if any. Each chemical has specific character and hence all the chemicals will not be stored in one storage shed, but not supposed to be mixed, stored together, during storage and handling. It is the nature of chemicals that they do not co-exist. The major incompatibilities for storage and handling of hazard chemicals are presented in **Table 7.15.**

Proponent made a provision to all tanks with breather valves and Nitrogen blanketing system. Also specific precautionary measures will be taken on case to case for following accidental release of hazard chemicals.

Table 7.15: The major incompatibilities for storage and handling of hazardous chemicals

Chemical	Incompatible with
Acetic acid	Solvents,oxidizing agents, water, other chemicals
Aceto nitrile	Strong oxidisers
Acetone	H_2SO_4, HNO_3, Oxidizing agents, $H_2O_2$and Chloroform.
Acrylo nitrile	Strong oxidizers, acids & alkalis; bromine; amines [**Note:** Unless inhibited (usually with methyl hydroquinone), may polymerize spontaneously or when heated or in presence of strong alkali, attacks copper)
1, 4 Dioxane	Strong oxidizers, de caborane, tri ethynyl aluminum
Ethyl acetate	Nitrates; strong oxidizers, alkalis & acids
Ethyl alcohol	Strong oxidizers, potassium dioxide, bromine penta fluoride, acetyl bromide, acetyl chloride, platinum, sodium
Hexane	Strong oxidizers
Cyclo hexane	Oxidizers
Bromine	Combustible organics, oxidizable materials, Halogens, acetylene, phosphorous, potassium, sodium
Ammonia	Acids, strong oxidizers, Halogens
Chloroform	Strong,caustic, chemically active metals Na, K, Al, Mg
Chlorine	Reacts explosively or forms explosive compounds with many common substances such as acetylene, ether, turpentine, ammonia, fuel gas, hydrogen & finely divided metals
Hydrogen	
Toluene,	Strong acids, combustible and flammable substances, oxidizing agents
Iso Propyl Alcohol (IPA)	Strong oxidizers, Acetaldehyde, chlorine, Ethylene oxide, acids and Isocynate

Chemical	Incompatible with
n-Butanol	Strong oxidizers, Mineral acids, Alkali metals and Halogens
Benzyl chloride	Oxidizers, acids, copper, aluminum, magnesium, iron, zinc, tin [**Note:** Can polymerize when in contact with all common metals except nickel & lead. Hydrolyzes in H_2O to benzyl alcohol.]
Methanol	Other chemicals
Dimethyl sulfoxide	Strong oxidizers, ammonia solutions [**Note:** Decomposes in water to sulfuric acid; corrosive to metals.]
Methylene dichloride	Strong oxidizers, caustic, chemically active metals Al, Na, K and conc. Nitric acid.
MIBK	Strong oxidizers
Sulphuric acid	Organic materials, chlorates, carbides, water powdered metals
Triethyl Amine	Strong oxidizers, chlorine, strong acids, hypochlorite, halogenated compounds**.**
Thionyl chloride	Alkalis, oxidizing agents, other chemicals.
Diesel	

7.5.2.1 Combustible materials

Industry proposed to store acetic acid in horizontal tank of 30 KL capacity and Diesel in 2x30 KL vertical tank and both are providing dyke and are combustible. MCA analysis of acetic acid and diesel indicate that effect of heat radiation is close to edge of pool. In case of acetic acid for small fire -water and for large fire dry chemical, alcohol foam, water spray and keep source of ignition neutralize with dilute sodium carbonate. To control large spillage, inert material or dry earth will be utilized.

7.5.2.2 Flammable – Pool Fire/ Vapour cloud Explosions / BLEVE

There are several flammable liquids storing in tank form area as well as in drums in ware houses and few of flammable liquids are also toxic in nature. Flammable liquids are mainly Acetone, IPA, Methanol, MIBK, N- butanol, Hexane, cyclo hexane, Toluene, MCL and ethyl acetate are storing in tank form are in horizontal storage tank, where as other flammable liquids are stored in 160 to 230 kg capacity drums and Benzyl chloride and Dimethyl sulfoxide are also considered as toxic as well as flammable storing in HDPE drums of capacity 220 kg and 230 kg in ware house -I respectively. In case of leak or catastrophic rupture of storage tanks in tank form area and drums in ware houses, total material taken as source strength and forms a pool in respective dyke and unconfined pool in case of drums. If ignition takes causes pool fire.

In the case of leak pit tank is available in tank form area to collect leaked solvent as precautionary measure to collect and disposed accordingly and simultaneously leakage control with safe precautionary measures. If pool fire occurs start using the fire hydrant

points, water sprinklers, water monitor and foam gun kept near the tank farm area. In case of unconfined pool of flammable liquid in ware house, spill containment procedure to be followed and if ignited firefighting measures and take follow up action.

- Evacuate all the personnel in the tank farm area.
- Stop all activities/loading unloading in the tank farm area
- Cordon off the area and do not allow any person inside tank farm.
- Follow emergency procedure for fire protection measures in solvent storage tank form area.

If ignition takes after vapour cloud formation or BLEVE takes due to exposure of storage tank by external heat or any other means. Result causes over pressure and heat radiation effect on-site area and crosses plant boundary (off-site), area closed by plant boundary. The risk mitigation measures are as follows:

- All solvent tanks having condenser cooling with Flame arrestor provided.
- Appropriate firefighting system is to be applied in case of accidental release of other flammable liquids.
- Lightening arrestors provided to near tank
- Breather valves facility with Nitrogen blanketing provided to all
- MCP provided inside the solvent tank farm area

In the above case use alcohol form, water spray or fog, cool containing water jet to prevent pressure buildup or auto ignition or explosion. In case of small fire due to leak of flammable liquid / vapour appropriate firefighting system may be deployed accordingly on basis of Risk level.

7.5.2.3 Toxic Releases

Industry is proposed to handle toxic chemical (gases/ liquids) which are stored / proposed in specified tanks. Chloroform, and Methylene chloride in tank form area, where as sulfuric stored tank near ware house- I, Bromine bottles in crates, Thionyl chloride, benzyl chloride, aceto nitrile, acrylonirile , 1 4 dioxane, Triethyl amine , MIBK and dimethyl sulfoxide in drums in ware houses. Ammonia and chlorine stored in cylinders in dedicated storage areas.

Bromine: It is stored in liquid form, considered as highly toxic and incompatible with combustible organics, Na, K, phosphorous including Acetylene and halogens. It is considered as acute health effect if person exposed to 3 ppm conc. Level.

In case of spill dry chemicals and incase of fire CO_2 extinguishers, water spray, alcohol foam or flooding with water to control the same. Being heavy gas disperse towards wind

ward at ground level. However it should control by neutralizing by anhydrous ammonia vapour. Evacuate towards upwind side of accident side, if evacuation needed and the same may be applied for off- site area. First aid measures will be followed by medical aid immediately to be for exposed population.

Thionyl chloride: 300 kg drums are using in this plant, though it is in liquid form once accidental leak or complete discharge of chemical, it spill over in unconfined area and evaporates and move towards wind ward direction causes severe health effect, being its IDLH value 4 ppm only and once exposed provide medical aid immediately.

It reacts with water may release flammable and toxic gases and vapors may be heavier and moves along the ground level towards down wind. Ask the people to vacate the area and to move for fresh air towards crosswind side. For spill/ fire dry chemical may be used, If water is only media flooding of water necessary as in any fire and wear breathing apparatus during operation.

Benzyl chloride: it is considered as combustible III chemical and also considered as toxic. Industry storing at a time maximum capacity of 3T (8 x 250 L drums) rupture of drum causes instantaneous releases of liquid and spill over unconfined area, toxic gases vapors generates move towards safe side (cross wind/ upwind side if possible) as in above. Immediate first aid measures as well as gets medical aid immediately.

It is highly incompatible with most of the metals and polymerize when contact with common metals and strong oxidizer. Hence, specific attention will be given to during emergency action plan (on-site/ offsite). For spill over small/ large to control use inert dry material- sand silica, saw dust, acid binder etc. do not allow exposed adsorbent water ways.

Chlorine: Liquid Chlorine 10 nos. of one-ton chlorine cylinders (900 kg) is stored in the chlorine storage shed - Near the Production Block – V.

Chlorine handling - Safety measures: Barometric head of 12 m height column is maintained for chlorine passing to avoid back pressure and provided the Chlorine leak detection system (sensors).

Consequences of Chlorine release: Rupture of SS line after chlorine cylinder. The rupture of 6mm copper tubing connection will cause spreading of toxic gas in the factory, which is considered as the worst case, and not likely to occur.

- In case of leak evacuate the people to safe area and responders must wear Self-contained breathing apparatus (SCBA) and PVC suit, Use emergency kit for arresting leaks.
- The emergency kit provided for chlorine leak from tonner can also be used.

- Always stand in upwind direction while attending to chlorine leak.
- Use Ammonia torch for detecting the exact location of leak.
- Follow the procedure for arresting leak: Emergency Chlorine leak detection and alarm system, Manual scrubber system provided with canopy hood and Scrubber consists of minimum of one tonne of caustic solution.

The personal protection and safety system: Air masks at the chlorine cylinders storage area, SCBA sets provided at storage area to control at source**.** Fire hydrant system and eye shower should be provided at the area. One set of emergency chlorine kit including Public address system for emergency communication and Wind sack should be available to identify the direction of wind.

Ammonia (g) cylinders

The gas is flammable (auto ignition temperature: 651 °C) and can form explosive mixtures with air (16–25%) prevent it from leakage.

Anhydrous ammonia is classified as toxic (T) and dangerous for the environment (N)

Fire protection materials should be used to protect for pressurized gas against the effect of fire. If any leak appears, the valve should be immediately closed if possible and isolate cylinder from other. As a safety measure, proponent provided the Sprinkler system & gas detections system.

Sulfuric Acid (Storage Tank capacity- 12 T)

Wear appropriate personal protective clothing to prevent skin contact. and avoid breathing vapors.

Avoid contact with eye, Wear appropriate eye protection to prevent eye contact. he worker should immediately wash the skin when it becomes contact with acid Filling/ Transfer operation should be stopped immediately in the event of:

- Uncontrolled leakage occurring
- A fire occurring in the vicinity
- Lightning and thunder storm

In case of small leaks increase ventilation and allows gas to vent. Bounding with sand earth and dilute spill with water. In case of large spell use water fog, to dampen cloud of sulphuric acid fumes to reduce vapours. Some of the specific chemical, which are highly toxic corrosive and immediate with water discussed below and respective spill control procedure.

Few of the chemicals are stored in Tins and bags which are considered as highly toxic, corrosive and highly reactive with water, for the same spill control measure is to be followed:

Spill Control Procedure for LAH (Lithium aluminum hydride): Extremely dangerous, corrosive material and possible local combustion and even explosion of hydrogen in the mouth, and may be fatal. It is also corrosive, can cause serious burns due to almost immediate reaction with water, especially on moist skin.

- Use Secondary containment
- In case spillage, neutralize the spill with ternary eutectic chloride powder
- In case of fire use DCP (tech) for extinguishing the fire

Spill Control Procedure for sodium hydride: Extremely dangerous, corrosive material and possible local combustion and even explosion of hydrogen in the mouth or May be fatal. Corrosive can cause serious burns due to almost immediate reaction with water, especially on moist skin. If material ignites, very deep burns and tissue destruction.

- Secondary containment
- In case spillage, neutralize the spill with methanol
- In case of fire use DCP (tech) for extinguishing the fire

Spill Control Procedure for Sodium and copper cyanide: it is consider as highly toxic and corrosive in nature. Immediate attention to be made for spillover of material, being due to corrosive to the respiratory tract, central nervous system, and thyroid changes may cause unconsciousness. It is also consider as Highly Toxic, Corrosive to the gastro-intestinal tract, larger doses may produce sudden loss of consciousness and prompt death from respiratory arrest.

1. Secondary containment is to be available.
2. In case spillage, neutralize the spill with potassium permanganate

Other chemicals: Acetonitrile, Acrylonitrile, dioxane etc.

Most of the hazard chemicals are storing in ware houses in specified drums in liquid and solid form, these chemicals flammable, toxic as well as corrosive in nature, and storing in ware house I and II.

Small spillage: Any hazardous chemical spill that does not involve highly toxic, highly reactive, or explosive chemicals in a situation that is not life threatening. This type of spill present a manageable physical or health hazard to personnel who, when wearing proper Personal Protective Equipment (PPE), will not be exposed to any chemical at a level that exceeds any level or permissible exposure.

Smaller Spillage Response & Cleanup Procedure: If the spillage is of smaller quantity, cleanup the spilled material with suitable absorbent as per MSDS and collecting suitable

portable container and send it to Effluent Treatment Plant (ETP) where it be treated / incinerated

Large spillages: Any hazardous chemical spill involves highly toxic, highly reactive, explosive or life threatening chemicals. **(OR)** Any spill situation that presents significant fire, explosion, or other physical or health hazard risks, particularly if a person may be or has been significantly exposed, contaminated or injured to such an extent that medical or other assistance is required. Situation that may adversely impact the external environment irrespective of spill occurred internal or external to a building.

Large Spillage Response & Cleanup Procedure:

- The area should be immediately evacuated particularly downwind area and Restrict access to the area until completion of recovery and cleanup.
- Eliminate all ignition sources and provide adequate ventilation depending upon the chemical.
- Stop or reduce leak if safe to do so.
- Contain the material with earth sand or absorbent material which does not Reactive with spilled material.
- Recovery and cleanup should be done by the trained personnel only. The person cleaning the material should wear required Personal Protective Equipment (PPE) such as respiratory cartridge mask, safety goggles, gumboots, PVC Suit and rubber hand gloves etc.
- Do not touch the spilled material and avoid prolonged and repeat exposure to Toxi
- Prevent spilled material entering waterways, sewers or drainages.
- Ground the containers if the spilled materials generate the static electricity.
- Vacuum / sweep up the spilled material in approved, portable and suitable containers as mentioned the MSDS.
- Place the containers with covers, labels and in suitable locations.
- After recovering the material, cleanup the area with suitable absorbent Material as mentioned in the MSDS.
- Flush the area with water if it is required.

Disposal of Larger Spillages Materials:

- After recovering the material, sent it to Effluent Treatment Plant (ETP).
- Depending on the nature (physical & chemical properties) of material either the material is to be neutralized or incinerated or it shall send for treatment and land filling

However in all the case of above and other chemicals are used by M/s NATCO follow MSDS/ NIOSH data sheet guide lines for First aid , accidental release measures, fire-fighting if any.

