Chapter-7
Additional Studies

(A) Hazard Analysis & Risk Assessment

7.1 INTRODUCTION

Industrial plants deal with materials, which are generally hazardous in nature by virtue of their intrinsic chemical properties or their operating temperatures or pressures or a combination of these. Fire, explosion, toxic release or combinations of these are the hazards associated with industrial plants using hazardous chemicals. More comprehensive, systematic and sophisticated methods of **Safety Engineering**, such as, **Hazard Analysis** and **Quantitative Risk Assessment** have now been developed to improve upon the integrity, reliability and safety of industrial plants. The primary emphasis in safety engineering is to reduce risk to human life, property and environment. Some of the more important methods used to achieve this are:

- **Quantitative Risk Analysis:** Provides a relative measure of the likelihood and severity of various possible hazardous events by critically examining the plant process and design.
- **Work Safety Analysis:** The technique discerns whether the plant layout and operating procedures in practice have any inherent infirmities.
- **Safety Audit:** Takes a careful look at plant operating conditions, work practices and work environments to detect unsafe conditions.

Together, these three broad tools attempt to minimize the chances of accidents occurring. Yet, there always exists, no matter how remote, probability of occurrence of a major accident. If the accident involves highly hazardous chemicals in sufficiently large quantities, the consequences may be serious to the plant, to surrounding areas and the populations residing therein.

7.2 RISK ASSESSMENT-Identification of Hazard

A three 'levels' risk assessment approach has been adopted for **M/s. PI Industries Ltd.** (Henceforth **PIL**) facilities. The risk assessment levels are generally consistent with the practices encountered through various

assignments for medium and large chemical complexes. The brief outline of the three tier approach is given below:

- **Level 1 – Risk Screening**

This is top-down review of worst- case potential hazards/risks, aimed primarily at identifying plant sites or areas within plant, which pose the highest risk. Various screening factors considered include:

- Inventory of hazardous materials;
- Hazardous Materials properties;
- Storage conditions (e.g. temperature and pressure);
- Location sensitivity (distance to residential areas/populace).

The data/information is obtained from plant. The results provide a relative indication of the extent of hazards and potential for risk exposure.

- **Level 2 – Major Risk Survey** (Semi - Quantitative)

The survey approach combines the site inspection with established risk assessment techniques applied both qualitative as well quantitative mode. The primary objective is to identify and select major risks at a specific location in the plant considering possible soft spots/weak links during operation/maintenance. Aspects covered in the risk usually include:

- Process Hazards;
- Process Safety Management Systems;
- Fire Protection and Emergency response equipment and programs.
- Security Vulnerability;
- Impact of hazards consequences (equipment damage, business interruption, injury, fatalities);
- Qualitative risk identification of scenarios involving hazardous materials;
- Risk reduction measures.

Selection of critical scenarios and their potential of damage provide means of prioritising mitigative measures and allocate the resources to the areas with highest risks.

- **Level 3 – Quantitative Risk Assessment** (Deterministic)

This is the stage of assessment of risks associated with all credible hazards (scenarios) with potential to cause an undesirable outcome such as human injury, fatality or destruction of property. The four basic elements include:

- Hazards identification utilizing formal approach (Level 2, HAZOP etc.);
- Frequency Analysis. Based on past safety data (incidents / accidents); Identifying likely pathway of failures and quantifying the toxic / inflammable material release;
- Hazards analysis to quantify the consequences of various hazards scenarios (fire, explosion, BLEVE, toxic vapour release etc.). Establish minimum value for damage (e.g. IDLH, over pressure, radiation flux) to assess the impact on environment.
- Risk Quantification: Quantitative techniques are used considering effect/impact due to weather data, population data, and frequency of occurrences and likely hood of ignition/toxic release. Data are analyzed considering likely damage (in terms of injury/fatality, property damage) each scenarios is likely to cause.

QRA provides a means to determine the relative significance of a number of undesired events, allowing analyst and the team to focus their risk reduction efforts where they will be beneficial most.

M/s. PI Industries Ltd. (PIL) proposed expansion project is hazardous in nature. The QRA for this plant is based on Level 1 and Level 2. **Table 2.3** in Chapter 2 gives the list of products (and their monthly production capacity) to be manufactured in the proposed project. Table below gives the bulk storages of liquid and gaseous raw materials and their consumption.

7.3 HAZARDOUS MATERIALS STORAGE

The solid raw materials will be received in bags or drums and will be stored in chemicals godowns. The products (liquid or solid) will be packed in drums and stored in product godowns as per market demand. The bulk storages of liquid hazardous materials are given in the **Table 7.1** below:

The solid products powder or granules spillage can results in polluting small area only. The damage to personnel can be through ingress- dermal

(if individual come in contact), oral (if individual food gets infected through fugitive dust) or inhalation (fugitive dust). The main route is fugitive dust which in covered area will move to short distance only.

The risk is through liquid products which are volatile material. The toxic vapours due to spillage of such material can travel to some distance (as they are stored in covered godowns) and cause damage. The extremely hazardous {ET} pesticides are solids only. The liquid products will be packed in drums (50 litres, 100 litres or 200 litres drums).

Table 7.1: Bulk Storage of Hazardous Chemicals

S. No.	Scenario	Storage (MT)
1.	Hydrogen Chloride	10 MT
2.	Chloro Benzene	40MT
3.	Sulfuric Acid	85MT
4.	Toluene	75MT
5.	Caustic Soda	
6.	Sodium Hydroxide 47% w/w	80MT
7.	Methoxylamine hydrochloride Solution	24MT
8.	Methyl Alcohol	48MT
9.	Sodium Hypochlorite	
10.	Chloro Sulfonic Acid	20MT
11.	2-Bromoheptafluoropropane	16 nos.
12.	Dimethyl Sulfate	20MT
13.	Tert-butyl Methyl Ether	20MT
14.	Bromine Liquid	20 KL MT
15.	N-Butyl Acetate	50 KL
16.	Isobutylene	10 KL
17.	Aceto Nitrile 99% min	50 KL
18.	Formaldehyde 37%	50 KL
19.	Iso Propyl Alcohol	50 KL
20.	Hexanes	40 KL
21.	Hydrogen Compressed Gas	30 KGS
22.	N- Isopropyl Methylamine	25 KL
23.	Hydrogen Peroxide Liquid 50%	35 MT

7.4 RISK SCREENING APPROACH

Proposed Plant: Risk screening of **M/s. PI Industries Ltd. (PIL)** plant was undertaken through process study and study of data/information provided by PIL. Data of major/bulk storages of raw materials,

intermediates and other chemicals were collected. MSDS of hazardous chemicals were studied vis a vis their inventories and mode of storage. PIL plant will be using number of hazardous chemicals and also producing pesticides and Speciality Chemicals – all hazardous in nature. The chemicals stored in bulk (liquid or gaseous) and defined under MSIHC Rules, 1989 will be considered for detailed analysis.

All PIL pesticides are hazardous in nature. However hazards potential (for damage) of products and other materials to plant personnel, environment and off-site area is different for different materials. PIL will be using large numbers of raw materials but few of them are stored in bulk. Among the bulk stored chemicals, only 23 are listed under "List of hazardous and Toxic Chemicals" category under MSIHC Rules, 1989. The raw materials stored in bulk and coming under hazardous category as specified by MSIHC Rules, 1989 (including subsequent amendments) is given in **Table 7.2** below:

Table 7.2 Hazard Analysis- Raw materials

S. No.	Raw Material	S. No & Threshold Quantity (TQ in MT) as per MSHIC Rules			Chemicals Hazards Potential		Remarks
		Schedule- 1, Part-II	Schedule-2, Part-I	Schedule-3, Part-I	Hazards	Toxic	
1	Hydrochloric acid (Gas) CAS No: 7647-01-0 UN No: 1789	313	--	--	Not Flammable; Inhalation of fumes results in coughing and choking sensation, and irritation of nose and lungs. Liquid causes burns	ERPG-1: 3.0 ppm ERPG-2: 20 ppm ERPG-3: 150 ppm IDLH: ---- ppm	Plant uses liquid and emits HCl gas
2	Chloro Benzene C6H5Cl CAS No: 108-90-7 Flammable colorless liquid; almond- like odour FP:230C Explosion Limit: LEL:1.8%; UEL: 9.6%	128	--	--	Harmful if inhaled. May cause liver damage. Breathing vapors may cause drowsiness & dizziness. Causes eye, skin, and respiratory tract irritation	LD50:2200 mg/kg (rabbit) LD oral: 1110 mg/kg (rat) LC50:2965 ppm(rat)	Decomposition Products: Hydrogen chloride, phosgene, carbon monoxide, carbon dioxide
3	Sulphuric Acid CAS No: 7664-93-9 UN No: 1830	591	--	--	Flammability: Will not burn Health Hazard: Extremely hazardous - use full protection; Reactivity: Violent chemical change possible	ERPG-1: 2.0 mg/m^3 ERPG-2: 10 mg/m^3 ERPG-3: 30 mg/m^3 IDLH: 15 mg/m^3	---

4	Toluene CAS No: 108-88-3 UN No: 1294 A clear colorless liquid with a characteristic aromatic odor. Flash point 40°F	628	--	--	Flammability: Ignites at normal temperatures; Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back; Health Hazard Vapors irritate eyes and upper respiratory tract; cause dizziness, headache, anesthesia, respiratory arrest. Liquid irritates eyes and causes drying of skin.	ERPG-1: 50 ppm ERPG-2: 300 ppm ERPG-3: 1000 ppm IDLH: 500 ppm	--
5	Caustic Soda (Sodium Hydroxide) CAS No: 1310-730-2 UN No: 1823	571	---	---	Not flammable; Corrosive to metals and tissue. Hazardous.	ERPG-1: 0.5 ppm ERPG-2: 5.0 ppm ERPG-3: 50 ppm IDLH: ---- ppm	--
6	Methoxyl amine hydrochloride Solution $CH_3NH_2.HCl$ CAS No:593-61-1 White colour Solid	---	---	---	Very hazardous in case of eye contact (irritant), of ingestion, of inhalation. Hazardous in case of skin contact (irritant).	Data not available	---
7	Methanol CAS No:67-56-1 UN No:1230	377	---	---	A colorless fairly volatile liquid with a faintly sweet pungent odor like that of ethyl alcohol. Highly Flammable; Behavior in Fire: Containers may explode.	ERPG-1: 200 ppm ERPG-2: 1000 ppm ERPG-3: 5000 ppm IDLH: 6000 ppm	Health Hazards: Exposure to excessive vapor causes eye irritation, headache, fatigue & drowsiness. 50,000 ppm will probably cause death in 1 to 2 hrs. Swallowing may cause death or eye damage.
8	Sodium Hypochlorite NaOCl (15%) CAS No:7681-52-9; Light greenish Liquid with Chlorine odour; Unstable	---	---	---	May cause burns to the eyes, skin and mucous membranes	STEL (OSHA): 3ppm as Cl STEL (ACHIH): 1 ppm as Cl	---
9	Chloro Sulfonic Acid; $ClSO_3H$ CAS No:7790-94-5 Light colour Liquid with strong odour	---	---	---	Extremely hazardous in case of skin contact (irritant), of ingestion. Very hazardous in case of skin contact (corrosive), of eye contact (irritant), of inhalation	No Data Available	--
10	2-Bromohepta fluoro propane C_3BrF_7 CAS No:422-77-5 Liquid with BP: 140C	---	---	---	Irritant	---	Limited Data
11	Dimethyl Sulfate	---	---	---	Extremely hazardous in case of skin	ORAL (LD_{50}): Acute: 205	--