7.6 Hazard Control Measures

1. Procedures and actions will be well defined and known to all operating personnel's for safe shut down of plant in case of failure of any power, instrumentation, cooling water, air, etc.
2. All the storage tanks having a provision of breather valves, nitrogen blanketing system, Gas detection system, sprinklers system with deluge valve operation. These tanks will be provided with temperature indicator, pressure gauge and safety valves as depending upon the process and operating parameters.
3. Plant specific HAZOP studies will be carried out using P & IDs for identification of hazards during operation considering deviation of operational parameters, their possible cause of material loss and consequence and safe guards.
4. Interlocks and DCS control will be provided during reaction process.
5. All the motors and other rotating equipment machines will be provided with suitable safety guards.
6. Existing Fire extinguishers fixed / movable will be up graded in the plant area.
7. Movable fire tenders may be arranged, being it need of hour during emergency.
8. Flame arrestors will be provided at all vent lines for proposed solvent tanks.
9. Suitable first aid fire extinguishers, such as, DCP, CO_2 & foam type will be kept in every plant area at easily approachable spots. Fire hydrant points with sufficient length of hose reel will be provided at major emergency spots.
10. Bound walls, bonded wire fencing, detached storage area will be kept away from probable ignition sources; Dykes should be provided by giving sufficient space provision between all liquid storage tanks.
11. Safety shower and eye washer will be installed at storages/ handling of hazard, process/ operation units
12. Sufficient space will be provided for free movement in the plant area. Avoid transfer of hazard material from storage to process units by manually if any.
13. Safe distances have been considered between storages and process operation units and utilities in designing of plant lay out.
14. Regarding all components of the plant proper certificate will be taken. Testing and inspection will not be compromised before deliveries.
15. Certificate of structure stability will be taken from competent person.
16. Insulation of piping will be provided as per requirement.
17. All elevated structures will be provided with lightening arrestors.

18. All exposed parts of moving machineries will be provided with suitable guards for personnel safety.
19. All piping and equipment will be provided with earthing connection and it will be tested regularly.
20. Safety valves & rupture disc will be provided to prevent over Pressure I n tanks/ vessels and reactors.
21. SOP will be available of safe shut-down of plant during any emergency

7.7 Mitigation Measures for Natural Disasters

(A) Flood

Mitigation measures can be structural or non-structural. Structural measures use technological solutions, like flood levels that is only possible local seasonal heavy rains. There is no possibility of water logging being area is slightly sloppy (undulated elevated terrain). As such there is the least possibility of flooding since the area is located in Deccan plateau and moreover, the average rain fall is 60 cm. However, the following procedure is followed in case of flooding

Focus resources on minimizing the spread of water into other areas of the plant

- Stop all operations immediately. Close all valves of solvent storage tank
- Switch off power supply to avoid electrocution due to short circuit.
- Protect property and records by removing items from floors and/or covering with water resistant coverings
- Evaluated information will be disseminated to personnel.
- Shift the water reactive material to elevated places like racks / building. Attempt to move items of value to “higher ground” if possible
- Activate the onsite warning and instructional system as necessary.
- Follow unit shut down procedures and Shutdown Electrical power.
- Control water flow by dike arrangement using sandbags, and or pumping.
- Start up after checking and clearing water from each and every unit

(B) Cyclones and Severe Storms

Location of M/s NATCO is at elevated area when compared with rest of the state and is not in flood prone area, being location of site is more than 350m MSL. However during storm and if any flood water enters from outside plant area, land use management will provide protection from wind and storm surge.

Engineering of structures would withstand wind forces and building will be constructed with wind-resistant capacity.

Securing elements such as metal sheeting, roofing, and fences will be done to avoid severe damages.

Cyclone and severe weather warning systems will be installed and awareness regarding cyclone risk and evacuation plan will be addressed.

(C) Earthquake

The factory premises falls under Zone II under Seismic zone, classification and accordingly the probability and impact will be least to moderate. However steps will be taken for Personal structural mitigation in earthquake prone areas includes seismic retrofits of property.

- Precautionary measures such as securing of items inside a building to enhance household seismic safety.
- Stay away from glass, windows, outside doors and walls, and anything that could fall Lighting fixtures or furniture.
- Stay inside until the shaking stops after that it is safe to go outside
- Do not attempt to move to a different location inside the building or try to leave
- DO NOT use the elevators

7.8 Disaster Management Plan

Introduction

A major emergency is one, which has the potential to cause serious injury or loss of life. It may cause extensive damage to property and serious disruption, both inside and outside a plant. Sometimes, it requires the assistance of outside emergency services to handle it effectively. Emergency may be caused by a number of factors, e.g. plant failure, human error, natural calamities, crash or sabotage, if any other means. Several Government agencies, both at the Central and State levels, are entrusted with the responsibility of ensuring safety and management of hazardous chemicals under Acts and Rules made for the purpose. Despite these measures, the possibility of accidents cannot be ruled out. In order to be ready to face risk of accidents during processing, a disaster management plan (DMP) will be prepared to mitigate the impact.

- The purpose of this DMP is to give an approach to detail organizational responsibilities, actions, reporting requirements and support resources available to ensure effective and timely management of emergencies associated to production operations in the site. The overall objectives of DMP are to:
- Minimize the occurrence of Leak/ Catastrophic events leading to human, property and material damage/losses by a suitable policy initiative.

- Prevent injury, loss of life or damages by a timely and appropriate response of emergency preparedness plan for onsite and offsite area of M/s NATCO obtain early warning of emergency conditions so as to prevent impact on personnel, assets and environment;
- Activate and ensure involvement of all personnel and agencies in emergency response planning and community preparedness.
- Immediate response to emergency scene with effective communication network and organized procedures.
- Involve citizens and other emergency response team members in design, testing and implementation of the DMP

The results of MCA analysis of the Risk Assessment (RA) study is used in the preparation of DMP. To safeguard personnel to prevent injuries or loss of life by protecting personnel from the hazard and evacuating personnel from an installation when necessary, provide guidance to help stake holders take appropriate action to prevent accidents involving hazardous substances and to mitigate adverse effects of accidents that do nevertheless occur and to minimize the impact of the event on the installation and the environment by:

- Minimizing the hazard as far as possible
- Minimizing the potential for escalation
- Containing any release

This is achieved by describing procedures to deal with emergencies affecting personnel, equipment, third party contractors, local communities or the environment

Key Elements of DMP

Following are the key elements of Disaster Management Plan:

- Basis of the plan
- Accident/ emergency response planning procedures
- On-site Emergency Preparedness Plan
- Off-site Emergency Preparedness Plan

Basis of the Plan

Identification and assessment of hazards is crucial for on-site emergency planning and it is therefore necessary to identify what emergencies could arise in production of various products and their storages including hazard transfer pipe line. Hazard analysis or consequence analysis gives fire, explosive and toxic scenarios due to accidental release of flammable/ toxic chemicals from storage(tanks/containers/ drums) and any other means.

Accident/ Emergency Response Planning Procedures

There are four emergency levels of incident management and response to industrial accidents that the public should be aware of.

Level I*:* An incident has occurred and can be controlled by facility personnel. The situation is under control

Level II*:* An incident has occurred the situation is not under control but is confined. The incident is confined to a small area or to a fixed-site and does not pose a threat of spreading to a larger area or off-site.

Level III*:* An incident has occurred the situation is not under control and protective action may be necessary for the surrounding or offsite area.
Level IV: An incident has occurred and the situation is not under control. Actions by more than first responders or facility personnel are necessary. Incident involving a severe hazard or an area which poses an extreme threat to life and property and will probably require an evacuation.

Emergency rarely occurs therefore activities during emergencies require coordination of higher order than for planned activities and should be carried out according to fixed time schedule or on a routine day-to-day basis. To effectively coordinate emergency response activities, an organizational approach to planning is required. The important areas of emergency planning are Organization and Responsibilities, Procedures, Communication, Transport, Resource requirements and Control centre.

Offsite emergency requires additional planning over and above those considered under onsite plans, which will be properly integrated to ensure better coordination. An emergency core group (ECG) is constituted to pool and analyze the necessary information for effective decision making.

Emergency core group (ECG) consists of different task of specific coordinators i,e, Plant general manager, plant manager of process and maintenance, Engineering group, Safety officer and Fire officer, who in turn mobilise and formulate requisite number of action teams who will provide necessary emergency response in order to implement these decisions and to provide necessary and timely response in the affected areas.

An emergency action groups (EAG) will be constituted as a part of first response team. Thus the first response team for the plan includes all the members of both ECG and EAG. The constituents have been assigned specific responsibilities for the plan. The responsibility of managing onsite crisis lies solely with the concerned organization whereas the organization structure for offsite emergency includes both Local/ State government agencies. The functions of the ECG are:

- Formulation and implementation of emergency plan.
- Provide guidance / making basic policy decisions.
- Convening the emergency core group meeting after receipt of emergency call.
- Review of operational preparedness of emergency machinery
- Hold periodic mock/ training to ensure optimum preparedness at operational levels
- Develop and update various hazard scenarios, and cascading effect based on the onsite plan
- Mobilize the financial resources for expenditure in case of emergency
- Depute nodal officer with the district or state authority for offsite crisis
- Transfer the information collected from the advisory group to EAG
- Liaison with external and mutual aid agencies and identify cases where material aid is needed
- Provide information on the incident to district, state / level authorities and if needed call for assistance from competent bodies
- Liaison with press / media to report the emergency
- Declare rehabilitation centers in case of evacuation of people.
- Takes care of emergency situation like continual health care, re-establishment and creation of social compatibility
- Declare all clear, once everything is normal

Emergency action group (EAG) is the front line team which responds based on the instructions given by ECG. It coordinates among itself for various activities. The functions of EAG are:

- Rushes to the emergency area
- Make systematic assessment of hazard
- Liaison with emergency control centre
- Warns the personnel of an impending danger
- Cordon off the people and control the traffic
- Render first aid medical service
- Seek rehabilitation centers

7.8.1 On-site Emergency Preparedness Plan

An on-site emergency is caused by an accident that takes place in the plant itself and the effects are confined to the factory premises involving only the people working in the factory. On-site emergency plan to deal with such event and it is responsibility of the occupier and also mandatory.

The preparation of an on-site emergency plan and furnishing relevant information to

the District Emergency Authority for the preparation of the off-site emergency plan are statutory responsibilities of the occupier of every industry and other units handling hazardous substances. An on-site emergency plan will contain the following key elements:

- Basis of the plan
- Hazard analysis
- Accident prevention procedure/ measures
- Accident/ emergency response procedure /measures and
- Recovery procedure.

7.8.1.1 Purpose

- To protect persons and property of process/ operation equipment's in case of all kinds of accidents/ emergencies
- To inform people and surroundings about emergency if it is likely to adversely affect them
- To inform authorities including helping agencies (doctors, hospitals, fire, police transport etc.) in advance, and also at the time of actual happening
- To identify, assess, foresee and work out various kinds of possible hazards their places, potential and damaging capacity and area
- In case of M/s NATCO, MCA analysis indicates that the following places required Emergency preparedness plan.
- Storage tank of combustible and flammable liquid in tank form area - pool fire/ vapour cloud explosion / fire ball.

Pool fire of (confined) acetic acid and Diesel radiation effect 4.5 KW/ m2 close to edge of pool, where as in case of flammable liquids acetone, methanol, hexane and in other flammable liquids up to 10 to 15 m from edge of pool. Radiation effect of fatality is within pool and in few cases 2 to 3 m from edge of pool. In case of delayed ignition/ spark of vapour cloud due to leak / release of flammable liquid causes damage inside and outside plant, however it is unlikely occurs, being material holding in confined pool and possibility of average LEL value within limits. Catastrophic rupture under BLEVE also unlikely occurs, only it is due to exposure of storage tanks by external heat or sabotage.

Location of drums (HDPE, MS and GI) and container storages are in ware houses mainly in Ware house-I, Ware house -II and Ware house- IV: – fire/ explosion/ toxic release.

There are hazard flammable/ toxic and corrosive liquids are storing in drums mainly Dioxane, Ethanol, Diemethyl sulfoxide, Acetonitrile, Acrylonitrile, Thionyl chloride, Bromine benzyl chloride and others. In case of leak or rupture it will spread of liquid over unconfined

area and forms vapour cloud and under spark/ ignition people exposed to heat radiation effect, whereas in the case of dispersion of toxic gas/ vapour even it may cross over plant boundary, need off- site emergency preparedness plan.

Most of the flammable liquid are storing in drums of different capacity, emergency level depends on extent of material release and vapour cloud formation. Delayed ignition or spark explosion causes thermal radian and over pressure effect mainly within boundary and outside plant some extent depends on site event. In case of spillage of toxic chemicals material released to atmosphere as gas/vapor form dispersed towards downwind direction covers off-site area, if delayed in control at source mainly thionyl chloride and bromine, being considered as toxic.

Location of gas cylinder storage – In this unit toxic gas cylinders ammonia (50kg), and chlorine (900Kg) and highly flammable gas cylinders Hydrogen (7m3) at dedicated areas - leak of cylinders such as ammonia and chlorine releases toxic gas / vapors dispersed towards downwind side and covers on-site as well as off-site area, which depends on type of leak and duration, where as in case of hydrogen cylinder radiation and over pressure effect mainly on-site disaster. However, various precautionary measures suggested to avoid the possible leak and to minimise duration of leak by control at source.

Location of material transfer points (process/ operation unit) – fire/ explosion/ toxic release – however depends on material and extent of material leaked/ releases.