	$(CH_3)_2SO_4$ CAS No:77-78-1 Odourless Colourless oily liquid				contact (corrosive, irritant), of eye contact (irritant), of inhalation. Very hazardous in case of ingestion. Liquid or spray mist may produce tissue damage particularly on mucous membranes of eyes, mouth and respiratory tract. spray mist may produce severe irritation of respiratory tract,	mg/kg [Rat]. VAPOR (LC_{50}): Acute: 45 ppm 4 hour(s) [Rat].	
12	Tert-butyl Methyl Ether C5-H12-O CAS No: 1634-04-4 Clear colourless flammable liquid with strong characteristic odour	---	---	---	Extremely hazardous in case of eye contact (irritant), of ingestion. Very hazardous in case of skin contact (irritant), of inhalation	Oral (LD50): Acute: 4000 mg/kg [Rat]. 5960 mg/kg [Mouse]. VAPOR (LC50): Acute: 23576 ppm 4 hour(s) [Rat].	---
13	Bromine CAS No:7726-95-6 UN No:1744	84	17 TQ-1: 50 MT TQ-2: 500 MT	106 TQ-1: 40 MT TQ-2: 500 MT	Stable. Incompatible with reducing agents, alkali metals, powdered metals, steel, iron, copper, organic materials. Toxicology May be fatal if inhaled. Highly toxic by inhalation, ingestion or skin contact. Causes severe burns. Lachrymator. Typical TLV 0.1 ppm. Typical STEL 0.3 ppm	---	PIL Storage: 10 KL
14	N – Butyl Acetate CH3COO(CH2) CH3 CAS No:123-86-4 Flammable liquid	---	---	---	Very hazardous in case of ingestion. Hazardous in case of skin contact (irritant), of eye contact (irritant), of inhalation. Slightly hazardous in case of skin contact (permeator).	ORAL (LD50): Acute: 10768 mg/kg [Rat]. DERMAL (LD50): Acute: 17601 mg/kg [Rabbit]	---
15	Isobutylene CAS No:115-11-7 Liquefied extremely flammable gas BP:--6.90C	---	---	---	Extremely flammable gas. May form explosive mixtures with air. Contains gas under pressure; may explode if heated. May cause frostbite. May displace oxygen and cause rapid suffocation	LC50 (rat) 550000 mg/m^3	--
16	Acetonitrile CAS No:75-05-8 UN No:1648 A colorless limpid liquid with an aromatic odor. Flash point	7	---	---	Highly flammable; toxic vapours (HCN /NOX) are generated when heated; Vapor heavier than air and may travel a considerable distance to a source of ignition and flash	TEEL-1: 13 ppm TEEL-2: 320 ppm TEEL-3: 670 ppm IDLH 500 ppm	---

	42°F				back. Health Hazards: Exposure to 160 ppm for 4 hours causes flushing of the face and a feeling of constriction in the chest; 500 ppm for brief periods is irritating to the nose and throat.		
17	Formaldehyde CAS No.: 50-00-0	285	--	112 TQ-1: 5 MT TQ-2: 50 MT	FP-56 0C ; BP-980C LEL-7%; UEL-73% May react violently with acids/ alkali/ oxidising agents etc.	LD50- 42 mg/kg Exposure Limit: 0.3 ppm	Death if inhaled or absorbed; severe eye irritation and burns; allergic dermatitis, skin burns; bronchitis, pulmonary oedema;
18	Isopropyl Alcohols CAS No: 67-63-0	334			Flash Pt: 55.00 F Method Used: TCC Explosive Limits: LEL: 2.5% UEL: 12.1% LD 50/ LC 50: Acute dermal Rabbit 1300 mg/kg; Acute inhalation Rat (8 hours) 12000 ppm.	---	---
19	n-Hexane CAS No:110-54-3 UN No:1208	306	---	---	Clear colorless liquids with a petrol - like odor. Flash points -9°F Highly flammable; Vapours may explode;	TEEL-1: 400 ppm TEEL-2: 3300 ppm TEEL-3: 8600 ppm IDLH 1100 ppm	Health Hazards: Inhalation causes irritation of respiratory tract, cough, mild depression, arrhythmias. Aspiration causes severe lung irritation, coughing, pulmonary edema;
20	Hydrogen Compressed Gas	247	---	---	Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant, permeator), of eye contact (irritant).	ORAL (LD50): Acute: 5620 mg/kg [Rat]. 4100 mg/kg [Mouse]. 4935 mg/kg [Rabbit]. VAPOR (LC50): Acute: 45000 mg/m 3 -3 hours [Mouse]. 16000 ppm 6 hours [Rat].	Highly Flammable/ Explosive
21	N- Isopropyl Methylamine $(CH_3)CHNHCH_3$ CAS No:4747-21-1; Liquid BP:530C	---	---	---	Highly inflammable; FP:--320C	----	Limited Data
22	Hydrogen Peroxide (50%) (H_2O_2) CAS No: 7732-18-5 Colourless/ odourless liquid; BP-108 0C	--	--	--	Very hazardous in case of skin contact (irritant), of eye contact (irritant). Hazardous in case of skin contact (corrosive, permeator), of eye contact (corrosive), of ingestion,	ORAL (LD50): Acute: 2000 mg/kg [Mouse]. DERMAL (LD50): Acute: 4060 mg/kg [Rat]. VAPOR (LC50): Acute: 2000 mg/m 4 hours [Rat].	Non-flammable but fire hazards in presence of combustible materials; Explosive in presence of open flames and sparks
23	Ammonia CAS No:7664-41-7 UN No:1005	31	2 TQ-1: 60 MT TQ-	105 TQ-1: 50 MT TQ-	Fire Hazards: Mixing of ammonia with several chemicals can cause severe fire hazards and/or	ERPG-1: 25 ppm ERPG-2: 150 ppm ERPG-3: 750	PIL Storage: 20 KL

			2: 600 MT	2: 500 MT	explosions. Ammonia in container may explode in heat of fire. Health Hazards: Vapors cause irritation of eyes and respiratory tract. Liquid will burn skin and eyes. Poisonous; may be fatal if inhaled. Contact may cause burns to skin and eyes. Contact with liquid may cause frostbite.	ppm IDLH: 300 ppm	

Note:

1. TQ-I: Threshold quantity (for application of rules 4,5,7 to 9 and 13 to 15)
   TQ-II: Threshold quantity (for application of rules 10 to 12)
   As detailed in the above table; out of 23 raw materials stored in bulk nine are not listed in MSIHC rules. Three are (namely Bromine, Hydrogen and Isobutylene) flammable and toxic gases, few are acids /alkali. For some raw materials limited data are available. Chloro Benzene is flammable as well as toxic. However its combustion/decomposition product includes Phosgene and carbon Monoxide which are highly poisonous gases. Special precautions (suitable gas masks) are to be taken while dealing with Chloro Benzene fire.
   None of the products except Phosmet are listed in MSIHC Rules, 1989. The MSIHC classification of various products are given in
   Table 7.3 below:

Table 7.3 Hazard Analysis- Products

Sr. No.	Common Name	IUPAC Name	S. No & Threshold Quantity (TQ in MT) as per MSHIC Rules		
			Schedule-1, Part-II	Schedule-1, Part-II	Schedule-1, Part-II
1	CPFK	1-cyclopropy-2(2 fluorophenyl) ethanone	----	----	---
2	CNZ	Cyanazine	----	----	---
3	AE 473	(2-{2-chloro-4-mesyl-3-[(RS)]-tetrahydro-2-furylmethoxymethyl} benzoyl)-cyclohexane-1, 3-Dione)	----	----	---
4	IBCZ	(4-chlorophenyl) methyl N-(2,4-dichlorophenyl)-1H-1,2,4-triazole-1-ethanimidothioate	----	----	---
5	MY-71	3-[1-(3,5-dichlorophenyl)-1-methylethyl]-6-methyl-5-phenyl-2,3-dihydro-4H-1,3-oxazin-4-one	----	----	---
6	MY-100	3-[1-(3,5-dichlorophenyl)-1-methylethyl]-3,4-dihydro-6-methyl-5-phenyl-2H-1,3-oxazin-4-one	----	----	---
7	PFD	N-{3-isobutyl-4-[1,2,2,2-tetrafluoro-1-(trifluoromethyl) ethyl]phenyl}-1,3,5-trimethyl pyrazole -4- carboxylic amide	----	----	---
8	TLF	Tolfenpyrad	----	----	---
9	TBFN	4-chloro-N-[[4-(1,1-dimethylethyl) phenyl] methyl]-3-ethyl-1-methyl-1H-pyrazole-5-carboxamide	----	----	---
10	PYCL	1-(3-chloro-4,5,6,7-tetrahydropyrazolo[1,5-	----	----	---

		a]pyridin-2-yl)-5-[methyl(prop-2-ynyl) amino]pyrazole-4-carbonitrile			
11	LAKE PALACE	3-[[(2,5-dichloro-4-ethoxyphenyl)methyl] sulfonyl]-4,5-dihydro-5,5-dimethylisoxazole	----	----	---
12	OCTOPUSSY	3-[[[5-(difluoromethoxy)-1-methyl-3-(trifluoromethyl)-1H-pyrazol-4-yl]methyl]sulfonyl]-4,5-dihydro-5,5-dimethylisoxazole	----	----	---
13	2C6SMT	3-Chloro-2-Methylthioanisole	----	----	---
14	DMI	2,6-dimethylindanone	----	----	---
15	ORST	Orysastrobin	----	----	---
16	PCM	N-(2 Chloro-4 Fluoro-5-((ethoxy carbonyl)-amino)-benzoyl)-N-iso-propyl-N-methyl-sulfamid	----	----	---
17	ACH	3-(difluoro methyl)-1-methyl-1H-pyrazole-4-carboxylic acid	----	----	---
18	Star-1	Pethoxamid Technical	----	----	---
19	CFPA	3,4-dichloro-5-fluorobiphenyl-2-amine	----	----	---
20	AMB	3,4,5-Trifluoro-aminobiphenyl	----	----	---
21	PRZ	Difluoro Methyl-N-Methyl Pyrazolic acid	----	----	---
22	DCPA	1,3-dimethyl-5-chloro-4-pyrazolylcarboxylic acid chloride	----	----	---
23	CMTB	2-chloro-4-(methylsulfonyl)-3-[(2,2,2-trifluoroethoxy) methyl] benzoic acid	----	----	---
24	ZXMD	Zoxamide	----	----	---
25	AZST	methyl (E)-2-{2-[6-(2-cyanophenoxy) pyrimidin-4-yloxy]phenyl}-3-methoxyacrylate	----	----	---
26	CDMB	4-chloro 2,6-dimethyl-bromo benzene.	----	----	---
27	PMT	Phosmet	494	----	---
28	Flub/SOD	N-(2-Methylsulfinyl-1,1-dimethyl-ethyl)-N'-{ 2-methyl-4-[1,2,2,2-tetrafluoro-1-(trifluoromethyl) ethyl]phenyl} phthalamide	----	----	---
29	CCITM	Disodium cyanocarbonodithioimidate	----	----	---
30	IBA	3-(2-Methylpropyl)aniline	----	----	---
31	FNZQ	4-tert-Butylphenethyl quinazolin-4-yl ether	----	----	---
32	DMAI	(1R,2S) and (1S,2S)-2,6-dimethyl-2,3-dihydro-1H-inden-1-amine	----	----	---
33	Tembutrion	2-({2-chloro-4-(methylsulfonyl)-3-[(2,2,2-trifluoroethoxy) methyl] phenyl}carbonyl)cyclohexane-1,3-dione	----	----	---
34	CCMP	2-Chloro-5-(chloromethyl)pyridine	----	----	---
35	HFMOP	1,1,1,3,3,3-hexafluoro-2-methoxypropane	----	----	---
36	MDO	2,2-Dimethyl-4-methylidene-1,3-dioxolane	----	----	---
37	FMTQ	2-Ethyl-3,7-dimethyl-6-(4-(trifluoro methoxy)phenoxy)quinolin-4-yl methyl	----	----	---
Insecticides and Intermediates					
1	Amino Triazines		----	----	---
a	THM	----	----	----	---
2	Diamides		----	----	---
a	Flub	----	----	----	---
b	SOD	N2-(2-Methyl-1-(Methylsulfinyl)propan-2-yl)-N1-(2-Methyl- 4 - (perfluoropropan-2-yl) phenyl) phthalamide			
c	MMTPA/SAA	2-Methyl 1-Methylthio-2-Propanamine			
3	Hydazinopyridine				
a	CHDP	3-Chloro-2-Hydrazino Pyridine			
4	Nicotinamides				
a	TFNA	2,6-Dichloro-4-(Trifluromethyl) pyridine-3-Carbonitrile			
5	Nitroguanidines				
a	BNHT	5-Benzyl-1-Methyl, 2-Nitro 2 imino-tetrahydro 1, 3, 5-trizan.			
b	AETF	3-Amino methyl Tetrahydrofuran			
6	Organophosphorus Insecticide				
a	MTN	3-(Dimethoxy Phosphinothioyl sulfanyl methyl) -5-Methoxy-1,3,4-thiadiazol-2-one			
7	Phenyl organo thiophosphate				
a	PTF	(RS)-(O-2,4-Dichlorophenyl O-Ethyl S-Propyl			