In order to handle disaster/emergency situations, an organizational chart entrusting responsibility to various personnel of industrial unit is available and shown in **Fig. 7.3.**

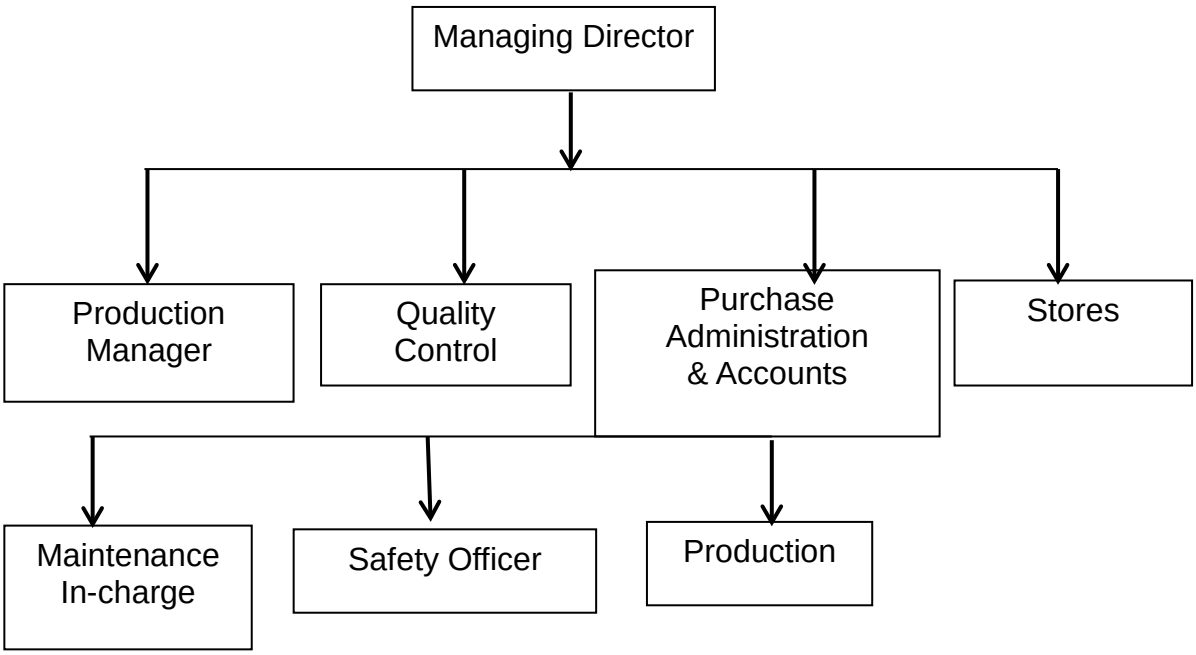


Fig.: 7.3 Factory Management Organisation Chart

7.8.1.2 Accident Prevention Procedures / Measures

A separate plan is provided to deal with the situations, which necessitate emergency action. The emergency response plan includes details of the organizational response to emergencies and the safety precautions to be observed in preventing loss of life and damage to property. Risk mitigation measures based on consequence analysis are recommended above based on the consequences analysis.

Fire Prevention Planning and Measures

Fire is one of the major hazard apart from toxic gas in this unit, Fire prevention and code enforcement is the area of responsibility of the fire service. Safe operating practices reduce the probability of an accidental fire on a plant. Personnel understand their duties and responsibilities and attentive to conditions that might lead to fire. The following precautions are recommended:

- There will be provision for safe handling and storage of dirty rags, trash and waste oil flammable liquids and chemicals spilled on platform will be immediately cleaned
- Containers of paints and hydrocarbon samples, gas cylinders for welding and cutting will be stored properly.
- Cutting and welding operations should be conducted in accordance with safe procedures. Smoking will be restricted to designated platform areas and “no smoking” areas will be clearly identified by warning signs
- Particular attention will be given to oil pumps, seals; diesel and gas engines which could be potential source of ignition in the event of a failure

Basic Actions

The basic actions required to handle any emergency are as follows:

- Operation of emergency shut-down systems
- Maintenance of communication ECG/ EAG groups as long as possible
- Persons to be nominated to prepare for evacuation
- Liaison with fire-fighting agencies local government/ private agencies required.
- Effective internal communication by public address system and walkie-talkie sets

Communication Link

A multi-user wireless paging system with selective call facility is useful for promptly locating key operating personnel in the plant, both during normal conditions and during emergencies. A public address (PA) system with loud speaker installed at vital installations is extremely useful during emergencies. Adequacy and efficiency of firefighting and fire detection

equipment's, personal, detective measures and medical aids will be ensured through proper communication link.

There are various facilities available in the site for communication.

- Intercom facility
- Public addressing system
- Walkie Talkies, Mega phone
- Mobile phone facility at security

7.8.1.3 Before Emergency

Prepare a plan for installations of storage and process/ operation equipment's clearly indicating probable areas of various hazards like fire, explosion, toxic releases etc. Locations of assembly points, fire station, telephone room, first aid or ambulance room, emergency control room, main gate, emergency gates, will be noted in plot plan.

The fire protection equipment will always be kept in good operating condition and fire fighting system will be periodically tested. The training regarding fire fighting techniques will be provided to all officers/ employees.

There will be a regular mock fire drill periodically; record of such drills will be maintained. Every employee or authorized person working in the plant will be familiarized with the fire alarm signal and will know the location of closed by fire alarm point; Assign key personnel and alternate responsible for site safety. In case of toxic liquid/ gas suitable adsorbent and inert material (sand, earth) and water to arrange at site of storage and process/ operation units including absorbents.

7.8.1.4 During Emergency

In the event of fire from accidental release of flammable gas or liquid, a person seeing the incident will follow the laid down procedure in the plant and report as follows:

- Will dial the nearest telephone
- Will state his name and exact location of emergency
- Will contact affected officers on duty and will remain at the location of site to guide crew
- Perform no other duties that may interfere with their primary responsibilities

Notify the attendant if they experience any warning signs or symptoms of exposures or dangerous condition and exit the permit space when instructed by attendant

In case fire emergency, person will activate the nearest available push button type instrument which will automatically sound an alarm in fire control room indicating the location of fire.

In case of toxic liquid drum leak/ rupture, immediately isolated and control not to spread and border the liquid with inert material (earth, sand if any non-reactive). Control leak if possible. However, it depends on material to material as per MSDS sheet. Adsorbed material will depose environmental friendly not to contaminant water and soil and toxic flooded with water also controlled and neutralised if necessary.

7.8.1.5 After Emergency

Report injuries or blood/body fluid exposures to the appropriate supervisor, immediately wash wounds and skin sites by soap and water.

Provide information to the relevant public authority and community including other closely located facilities regarding the nature of hazard and emergency procedure in event of major accident.

Record and discuss the lessons learned and the analysis of major accident.

7.8.2 Off-site Emergency Preparedness Program

Emergency is a sudden and unexpected event, which can cause serious damage to personnel life, property and environment as a whole, which necessitate evolving Off-site Emergency Plan to combat any such eventuality. In Offsite disaster management plan, many agencies like Revenue, Public Health, Fire Services, Police, Civil Defence, Home Guards, Medical Services and other Voluntary organization are involved. Thus, handling of such emergencies requires an organized multidisciplinary approach.

Evacuation of people, if required, can be done in orderly way. The different agencies involved in evacuation of people are civil administration, Non Govt. organizations, factory Inspectorate including mutual aid partners of industrial unit and Police authorities.

In the present case off-site emergency is mainly occurs fire explosion, fire ball and toxic dispersion causes people in and outside of plant exposed to heat radiation, shock waves and toxic vapour/ gas. Organisation chart of typical Off-site emergency plan is shown in **Fig. 7.4.**

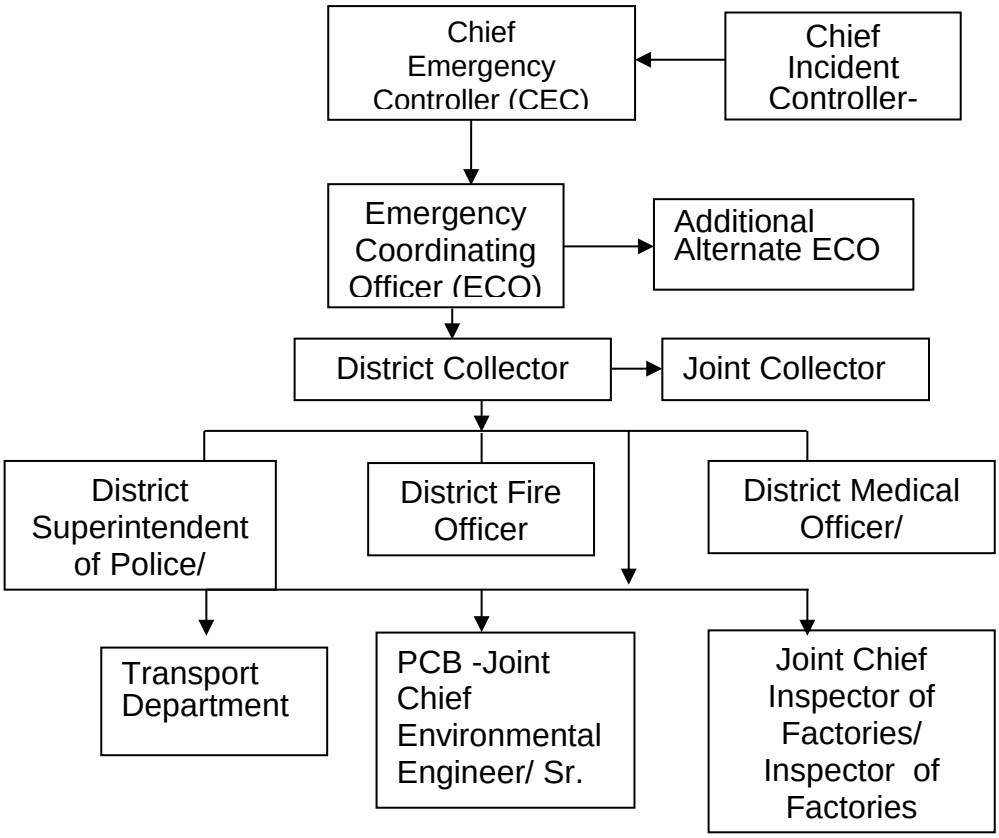


Fig.7.4: Organization chart: Off - Site Emergency Preparedness Plan

Fire: Effects of fire on population will be mainly due to thermal radiation. In such cases, houses situated to the proximity of disaster need to be evacuated, although a severe smoke hazard due to fire is to be reviewed periodically.

Explosion: An explosion will give a very little time to warn population and areas affected may be much longer than that in case of fire. The effects of explosion on population will be mainly due to shock waves, flying splinters, collapse of structures and simultaneously exposure to thermal radiation.

Toxic: Toxic dispersion will affect at down distance of industrial unit, for the same people will be evacuated within 15- 30 minutes being, people may expose to IDLH level of identified toxic gases, by giving necessary warnings and move towards crosswind side, for the same evacuation needed.

7.8.2.1 Purpose of Plan

- To save lives and injuries and to prevent or reduce property losses and to provide for quick resumption of normal situation or operation

- To make explicit inter related set of actions to be undertaken, being event of an industrial accident posing hazards to the community
- To inform people and surrounding about type of emergency and disaster if it is likely to adversely affect and to guide the people in proper way
- To rescue and recuperation of injuries and plan for relief and rehabilitation
- To plan for prevention of harms, total loss and recurrence of disaster and It will be ensured that absolute safety and security is achieved within the shortest time

7.8.2.2 Before Emergency

Safety procedure followed before during an emergency through posters, talks and mass media in different languages including local language. Leaflets containing do's/ don'ts before and during emergency will be circulated to educate the people in vicinity and provide information about hazardous installation, who are potentially affected in the event of an accident, will aware of the risks of accidents. Explain concerning the installation, and understand what to do in the event of an accident. Non-governmental Organizations (NGO's) (Such as environmental, humanitarian and consumer group) will motivate their constituents and others, to be involved in risk reduction and accident prevention efforts and will provide technical assistance to help the public analyse and understand information that is made available.

Public authorities(at all levels) and management of hazardous installation will be established emergency planning activities/ program's for accidents, In this respect public health authorities, including experts from research organisations will be involved in relevant aspects of offsite emergency planning.

Emergency warning alert system will be in place to warn the potentially affected public, and about an imminent threat of an accident.

The system chosen will be effective and provide timely warning. Suitable warning system could include e.g. sirens, automatic telephone message, and mobile public address system etc.

7.8.2.3 During Emergency

As the off-site plan is to be prepared by industrial unit by involving the government and other agencies of control committee will be formed under the chairmanship of area head the group includes officers from local units, police, fire, medical, engineering, social welfare, publicity, transport and requisite departments will be incorporated as members. Some experts will also be included for guidance.

The functions of committee will be:

- To work as main co-coordinating body constituted of necessary district heads and other authorities with overall command, coordination, guidance, supervision, policy and doing all necessary things to control disaster in shortest times
- To take advice and assistance from experts in fields to make plan more successful
- To prepare, review, to keep it document with all details
- The incident control committee, traffic control committee and press publicity committee will first be informed

Hospital Committee consisted of doctors for medical help to the injured persons because of disaster. Injuries may be of many types. As such doctors are rarely available we have to mobilize and utilize all available doctors in the area.

Functions and duties of the committee include:

On receiving information to rush to spot he will immediately inform his team and will proceed with all necessary equipment's to give medical help to all injured as early as possible.

First aid and possible treatment will be provided at the spot or at some convenient place and patients may be requested to shift to hospitals for further treatment.

Continuity of the treatment will be maintained till the disaster is controlled.

Traffic Control, Law and Order: Functions and duties of this committee will be:

- To control traffic towards and near disaster to maintain law and order
- To evacuate the places badly affected or likely to be affected
- To shift the evacuated people to safe assembly points and rehabilitate them after disaster is over.

However necessary vehicles, wireless sets and instruments for quick communications will be maintained and used as per need.

7.8.2.4 After emergency

Functions and duties of emergency (ECG/EAG) committee are:

- To find out persons in need of human help owing to disastrous effect. They may give first aid if medical team is not available
- They will serve the evacuated people kept at assembly points. They will arrange for their food, water, shelter, clothing, sanitation, and guidelines to reach any needful places
- They will look for removal and disposal of dead bodies if any and for help of sick, weak, children and needy persons for their essential requirements
- The team will also work for restoration of detached people, lost articles, essential commodities etc.

- The team will also look after the restoration of government articles
- The team will also ensure that the original activities, services and systems are resumed again as they were functioning before the disaster

Police Department

- The police will assist in controlling of the accident site, organizing evacuation and removing of any seriously injured people to hospitals.
- Co-ordination with the transport authorities, civil defence and home guards
- Arrange for post mortem of dead bodies
- Establish communication centre

Fire Officer / District or Divisional Fire Officer

The team will organize to put out fires and provide assistance as required.

Hospitals and Doctors

Hospitals and doctors may be ready to treat any injuries. Proponent Co-ordinate the activities of Primary Health Centres and Municipal Dispensaries to ensure required no. of and quantities of drugs and equipment's are available**.** We will secure assistance of medical and paramedical personnel from nearby hospitals/ medical institutions to control the situation.

Media

The media will have ready and continuous access to designated officials with relevant information, as well as to other sources in order to provide essential and accurate information to public throughout the emergency and to help avoid confusion

Efforts will be made to check the clarity and reliability of information as it becomes available, and before it is communicated to public health authorities will be consulted when issuing statements to the media concerning health aspects of chemical accidents.

Members of the media will facilitate response efforts by providing means for informing the public with credible information about accidents involving hazardous substances

Non-governmental organizations (NGOs)

NGOs will provide a valuable source of expertise and information to support emergency response efforts. Members of NGOs could assist response personnel by performing specified tasks, as planned in the emergency planning process. Such tasks would include providing humanitarian, psychological and social assistance to members of community and response person.