		Phosphorodithioate)			
8	Phthalimides				
a	PMT	Phosmet	494	----	---
9	Pyrazole-diamides		---	---	---
a	Q4039	----			
b	YB449	----			
c	DPX	----			
d	BPCA	----			
10	Quinazoline		----	----	---
a	FNZQ	----	----	---	
11	Quinolinyl carbonate		----	----	---
a	FMTQ	----	----	---	
12	Thiazolidines		----	----	---
a	CCITM	Dimethyl Cyano Dithioimido Carbonate			
b	CCMP	2-Chloro-5-Chloromethyl Pyridine			
Herbicides and Intermediates			----	----	---
1	Alkylazines		----	----	---
a	DMI	2,6-Dimethylindanone			
b	DMAI	2,6-Dimethyl-2,3-Dihydro-1H-inden-1-amine			
2	Amide-triazolones		----	----	---
a	IAT	3H-1,2,4-Triazol-3-one, 4-amino-2,4-dihydro-5-(1-methylethyl)-			
3	Aryloxyphenoxy propionates				
a	FPES	Ethyl(2R)-2-{4-[6-chloro-1,3-benzoxazol-2-yl)oxy] phenoxy} propanoate			
4	Benzoyl cyclohexanediones				
a	AE 473	(2-{2-chloro-4-mesyl-3-[(RS)]-tetrahydro-2-furylmethoxymethyl} benzoyl)-cyclohexane-1, 3-Dione)			
b	Tembutrion	2-{2-chloro-4-(methylsulfonyl)-3-[(2,2,2-trifluoroethoxy)methyl]benzoyl}cyclohexane-1,3-dione			
c	747 Either	2-Chloro-4-(methyl sulfonyl)-3-[(2, 2, 2-trifluoroethoxy) methyl] Benzoic acid			
d	2C6SMT	3-Chloro-2-Methylthioanisole			
5	Furanones				
a	FLURT	5-(Methylamino)-2-Phenyl-4-[3-(Trifluoromethyl) phenyl] furan-3(2H)-one			
6	Intermediate of Herbicide				
a	MTAA	Methyl (methylthio) Acetate			
7	Active nitrile Herbicide				
a	PYCL	1-(3-Chloro-4,5,6,7-tetra hydropyrazolo [1,5-a] pyridin-2-yl)-5-[methyl (prop-2-ynyl)amino] pyrazole-4-carbonitrile			
8	Oxazinones				
a	MY-100	3-[1-(3,5-dichlorophenyl)-1-methylethyl]-3,4-dihydro-6-methyl-5-phenyl-2H-1,3-oxazin-4-one			
9	Oxazoles				
a	Lake Palace	3-[[(2,5-dichloro-4-ethoxyphenyl) methyl] sulfonyl]-4,5-dihydro-5,5-dimethylisoxazole			
10	Oxazolidinediones				
a	KPP	Pantoxazone			
11	Phosphinates				
a	MPBS	Methyldichlorophosphine			
12	Pyrimidinediones				
a	PCM	N-(2 Chloro-4 Fluoro-5-((ethoxy carbonyl)-amino)-benzoyl)-N-iso-propyl-N-methyl-sulfamid			
b	EATB	Ethyl 3-amino-4,4,4-trifluorobut-2-enoate			
13	Pyrimidinyloxybenzoic acid				
a	Bispyribac sodium	2,6-bis(4,6-dimethoxypyrimidin-2-yloxy)benzoic acid			
14	Pyrimidinylsulfonylurea				
a	FRSF	N,N-Dimethyl-2-[N-[N-(4,6-dimethoxy pyrimidin-2-yl)-Amino carbonyl] Amino sulfonyl]-4-(N-formylamino) benzamide, sodium salt			