Duties of NGOs are listed below:

- Evacuation of personnel from the affected area
- Arrangements at rallying posts and parking yards
- Rehabilitation of evacuated persons
- Co-ordination with other agencies such as police, medical, agriculture, electricity board, fire services, home guards and civil defence.
- Establishing shelters for rescue, medical, fire fighting personnel.

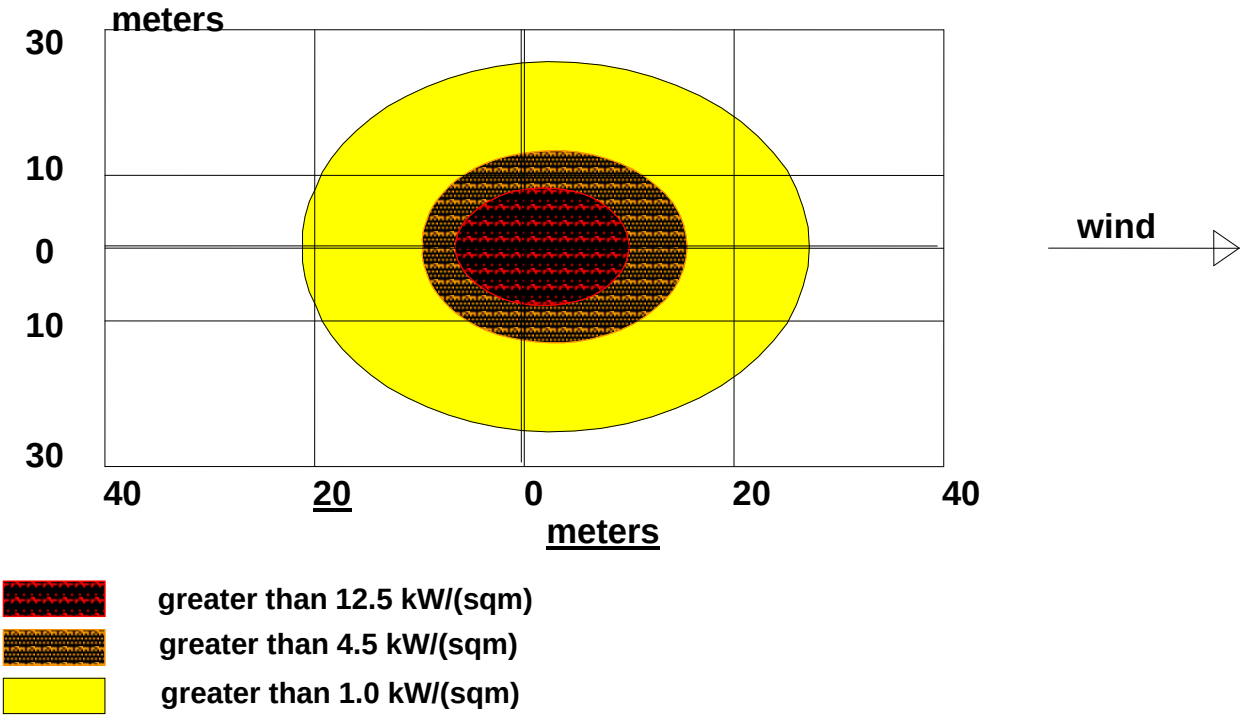
7.9 Conclusion & Recommendations

1. Fire/ Explosion considered as considerable accident scenario in Ms NATCO Pharma Ltd., being Methanol has provision of maximum of 100 KL and 30 KL capacity and considered as highly flammable. Other flammable liquids are IPA, Hexanol, Toluene, Butanol and others has a provision 30 KL capacity and all are storing in tank form Area.
2. Being stored in tank form area with respective dykes, leak and release of material causes pool fire if spark or ignited. It indicates heat radiation effect few meters from edge of pool, need of on-site emergency plan.
3. In case of Fire/ explosion due to delayed ignition/ spark after vapour cloud formation causes effect of heat radiation and pressure wave crosses the industry boundary need of Off- site emergency preparedness plan and the plan also required in case of BLEVE causes fire ball.
4. Specific measures to be taken to avoid or minimise accident, at storage yard fixed and movable fire-fighting system will be provided to control vapour cloud formation in case of leak/ discharge as well as to minimise exposure of heat by storage tanks.
5. M/s NATCO is also planning to be stored several flammable liquid in drums in ware houses. In case of leak or rupture of drums forms unconfined pool, if ignited of vapour cloud causes severe heat radiation and explosion effect on respective ware house area.
6. Spill contaminant pallets/ adsorbent to be used effectively to minimise the spill over of material and control leak effectively and contaminated material disposed environmental friendly.
7. M/ s NATCO will use several toxic liquid/ gases i.e. Bromine, Benzyl chloride Thionyl chloride, ammonia and chlorine gas including Sulfuric acid vapors. MCA analysis indicates that there is a possibility of IDLH level exposure within and outside the plant area at downwind direction.

8. Specific remedial measures to be adopted to minimise the leak and control at source and simultaneously off- site emergency plan may be initiated including evacuation plan followed by medical aid with need of hour.
9. In the case of leak and direct release of liquid corresponding vapours dispersed towards down side of plant area even more than 1.0 km crossing plant boundary and exposed to IDLH level.
10. Steps will be taken to control at source to minimise spread of unconfined area by bordering inert material adsorbent, control the leak if possible. In case of uncontrolled situation delineated emergency plan including evacuation of possible exposures.
11. Presence of other hazard storages and handling as per on -site plan necessary, expect in few occasions of total discharge of material, however time to time emergency plan may be upgraded as when needed as per regulations.

METHANOL
SITE DATA:
Location: NATCO Pharma Ltd., Chemical Division, Kothur
Building Air Exchanges Per Hour: 0.48 (unsheltered single storied)
Time: October 20, 2015 2306 hours ST (using computer's clock)
CHEMICAL DATA:
Chemical Name: METHANOL Molecular Weight: 32.04 g/mol
AEGL-1 (60 min): 530 ppm AEGL-2 (60 min): 2100 ppm AEGL-3 (60 min): 7200 ppm
IDLH: 6000 ppm LEL: 71800 ppm UEL: 365000 ppm
Ambient Boiling Point: 63.5° C
Vapor Pressure at Ambient Temperature: 0.17 atm
Ambient Saturation Concentration: 172,629 ppm or 17.3%
ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 2 meters/second from 120° true at 3 meters
Ground Roughness: open country Cloud Cover: 5 tenths
Air Temperature: 25° C
Stability Class: D (user override)
No Inversion Height Relative Humidity: 50%

1. SOURCE STRENGTH:
Leak from hole in from tank vent/ valve
Flammable chemical is burning as it escapes from tank
Tank Volume: 100 cubic meters
Tank contains liquid
Internal Temperature: 25° C
Chemical Mass in Tank: 78,961 kilograms
Tank is 100% full
Circular Opening Diameter: 4 inches
THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : less than 10 meters(10.9 yards) --- (12.5 kW/(sq m))
Orange: 15 meters --- (4.5 kW/(sq m))
Yellow: 27 meters --- (1.0 kW/(sq m))



2. A SOURCE STRENGTH:
Direct Source: 16.67 cubic meters/hr
Source Height: 0
Source State: Liquid
Source Temperature: equal to ambient
Release Duration: 15 minutes
Release Rate: 219 kilograms/min
Total Amount Released: 3,291 kilograms

THREAT ZONE:
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Heavy Gas
Red : LOC was never exceeded --- (4.5 psi)
Orange: 28 meters --- (1.5 psi)
Yellow: 46 meters – (0.5 Psi)

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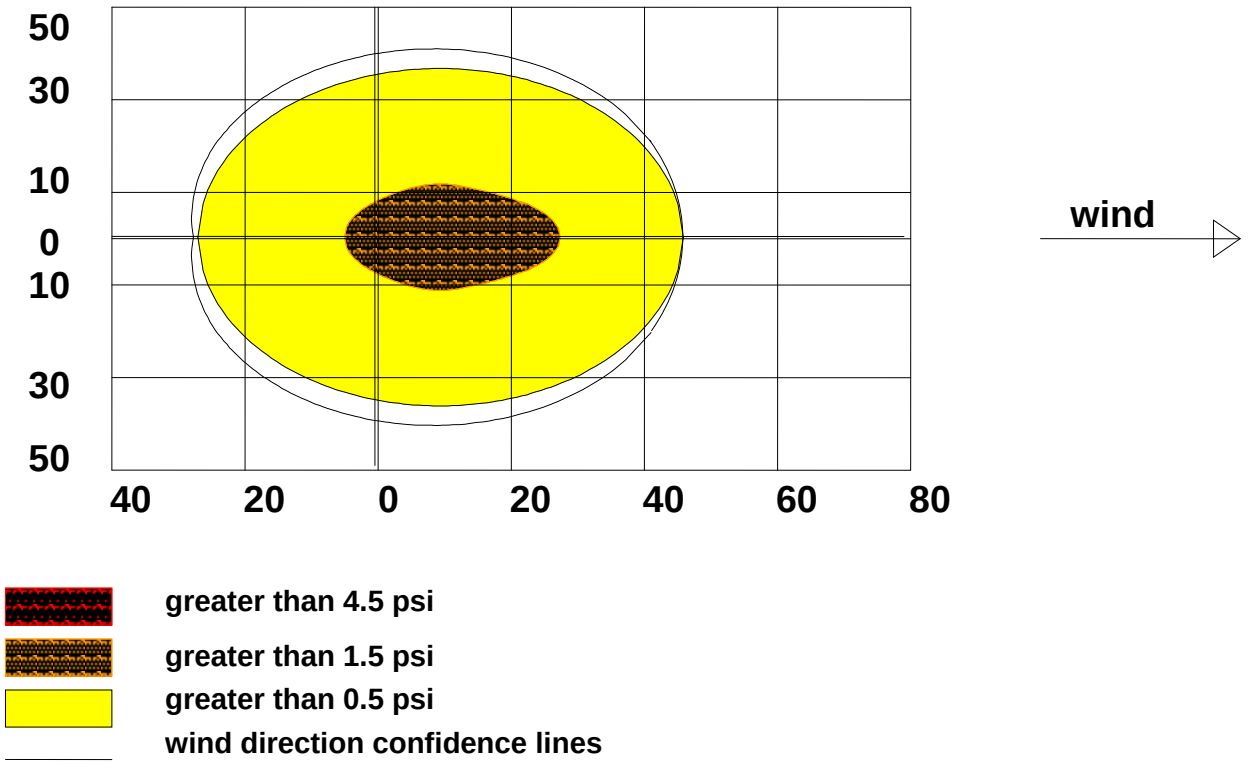


3. SOURCE STRENGTH:

Direct Source: 30 cubic meters Source Height: 0

Source State: Liquid

Source Temperature: equal to ambient

Release Duration: 1 minute

Release Rate: 395 kilograms/sec

Total Amount Released: 23,688 kilograms

THREAT ZONE:

Threat Modeled: Overpressure (blast force) from vapor cloud explosion

Type of Ignition: ignited by spark or flame

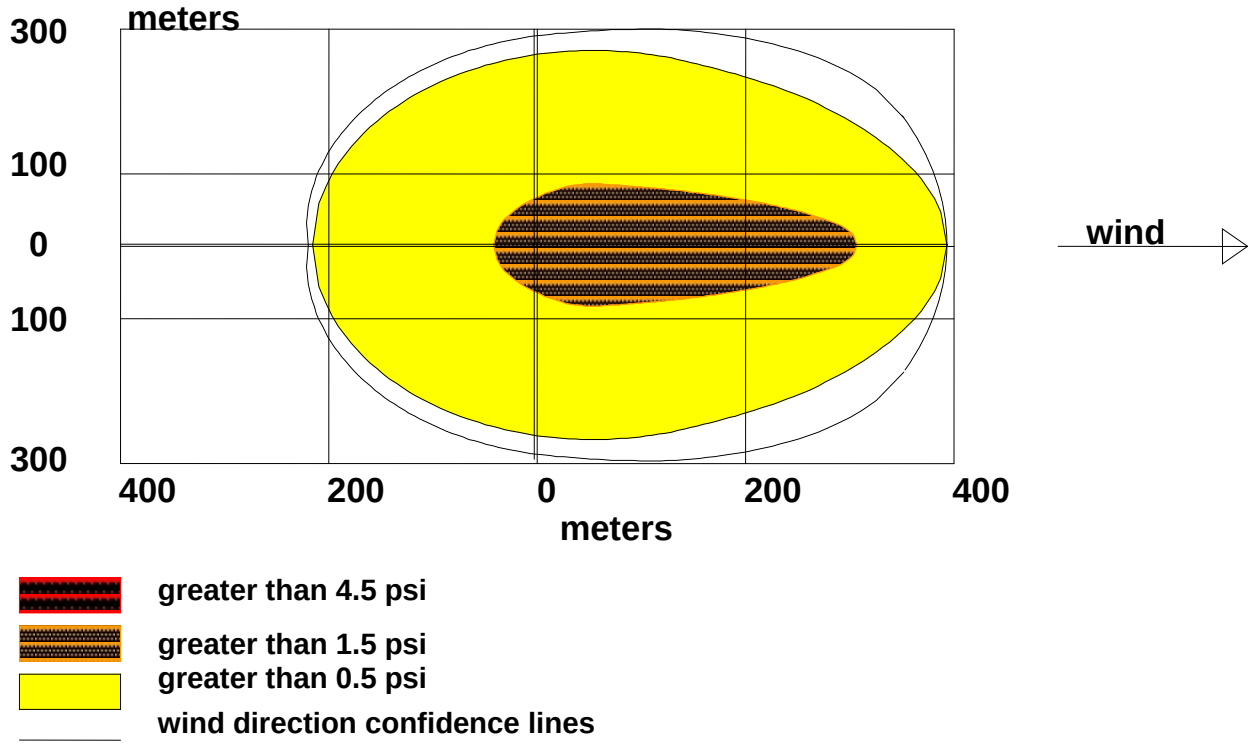
Level of Congestion: congested

Model Run: Heavy Gas

Red : LOC was never exceeded --- (4.5 psi)

Orange: 309 meters --- (1.5 psi)

Yellow: 395 meters --- (0.5 psi)



4. SOURCE STRENGTH:

BLEVE of flammable liquid in horizontal cylindrical tank

Tank Diameter: 2.5 meters Tank Length: 6.2 meters

Tank Volume: 30.4 cubic meters

Tank contains liquid

Internal Storage Temperature: 25° C

Chemical Mass in Tank: 26.1 tons Tank is 99% full

Percentage of Tank Mass in Fireball: 100%

Fireball Diameter: 167 meters Burn Duration: 11 seconds

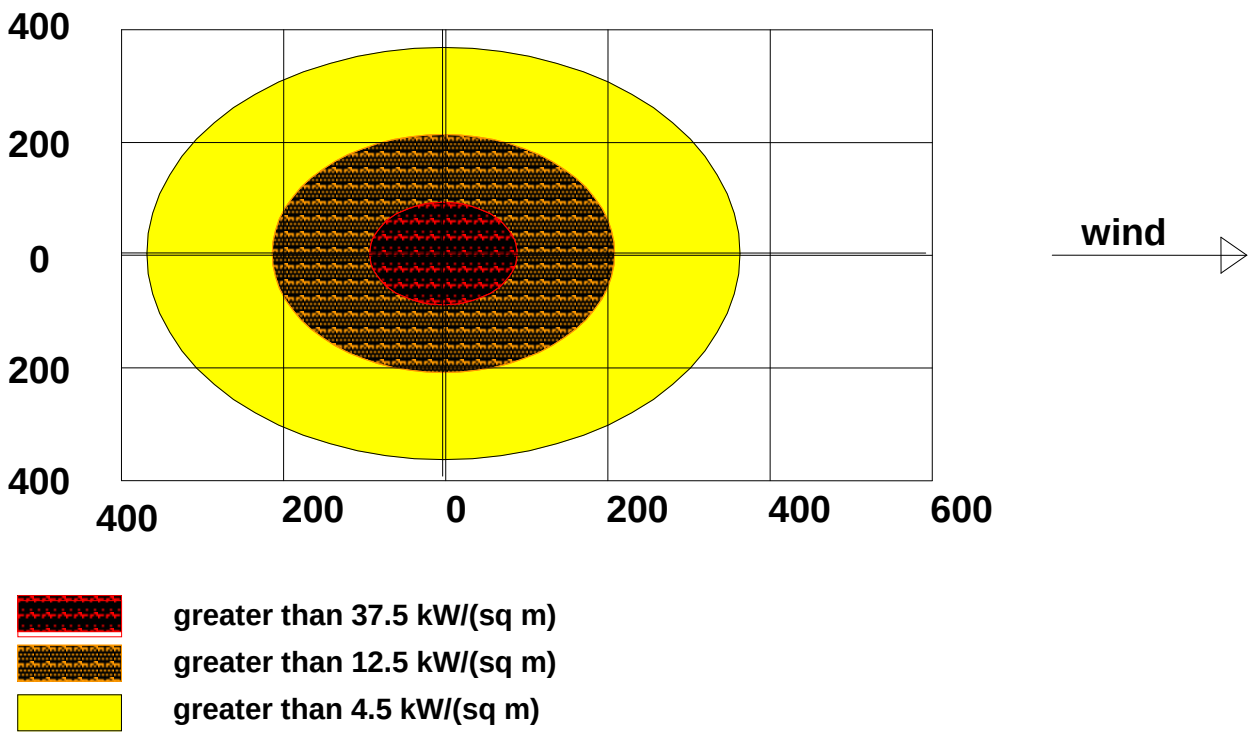
THREAT ZONE:

Threat Modeled: Thermal radiation from fireball

Red : 91 meters --- (37.5 kW/(sq m))

Orange: 212 meters --- (12.5 kW/(sq m))

Yellow: 367 meters --- (4.5 kW/(sq m))



ANNEXURE - XLIII

SITE DATA:
Location: NATCO Pharma Ltd., Chemical Division Kothur
Time: October 19, 2015 2257 hours ST (using computer's clock)

CHEMICAL DATA:
Chemical Name: N-HEXANE Molecular Weight: 86.18 g/mol
AEGL-1 (60 min): N/A AEGL-2 (60 min): 2900 ppm AEGL-3 (60 min): 8600 ppm
IDLH: 1100 ppm LEL: 12000 ppm UEL: 72000 ppm
Ambient Boiling Point: 67.5° C
Vapor Pressure at Ambient Temperature: 0.25 atm
Ambient Saturation Concentration: 257,269 ppm or 25.7%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 2 meters/second from 120° true at 3 meters
Ground Roughness: open country Cloud Cover: 5 tenths
Air Temperature: 30° C
Stability Class: D (user override)
No Inversion Height Relative Humidity: 50%

1. SOURCE STRENGTH:

Evaporating Puddle (Note: chemical is flammable)
Puddle Diameter: 6.2 meters Puddle Volume: 30 cubic meters
Ground Type: Concrete Ground Temperature: 30° C
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 h1.our
Max Average Sustained Release Rate: 7.76 kilograms/min
(averaged over a minute or more)
Total Amount Released: 438 kilograms

THREAT ZONE:

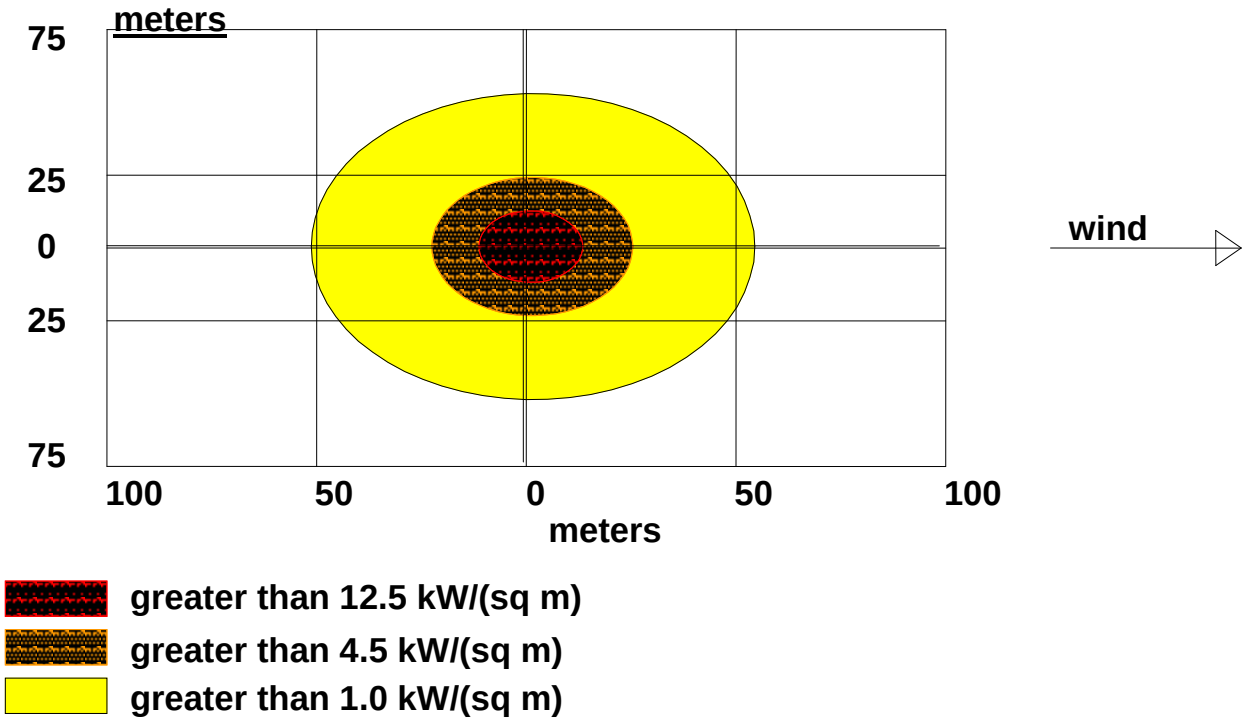
Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : LOC was never exceeded --- (7.7 % by vol)
Orange: less than 10 meters(10.9 yards) --- (1.2 % by vol)
Note: Threat zone was not drawn because effects of near-field patchiness
make dispersion predictions less reliable for short distances.
Yellow: 33 meters --- (1200 ppm = 10% LEL)
Note: Threat zone was not drawn because effects of near-field patchiness
make dispersion predictions less reliable for short distances.

2.SOURCE STRENGTH:

Burning Puddle / Pool Fire
Puddle Diameter: 6.2 meters Puddle Volume: 30 cubic meters
Initial Puddle Temperature: Air temperature
Flame Length: 18 meters
Burn Duration: ALOHA limited the duration to 1 hour
Burn Rate: 192 kilograms/min
Total Amount Burned: 11,540 kilograms

THREAT ZONE:

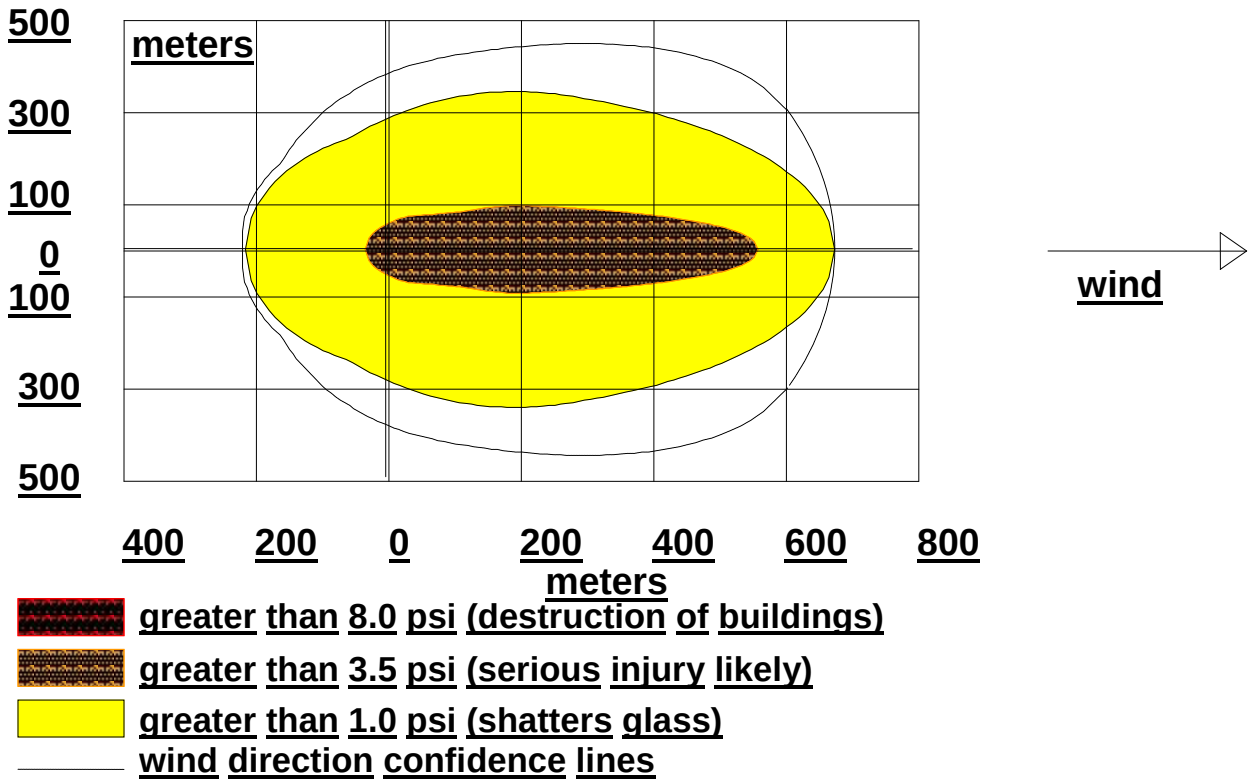
Threat Modeled: Thermal radiation from pool fire
Red : 14 meters --- (12.5 kW/(sq m))
Orange: 25 meters --- (4.5 kW/(sq m))
Yellow: 54 meters --- (1.0 kW/(sq m))



3. SOURCE STRENGTH:

Direct Source: 30 cubic meters Source Height: 0
Source State: Liquid
Source Temperature: equal to ambient
Release Duration: 1 minute
Release Rate: 326 kilograms/sec
Total Amount Released: 19,545 kilograms

THREAT ZONE:
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
M odel Run: Heavy Gas
Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)
Orange: 558 meters --- (3.5 psi = serious injury likely)
Yellow: 674 meters --- (1.0 psi = shatters glass)

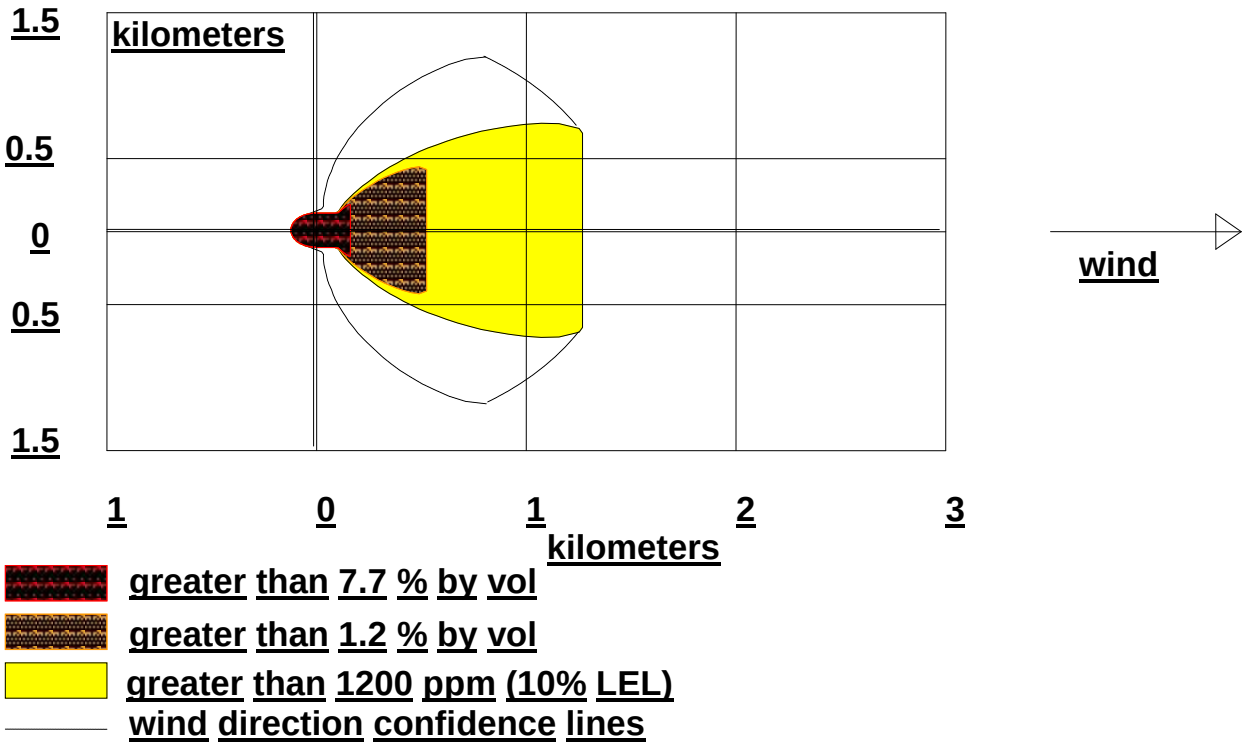


3. SOURCE STRENGTH:

Direct Source: 30 cubic meters Source Height: 0
Source State: Liquid
Source Temperature: equal to ambient
Release Duration: 1 minute
Release Rate: 326 kilograms/sec
Total Amount Released: 19,545 kilograms