b	ESPS	3-ethylsulfonyl-2-pyridine sulfonamide			
15	Sulfonylurea				
a	AMSB(Mesylamide)	Methyl 2-Amino-4-{[(methyl sulfonyl)amino] methyl} benzoate			
b	OTMA	2-(Trifluoro Methoxy) Aniline			
16	Triazines				
a	CNZ	Cyanazine			
17	Triazopyrimidine sulphonamides				
a	DTPBS	N-(5,8-Dimethoxy [1,2,4] Triazolo [1,5-c] pyrimidine-2-yl)-2-Fluoro-6-(Trifluoro Methyl) Benzene Sulfonamide			
Fungicides and intermediates			----	----	---
1	Active amide Fungicides				
a	SSF-126/OXIME	(2E)-2-(methoxyimino)-N-Methyl-2-(2-Phenoxy Phenyl) Acetamide			
b	TRFRN	N,N'-[1,4-Piperazinediyl-bis(2,2,2-Trichloro Ethylidene)]-Bis-[Formamide]			
c	FNXL	N-(1-Cyano-1,2-Dimethylpropyl)-2-(2,4— Dichlorophenoxy) Propanamide			
d	MIPD	(1E)-1-(2,5,5-Trimethyl-1,3-dioxan-2-yl) Propane -1,2-dione 1-(O-Methyloxime)			
e	ORST	Orysastrobin			
2	Benzamides				
a	ZXMD	(RS)-3,5-Dichloro-N-(3-Chloro-1-Ethyl-1-Methyl-2-Oxopropyl)-p-Toluamide			
3	Carboxamides				
a	AMB	3,4,5-Trifluoro-Amino biphenyl			
4	Organophosphates				
a	KTZ(Kitazin)	S-benzyl O,O-Diisopropyl Phosphorothioate			
5	Pyridine Fungicides				
a	CTPE	2-[3-Chloro-5-(Trifluoro methyl) Pyridin-2-yl] Ethanamine			
6	Pyrimidines				
a	AZST	Methyl (E)-2-{2-[6-(2-Cyanophenoxy) pyrimidin-4-yloxy] phenyl}-3-Methoxy acrylate			
7	Quinoxalines				
a	CMTH	4-(Methoxy-6-(trifluoro methyl)-1,3,5-triazin-2-amine			
8	Triazoles				
a	IPCZ	(1RS, 2SR, 5RS; 1RS, 2SR, 5SR)-2-(4-Chlorobenzyl)-5-Isopropyl-1-(1H-1,2,4-triazol-1-ylmethyl) Cyclopentanol			
b	FTL	1-(2-Fluorophenyl)-1-(4-Fluorophenyl)-2-(1, 2, 4-Triazol-1-yl) Ethanol			
c	FOX	2-(2-Fluorophenyl)-2-(4-Fluoro phenyl) Oxirane			
d	IBCZ	(4-Chlorophenyl) Methyl N-(2,4-Dichlorophenyl)-1H-1,2,4-Triazole-1-Ethanimidothioate			
Fine Chemicals			----	----	---
1	Substituted Anthraanilic acid				
a	ACBM	2-Amino-3-Chlorobenzoic Acid Methyl Ester			
2	Substituted 1,2,4-Triazole				
a	AMT	5-Amino-1,2,4-Triazole-3-thiol			
3	Substituted tetrahydo pyran				
a	ATHP	1-(Tetrahydropyran-4-yl) Ethanone			
4	Dimethyl halo substituted benzene				
a	CDMA	4-Chloro-2,6-Dimethyl Aniline			
b	CDMB	4-Chloro 2,6-Dimethyl-Bromo benzene.			
5	Substituted cyclopropyl ethanone				
a	CPFK	1-Cyclopropy-2(2 Fluorophenyl) Ethanone			
6	Substituted alkyl diamine				
a	DAEEA	N,N'-Bis(2-Hydroxyethyl) Ethylene Diamine			
7	Substituted dihalo pyridine				
a	DCTFP	2,3-Dichloro-5-(Trichloromethyl) Pyridine			
8	Subsituted dimethyl dioxane methanol				
a	DHD	2, 2-Dimethyl-5-Hydroxymethyl-1, 3-			

		Dioxane			
9	Substituted Butanone				
a	DMB	4,4-Dimethoxy-2-Butanone			
10	Substituted Butanoic acid				
a	EMBA	2-Ethyl-2-Methyl Butanoic acid			
11	Substituted Hydrazine				
a	MMH	Mono Methyl Hydrazine			
b	UDMH	1,1,-Dimethyl Hydrazine			
C	SDMH	1,2-Dimethyl Hydrazine			
12	Substituted Phenothiazine				
a	10-H Phenotiazine	10-H Phenotiazine			
13	Substituted diphenyl ether				
a	Metaphenoxy benzaldehyde	3-Phenoxy Benzaldehyde			
Pyrazoles			----	----	---
1	n-alkyl 3,4,5 sustituted pyrazoles				
a	PFD	N-{3-Isobutyl-4-[1,2,2,2-tetrafluoro-1-(trifluoromethyl) ethyl] phenyl}-1,3,5-Trimethyl Pyrazole -4- Carboxylic Amide			
b	TBFN	4-Chloro-N-[[4-(1,1-Dimethylethyl) Phenyl] Methyl]-3-Ethyl-1-Methyl-1H-Pyrazole-5-Carboxamide			
c	TLF	Tolfenpyrad			
d	IBA	3-Isobutylanoline			
e	OCTOPUSSY	3-[[[5-(Difluoro methoxy)-1-methyl-3-(Trifluoromethyl)-1H-pyrazol-4-yl] methyl] sulfonyl]-4,5-Dihydro-5,5-Dimethyl isoxazole			
f	MY-71	3-[1-(3,5-Dichlorophenyl)-1-Methylethyl]-3,4-Dihydro-6-Methyl-5-Phenyl-2H-1,3-oxazin-4-one			
g	MTP	1-Methyl-3-(Trifluro methyl)1H-Pyrazol-5-ol			
h	DCPA	1,3-Dimethyl-5-Chloro-4-Pyrazolyl Carboxylic Acid Chloride			
i	CFPA	3,4-Dichloro-5-Fluoro Biphenyl-2-Amine			
j	ACH	3-(Difluoro Methyl)-1-Methyl-1H-Pyrazole-4-Carboxylic Acid			
k	BDB	4-Bromo- 1,2-Dichloro Benzene			
l	PRZ	Difluoro Methyl-N-Methyl Pyrazolic acid			
Fluorospeciality products			----	----	---
1	Fluoro substituted alkyl amine				
a	DFEA	2,2-Difluoro Ethylamine			
Pharma intermediates			----	----	---
1	Substituted triazole carboxylate				
a	EMTC	Ethyl-4-Methyl-1,3-Thiazole-5-Carboxylate			
Specialty Chemicals			----	----	---
1	Substituted cyclohexane carboxylate				
a	ETMD	Methyl cis-1-[2-(2,5-Dimethyl phenyl)-Acetyl amino]-4-Methoxy-Cyclohexane Carboxylate			
2	Hepta Fluoro Alkane				
a	HFMOP	1,1,1,3,3,3-Hexafluoro Isopropyl Methyl Ether			
3	Substituted 1,3-dioxalane				
a	MDO	2,2-Dimethyl-4-Methylene-1,3-Dioxalane			
4	Substituted Isobutyrate				
a	CMIBA	Chloromethyl 2-Methyl Propanoate			
5	Substitued plenyl ether				
a	CMTB	2-Chloro-4-(Methyl sulfonyl)-3-[(2,2,2-trifluoro ethoxy) methyl] Benzoic Acid			
Performance Chemicals			----	----	---
1	Substituted phenyl morpholoine Ketone				
a	PCBM	1-(4-Chlorophenyl)-2-methyl-2-(morpholin-4-yl)propan-1-one			
2	Catecol mixed salt				
a	Negolyte	Titanium Biscatecholate Monopyrogallate Sodium Potassium Salt			
14	Sodium hypochloride solution		----	----	---
15	$AlCl_3$		----	----	---
16	Ammonium Chloride		----	----	---