THREAT ZONE:

Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : 166 meters --- (7.7 % by vol)
Orange: 530 meters --- (1.2 % by vol)
Yellow: 1.3 kilometers --- (1200 ppm = 10% LEL)

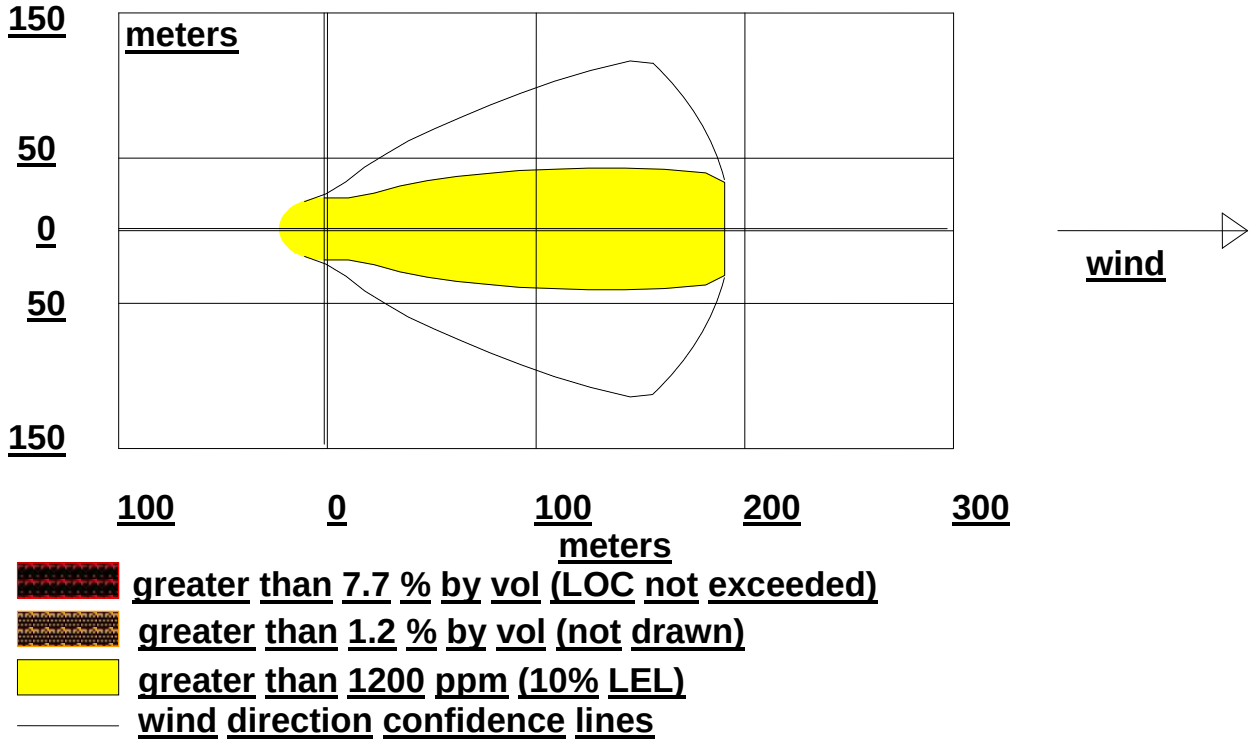


4. SOURCE STRENGTH:

Leak from hole in horizontal cylindrical tank Flammable chemical escaping from tank (not burning)
Tank Diameter: 2.5 meters Tank Length: 6.11 meters
Tank Volume: 30 cubic meters
Tank contains liquid Internal Temperature: 30° C
Chemical Mass in Tank: 21.5 tons Tank is 100% full
Circular Opening Diameter: 4 inches
Opening is 4 inches from tank bottom
Ground Type: Default soil Ground Temperature: 30° C
Max Puddle Diameter: Unknown
Release Duration: ALOHA limited the duration to 1 hour
Max Average Sustained Release Rate: 271 kilograms/min
(averaged over a minute or more)
Total Amount Released: 12,288 kilograms
Note: The chemical escaped as a liquid and formed an evaporating puddle.
The puddle spread to a diameter of 55 meters.

THREAT ZONE:

Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : LOC was never exceeded --- (7.7 % by vol)
Orange: 38 meters --- (1.2 % by vol)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
Yellow: 191 meters --- (1200 ppm = 10% LEL)

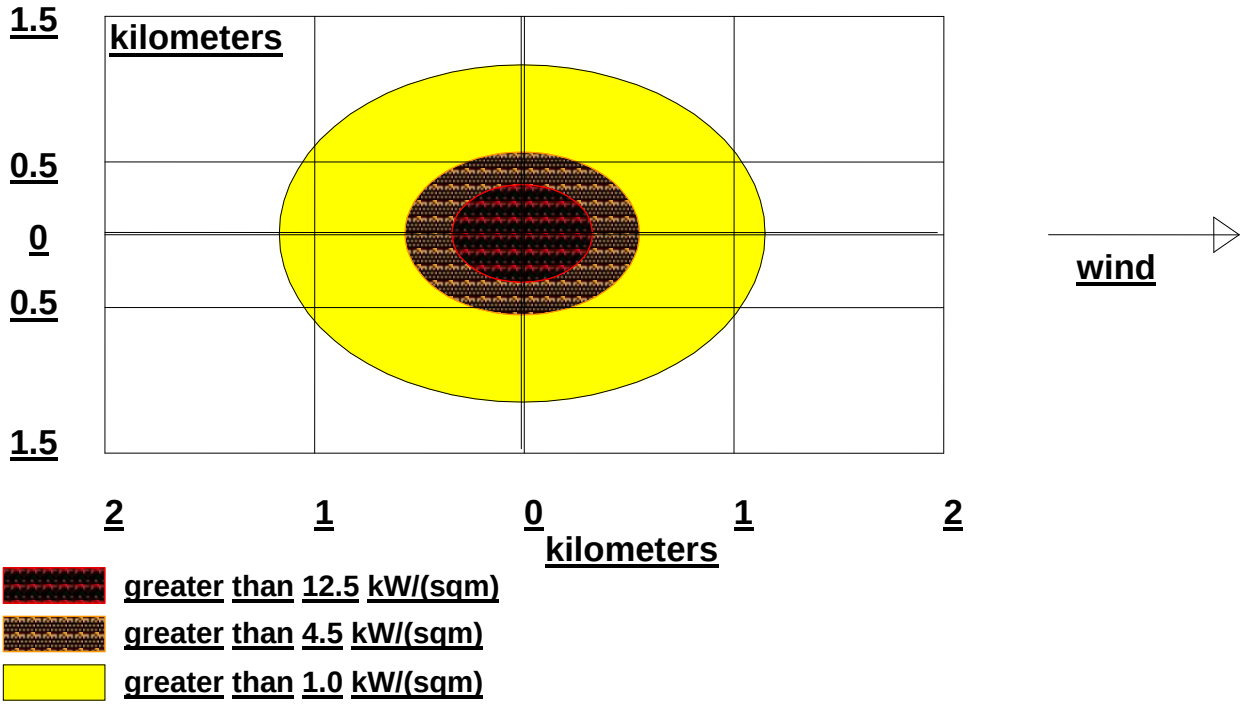


5. SOURCE STRENGTH:

BLEVE of flammable liquid in horizontal cylindrical tank
Tank Diameter: 2.5 meters Tank Length: 6.11 meters
Tank Volume: 30 cubic meters
Tank contains liquid
Internal Storage Temperature: 30° C
Chemical Mass in Tank: 21.5 tons Tank is 100% full
Percentage of Tank Mass in Fireball: 100%
Fireball Diameter: 156 meters Burn Duration: 11 seconds

THREAT ZONE:

Threat Modeled: Thermal radiation from fireball
Red : 334 meters --- (12.5 kW/(sq m))
Orange: 557 meters --- (4.5 kW/(sq m))
Yellow: 1.2 kilometers --- (1.0 kW/(sq m))



6.SOURCE STRENGTH:

Leak from hole in horizontal cylindrical tank
Flammable chemical is burning as it escapes from tank
Tank Diameter: 2.5 meters Tank Length: 6.11 meters
Tank Volume: 30 cubic meters
Tank contains liquid Internal Temperature: 30° C
Chemical Mass in Tank: 21.5 tons Tank is 100% full
Circular Opening Diameter: 4 inches
Opening is 4 inches from tank bottom
Max Flame Length: 2 meters
Burn Duration: ALOHA limited the duration to 1 hour
Max Burn Rate: 465 grams/min
Total Amount Burned: 27.9 kilograms
Note: The chemical escaped as a liquid and formed a burning puddle.
The puddle spread to a diameter of 0.3 meters.

THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : less than 10 meters(10.9 yards) --- (12.5 kW/(sq m))
Orange: less than 10 meters(10.9 yards) --- (4.5 kW/(sq m))
Yellow: less than 10 meters(10.9 yards) --- (1.0 kW/(sq m))

7. SOURCE STRENGTH:
Leak from hole in horizontal cylindrical tank
Flammable chemical is burning as it escapes from tank
Tank Diameter: 2.5 meters Tank Length: 6.11 meters
Tank Volume: 30 cubic meters
Tank contains liquid Internal Temperature: 30° C
Chemical Mass in Tank: 21.5 tons Tank is 100% full
Circular Opening Diameter: 4 inches
Opening is 4 inches from tank bottom
Max Flame Length: 2 meters
Burn Duration: ALOHA limited the duration to 1 hour
Max Burn Rate: 465 grams/min
Total Amount Burned: 27.9 kilograms
Note: The chemical escaped as a liquid and formed a burning puddle.
The puddle spread to a diameter of 0.3 meters.

THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : less than 10 meters(10.9 yards) --- (12.5 kW/(sq m))
Orange: less than 10 meters(10.9 yards) --- (4.5 kW/(sq m))
Yellow: less than 10 meters(10.9 yards) --- (1.0 kW/(sq m))

ANNEXURE - XLIV

SITE DATA: Butanol

Location: NATCO Pharma Ltd., Chemical Division, Kothur

Building Air Exchanges Per Hour: 0.48 (unsheltered single storied)

Time: November 11, 2015 2115 hours ST (using computer's clock)

CHEMICAL DATA:

Chemical Name: N-BUTYL ALCOHOL Molecular Weight: 74.12 g/mol

PAC-1: 20 ppm PAC-2: 50 ppm PAC-3: 8000 ppm

IDLH: 1400 ppm LEL: 17000 ppm UEL: 113000 ppm

Ambient Boiling Point: 118.7° C

Vapor Pressure at Ambient Temperature: 0.0089 atm

Ambient Saturation Concentration: 9,242 ppm or 0.92%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 2 meters/second from 120° true at 3 meters

Ground Roughness: open country Cloud Cover: 5 tenths

Air Temperature: 25° C

Stability Class: D (user override)

No Inversion Height Relative Humidity: 50%

1. SOURCE STRENGTH:

Direct Source: 200 kilograms/min Source Height: 0

Release Duration: 60 minutes

Release Rate: 200 kilograms/min

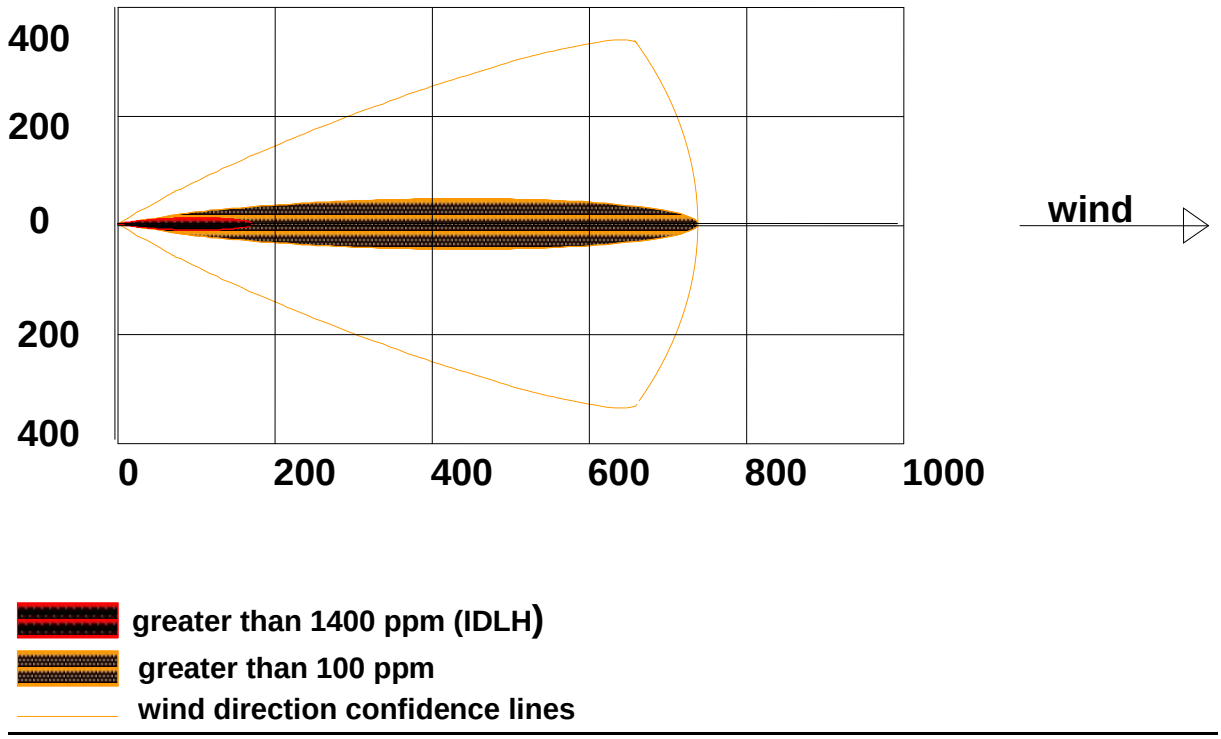
Total Amount Released: 12,000 kilograms

THREAT ZONE: (GAUSSIAN SELECTED)