Note:

1. Oral Toxicity (OT) in LD_{50} (mg/kg)
2. Dermal Toxicity (DT) in LD_{50} (mg/kg)
3. Inhalation Toxicity in LC_{50} (mg/l) [4 hrs.]

7.4.1 Acute Exposure Guideline Levels (AEGLS)

- **AEGL-3** is "the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death."
- **AEGL-2** is "the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape."
- **AEGL-1** is "the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic no sensory effects."

7.4.2 Emergency Response Planning Guidelines (ERPGs)

The 3 *ERPG* tiers are defined as follows:

- **ERPG-3** is "the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects."
- **ERPG-2** is "the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action."
- **ERPG-1** is "the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient health effects or perceiving a clearly defined, objectionable odor."

7.4.3 Temporary Emergency Exposure Limits (TEELs)

TEELs are used in similar situations as the 60-minute AEGLs and ERPGs. However, in situations where the concentration varies over time, the TEEL developers recommend using a conservative 15-minute time-

weighted average concentration. A chemical may have up to 4 TEEL values, each of which corresponds to a specific tier of health effects.

The 4 TEEL tiers are defined as follows:

- **TEEL-3** is "the maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing life-threatening health effects."
- **TEEL-2** is "the maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action."
- **TEEL-1** is "the maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing other than mild transient health effects or perceiving a clearly defined objectionable odor."
- **TEEL-0** is "the threshold concentration below which most people will experience no appreciable risk of health effects."
- The National Institute of Occupational Safety and Health (*NIOSH*) defines an immediately dangerous to life or health condition as a situation "that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment."
- The IDLH limit represents the concentration of a chemical in the air to which healthy adult workers could be exposed (if their respirators fail) without suffering permanent or escape-impairing health effects.

7.5 QRA APPROACH

Identification of hazards and likely scenarios (based on Level-1 and Level-2 activities) calls for detailed analysis of each scenario for potential of damage, impact area (may vary with weather conditions/wind direction) and safety system in place. Subsequently each incident is classified according to relative risk classifications provided in **Table 7.4.**

Table 7.4: Risk Classification

Stage	Description
High	A failure which could reasonably be expected to occur within

Stage	Description
(> 10^{-2}/yr.)	the expected life time of the plant. Examples of high failure likelihood are process leaks or single instrument or valve failures or a human error which could result in releases of hazardous materials.
Moderate (10^{-2} --10^{-4}/yr.)	A failure or sequence of failures which has a low probability of occurrence within the expected lifetime of the plant. Examples of moderate likelihood are dual instrument or valve failures, combination of instrument failures and human errors, or single failures of small process lines or fittings.
Low (<10^{-4})	A failure or series of failures which have a very low probability of occurrence within the expected lifetime of plant. Examples of 'low' likelihood are multiple instruments or valve failures or multiple human errors, or single spontaneous failures of tanks or process vessels.
Minor Incidents	Impact limited to the local area of the event with potent for 'knock – on- events'
Serious Incident	One that could cause: ❖ Any serious injury or fatality on/off site; ❖ Property damage of $ 1 million offsite or $ 5 million onsite.
Extensive Incident	One that is five or more times worse than a serious incident.

Assigning a relative risk to each scenario provides a means of prioritising associated risk mitigation measures and planned actions.

7.6 THERMAL HAZARDS

In order to understand the damages produced by various scenarios, it is appropriate to understand the physiological/physical effects of thermal radiation intensities. The thermal radiation due to tank fire usually results in burn on the human body. Furthermore, inanimate objects like equipment, piping, cables, etc. may also be affected and also need to be evaluated for damages. **Table 7.5, Table 7.6** and **Table 7.7** (below), respectively give tolerable intensities of various objects and desirable escape time for thermal radiation. Thermal hazards could be from fires or explosion. Fire releases energy slowly while explosion release energy very rapidly (typically in micro seconds). Explosion is rapid expansion of gases resulting in rapidly moving shock wave. Explosion can be confined (within a vessel or building) or unconfined (due to release of flammable gases).