Model Run: Gaussian

Red : 172 meters --- (1400 ppm = IDLH)

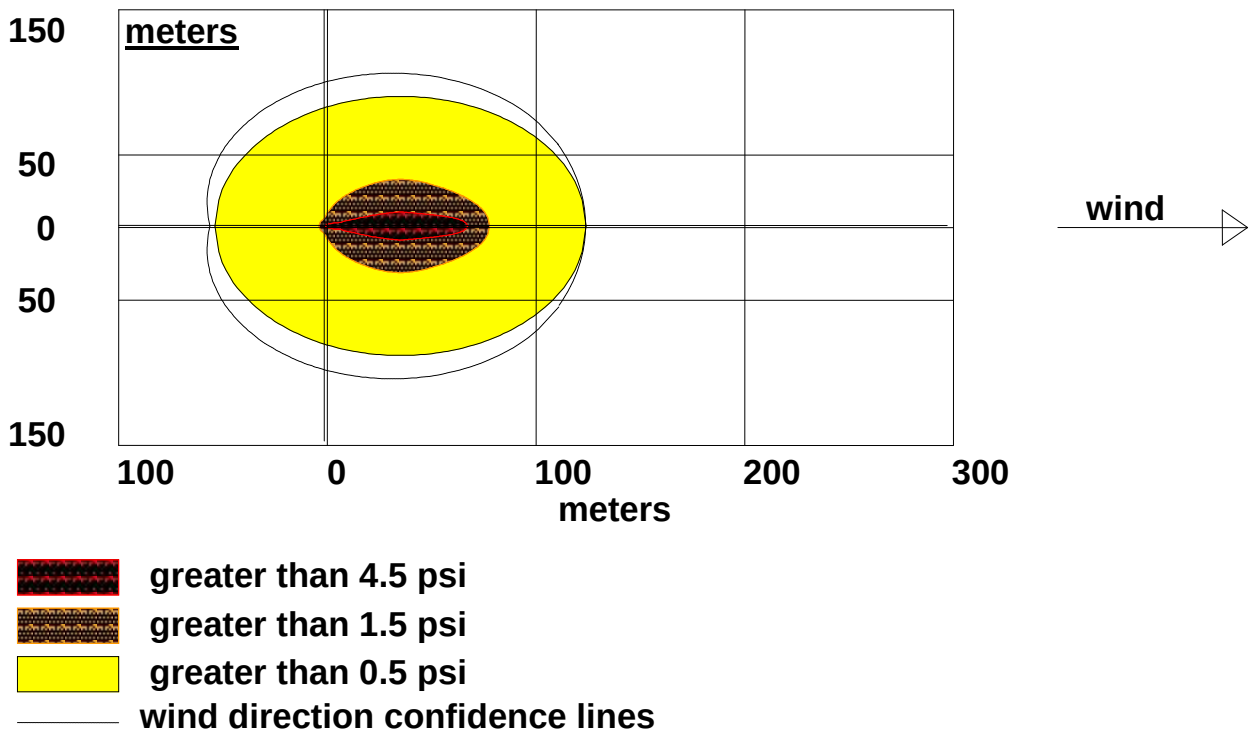
Orange: 741 meters --- (100 ppm)


400
200
0
200
400
0
200
400
600
800
1000
wind
greater than 1400 ppm (IDLH)
greater than 100 ppm
wind direction confidence lines

2. SOURCE STRENGTH:

Direct Source: 200 kilograms/min Source Height: 0
Release Duration: 60 minutes
Release Rate: 200 kilograms/min
Total Amount Released: 12,000 kilograms

THREAT ZONE: (GAUSSIAN SELECTED)
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Gaussian, Red : 68 meters --- (4.5 psi)
Orange: 79 meters --- (1.5 psi), Yellow: 125 meters --- (0.5 psi)

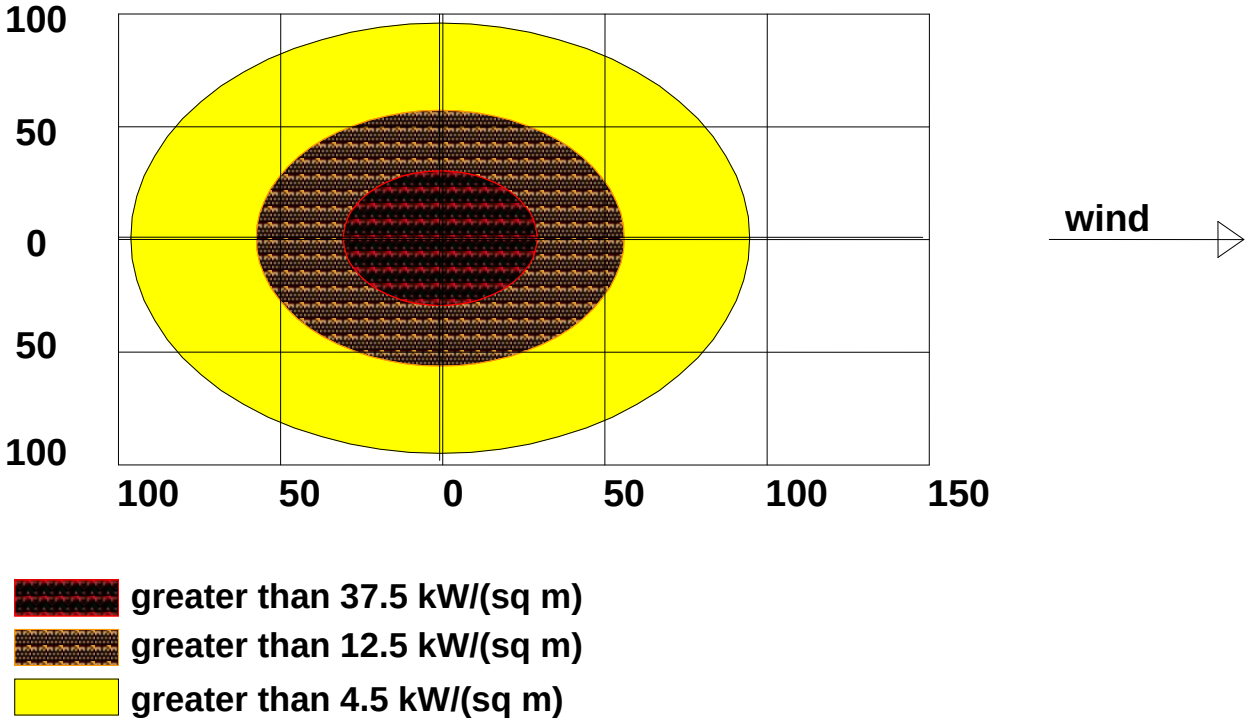


3. SOURCE STRENGTH:

BLEVE of flammable liquid in vertical cylindrical tank
Tank Diameter: 0.5 meters Tank Length: 1 meters
Tank Volume: 196 liters
Tank contains liquid
Internal Storage Temperature: 25° C
Chemical Mass in Tank: 0.17 tons Tank is 99% full
Percentage of Tank Mass in Fireball: 100%
Fireball Diameter: 31 meters Burn Duration: 3 seconds

THREAT ZONE:

Threat Modeled: Thermal radiation from fireball
Red : 30 meters --- (37.5 kW/(sq m))
Orange: 57 meters --- (12.5 kW/(sq m))
Yellow: 95 meters --- (4.5 kW/(sq m))



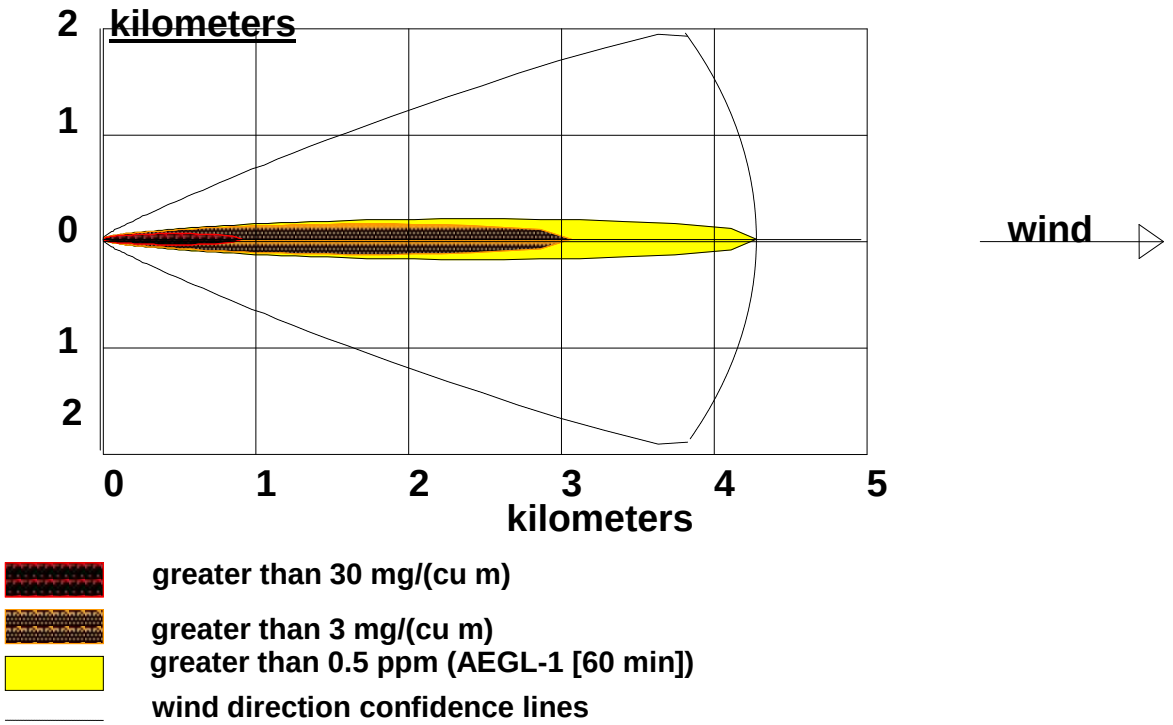
SITE DATA:
Location: NATCO Pharma Ltd., Chemical Division, Kothur
Building Air Exchanges Per Hour: 0.62 (unsheltered single storied)
Time: October 18, 2015 0051 hours ST (using computer's clock)

CHEMICAL DATA:
Chemical Name: CHLORINE Molecular Weight: 70.91 g/mol
AEGL-1 (60 min): 0.5 ppm AEGL-2 (60 min): 2 ppm AEGL-3 (60 min): 20 ppm
IDLH: 10 ppm
Ambient Boiling Point: -34.9° C
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 2 meters/second from 120° true at 3 meters Ground Roughness: open country
Cloud Cover: 5 tenths
Air Temperature: 30° F
Stability Class: D (user override)
No Inversion Height Relative Humidity: 50%

1. SOURCE STRENGTH:
Direct Source: 0.25 kilograms/sec Source Height: 0
Release Duration: 60 minutes
Release Rate: 15 kilograms/min
Total Amount Released: 900 kilograms
Note: This chemical may flash boil and/or result in two phase flow.

THREAT ZONE:
Model Run: Heavy Gas
Red : 908 meters --- (30 mg/(cu m))
Orange: 3.1 kilometers --- (3 mg/(cu m))
Yellow: 4.3 kilometers --- (0.5 ppm = AEGL-1 [60 min])

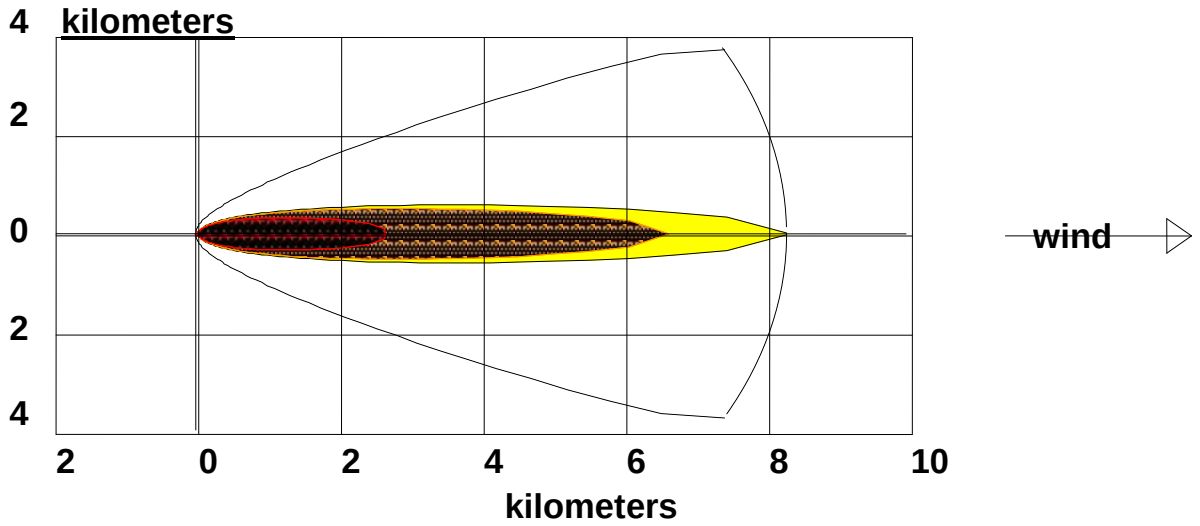


2. SOURCE STRENGTH:

Direct Source: 900 kilograms Source Height: 0
Release Duration: 1 minute
Release Rate: 15 kilograms/s ec
Total Amount Released: 900 kilograms
Note: This chemical may flash boil and/or result in two phase flow.

THREAT ZONE:

Model Run: Heavy Gas
Red : 2.6 kilometers --- (30 mg/(cu m))
Orange: 6.6 kilometers --- (3 mg/(cu m))
Yellow: 8.3 kilometers --- (0.5 ppm = AEGL-1 [60 min])

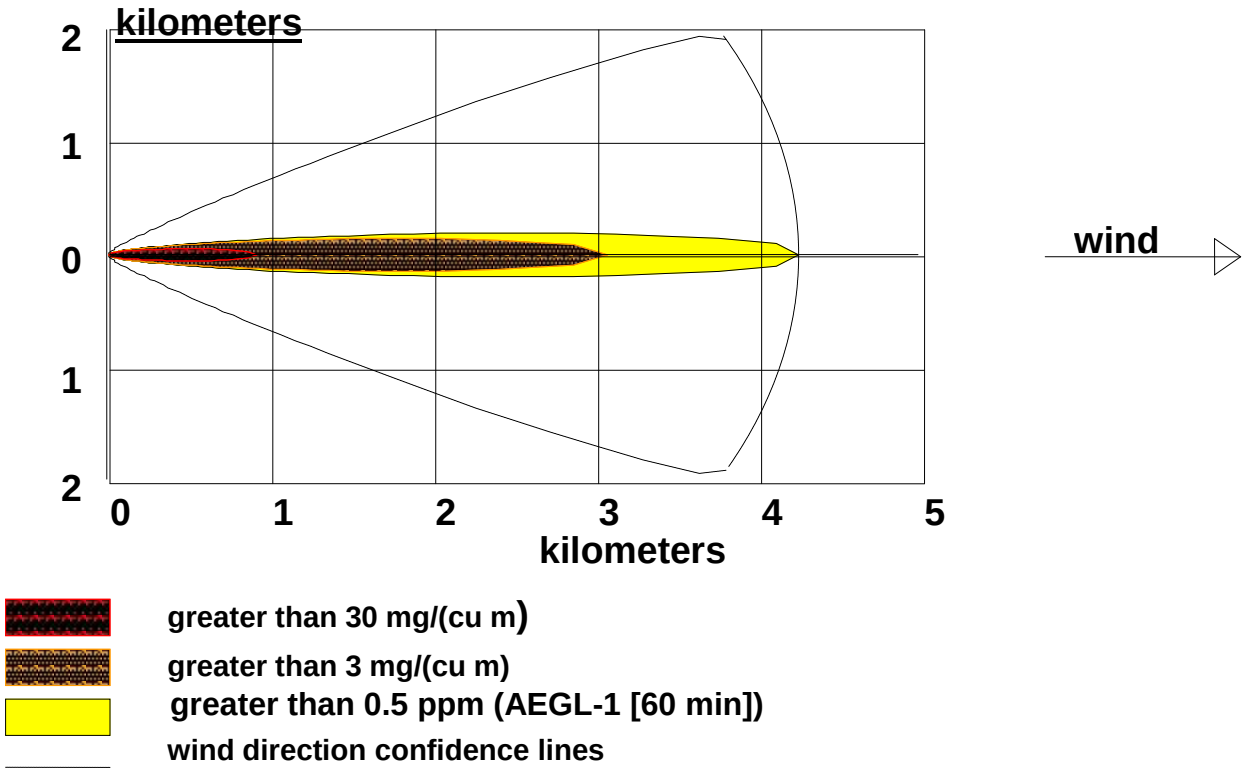


greater than 30 mg/(cu m)
greater than 3 mg/(cu m)
greater than 0.5 ppm (AEGL-1 [60 min])
wind direction confidence lines

3. SOURCE STRENGTH:

Direct Source: 0.25 kilograms/sec Source Height: 0
Release Duration: 15 minutes
Release Rate: 15 kilograms/min
Total Amount Released: 225 kilograms
Note: This chemical may flash boil and/or result in two phase flow.

THREAT ZONE:
Model Run: Heavy Gas
Red : 908 meters --- (30 mg/(cu m))
Orange: 3.1 kilometers --- (3 mg/(cu m))
Yellow: 4.2 kilometers --- (0.5 ppm = AEGL-1 [60 min])



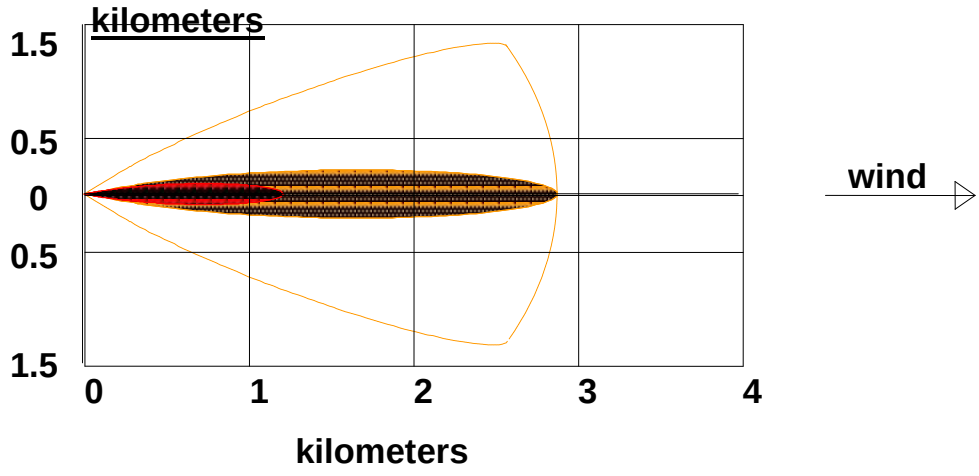
SITE DATA:
Location: NATCO Pharma Ltd., Chemical Division, Kothur
Building Air Exchanges Per Hour: 0.48 (unsheltered single storied)
Time: November 9, 2015 2016 hours ST (using computer's clock)

CHEMICAL DATA:
Chemical Name: BENZYL CHLORIDE Molecular Weight: 126.58 g/mol
ERPG-1: 1 ppm ERPG-2: 10 ppm ERPG-3: 50 ppm
IDLH: 10 ppm LEL: 11000 ppm UEL: 71000 ppm
Carcinogenic risk - see CAMEO Chemicals
Ambient Boiling Point: 178.5° C
Vapor Pressure at Ambient Temperature: 0.0017 atm
Ambient Saturation Concentration: 1,784 ppm or 0.18%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 2 meters/second from 120° true at 3 meters
Ground Roughness: open country Cloud Cover: 5 tenths
Air Temperature: 25° C
Stability Class: D (user override)
No Inversion Height Relative Humidity: 50%

SOURCE STRENGTH:
Direct Source: 220 kilograms Source Height: 0
Release Duration: 1 minute
Release Rate: 3.67 kilograms/sec, Total Amount Released: 220 kilograms

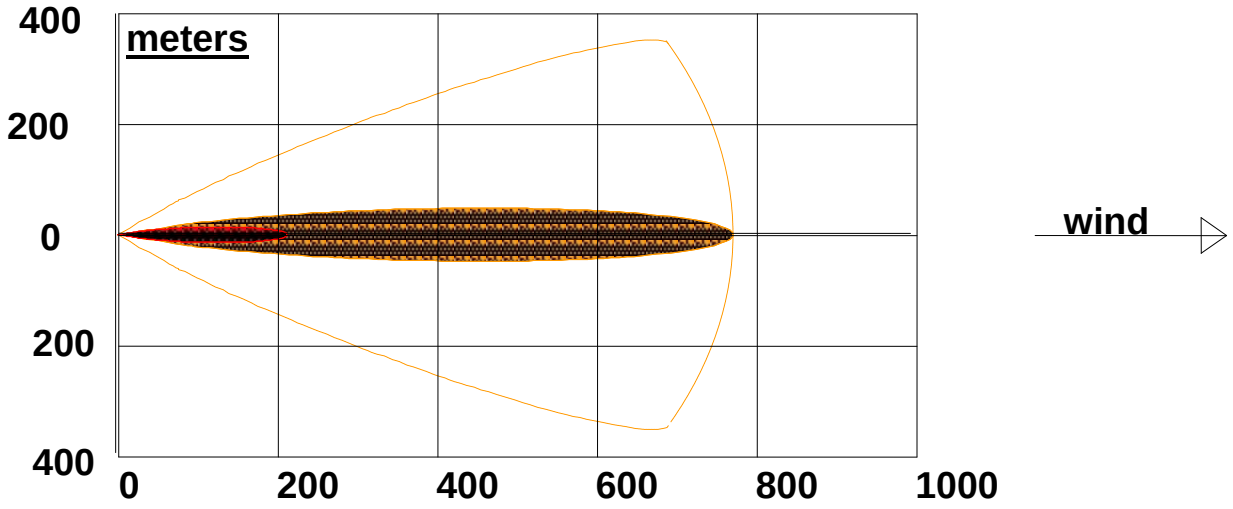
THREAT ZONE: (GAUSSIAN SELECTED)
Red : 1.2 kilometers --- (10 ppm = IDLH),
Orange: 2.9 kilometers --- (1 ppm = TLV)



SOURCE STRENGTH:

Direct Source: 220 kilograms/hr Source Height: 0
Release Duration: 60 minutes, Release Rate: 3.67 kilograms/min
Total Amount Released: 220 kilograms

THREAT ZONE: (GAUSSIAN SELECTED)
Red : 213 meters --- (10 ppm = IDLH)
Orange: 773 meters --- (1 ppm = TLV)

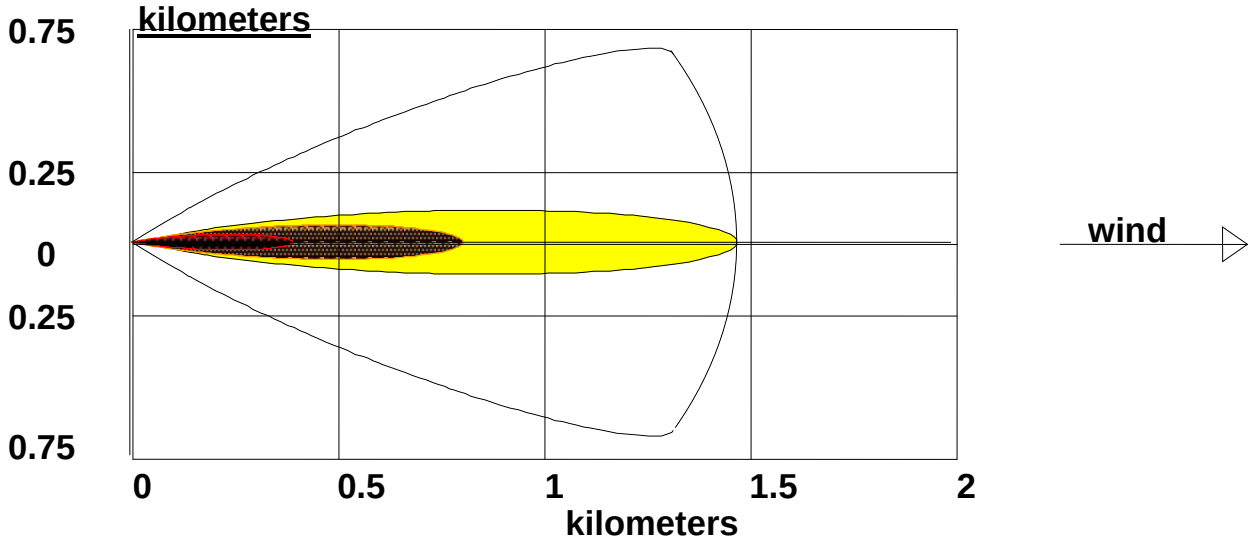


SITE DATA:
Location: NATCO Pharma Ltd., Chemical Division, Kothur
Building Air Exchanges Per Hour: 0.62 (unsheltered single storied)
Time: October 18, 2015 0051 hours ST (using computer's clock)

CHEMICAL DATA:
Chemical Name: AMMONIA Molecular Weight: 17.03 g/mol
AEGL-1 (60 min): 30 ppm AEGL-2 (60 min): 160 ppm AEGL-3 (60 min): 1100 ppm
IDLH: 300 ppm LEL: 150000 ppm UEL: 280000 ppm
Ambient Boiling Point: -34.2° C
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 2 meters/second from 120° true at 3 meters
Ground Roughness: open country Cloud Cover: 5 tenths
Air Temperature: 30° c
Stability Class: D (user override)
No Inversion Height Relative Humidity: 30%

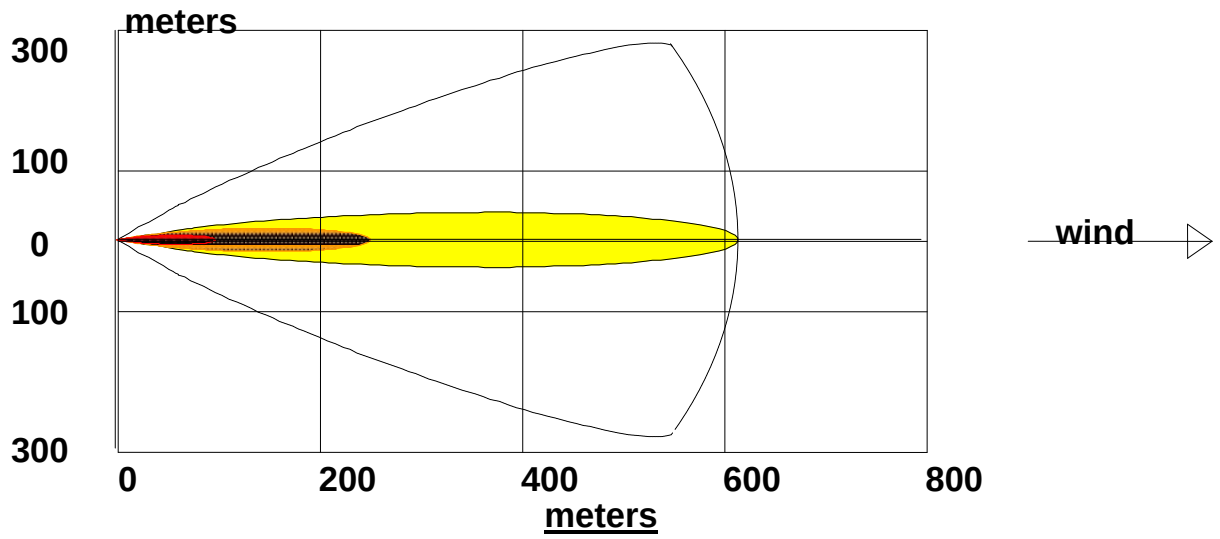
1. SOURCE STRENGTH:
Direct Source: 50 kilograms Source Height: 0
Release Duration: 1 minute
Release Rate: 833 grams/sec
Total Amount Released: 50.0 kilograms
Note: This chemical may flash boil and/or result in two phase flow.



THREAT ZONE:
Model Run: Gaussian
Red : 391 meters --- (210 mg/(cu m))
Orange: 807 meters --- (35 mg/(cu m))
Yellow: 1.5 kilometers --- (7 mg/(cu m))

2. SOURCE STRENGTH:
Direct Source: .056 kilograms/sec Source Height: 0
Release Duration: 15 minutes
Release Rate: 3.36 kilograms/min
Total Amount Released: 50.4 kilograms

.



THREAT ZONE:
Model Run: Gaussian
Red : 97 meters --- (210 mg/(cu m))
Orange: 251 meters --- (35 mg/(cu m))
Yellow: 616 meters --- (7 mg/(cu m))