BLEVE (boiling liquid expanding vapour explosion) occurs if a vessel containing a liquid at a temperature above its atmospheric boiling point ruptures. The subsequent BLEVE is the explosive vaporization of large fraction of its vapour contents; possibly followed by combustion or

explosion of the vaporized cloud if it is combustible. Thermal hazards have been considered for various scenarios including: Fire in inflammable chemicals storage tanks.

Table 7.5: Effects due to Incident Radiation Intensity

Incident Radiation kW/m^2	Damage Type
0.7	Equivalent to Solar Radiation
1.6	No discomfort on long duration
4.0	Sufficient to cause pain within 20 sec. Blistering of skin (first degree burn are likely).
9.5	Pain threshold reached after 8 sec. Second degree burn after 20 sec.
12.5	Minimum energy required for piloted ignition of wood, melting of plastic tubing etc.
25	Minimum Energy required for piloted ignition of wood, melting, plastic tubing etc.
37.5	Sufficient to cause damage to process equipment.
62.0	Spontaneous ignition of wood.

Table 7.6: Thermal Radiation Impact to Human

Exposure Duration	Radiation Energy {1% lethality; kW/m^2}	Radiation Energy for 2^{nd} degree burns; kW/m^2	Radiation Energy for 1^{st} degree burns; kW/m^2
10 sec	21.2	16	12.5
30	9.3	7.0	4.0

Table 7.7: Tolerable Intensities for Various Objects

Sl. No.	Objects	Tolerable Intensities (kw/m^2)
1	Drenched Tank	38
2	Special Buildings (No window, fire proof doors)	25
3	Normal Buildings	14
4	Vegetation	10-12
5	Escape Route	6 (up to 30 secs.)
6	Personnel in Emergencies	3 (up to 30 secs.)
7	Plastic Cables	2
8	Stationary Personnel	1.5

7.7 DAMAGE DUE TO EXPLOSION

The explosion of a dust or gas (either as a deflagration or detonation) results in a reaction front moving outwards from the ignition source preceded by a shock wave or pressure front. After the combustible material is consumed the reaction front terminates but the pressure wave

continues its outward movement. Blast damage is based on the determination of the peak overpressure resulting from the pressure wave impacting on the object or structure. Damage estimates based on overpressure are given in **Table 7.8** below:

Table 7.8: Damage due to Overpressure

Sr. No.	Overpressure (psig/bar)	Damage
1.	0.04	Loud Noise/sonic boom glass failure
2.	0.15	Typical pressure for glass failure
3.	0.5 - 1	Large and small windows usually shattered
4.	0.7	Minor damage to house structure
5.	1	Partial demolition of houses, made uninhabitable
6.	2.3	Lower limit of serious structure damage
7.	5 - 7	Nearly complete destruction of houses
8.	9	Loaded train box wagons completely demolished
9.	10	Probable total destruction of houses
10.	200	Limits of crater lip

In PIL case explosion probability is remote.

7.8 TOXIC RELEASE

Hazardous materials handled and stored in bulk in PIL complex are are two gases ammonia, chlorine/Sodium Hypochlorite and liquids (as detailed in **Table 7.1**) and many other raw materials as defined in MSHIC rules and indicated in **Table 7.2** and **Table 7.3**. Some of these chemicals are stored in bulk (in tank farm). Many of the pesticides products are new molecules with unique properties. The main use of these pesticides molecules are to kill insects, pests or other small organism which are harmful or do damage to the human system directly or indirectly. The new pesticides molecules are made because harmful organisms are becoming immune to existing pesticides or the existing pesticides are doing more damage to human than giving benefits.

Damage criteria: For toxic release the damage criteria considered is IDLH concentration (if data are available). In the absence of non-availability of IDLH, 'Inhalation Toxicity (IT) data for rats' are considered. 'IT' data are used for such chemicals for whom IDLH are not available for these chemicals.

7.9 DATA LIMITATIONS

It is also observed that very little data or information (regarding physical properties required for modelling) is available about the pesticides products. Considering these aspects modelling are based on the physical properties of solvents or other chemicals (more volatile) used in the manufacture of pesticides.

7.10 LIKELY FAILURE SCENARIOS

Few likely failure scenarios have been selected after critical appraisal of raw materials and storage inventories. Failure scenarios selected are as given in **Table 7.9** below:

Table 7.9: Different Failure Scenarios

S. No.	Scenario	Storage	Remark
Raw materials			
Case-1	Liq. Iso. Butylene Spillage	20 Kl	Thermal/ Explosion Impact
Case-2	Liq. Ammonia heavy release	20 Kl	Toxic Impact
Case-3	Liq. Bromine heavy release	10 Kl	Toxic Impact
Case-4	Hydrogen	275 Nos.	Thermal/ Explosion Impact
Case-5	Toluene Spillage	75 MT	Toxic Impact
Case-6	Hexane Spillage	40 KL	Thermal Impact
Case-7	Chloro Benzene Spillage	40 MT	Toxic/Thermal Impact
Case-8	Dimethyl Sulfate Spillage	25 MT	Toxic Impact

(B) QUANTITATIVE Risk ASSESSMENT & CONSEQUENCE ANALYSIS

7.11 PREAMBLE

In the previous chapter, we have carried out the hazards analysis of the PIL existing complex considering various aspects including bulk storages of hazardous chemicals, plant process system, plant incidents/ accidents records, critical appraisal and discussion at site for soft spots in the plant etc. Based on the hazards analysis few critical scenarios have been selected for QRA and consequence analysis. QRA quantifies vulnerable zones for a conceived incident with various levels of severity. Consequence calculations for risk assessment are invariably in terms of percentage of fatalities but for emergency handling, fatalities are of no

interest saving lives is the main objectives then. The injury criteria have to be agreed in terms of thermal load or toxic concentration versus exposure duration in the first instance. In consequence calculation, use is made of a number of calculation models to estimate the physical effects of an accident (spill of hazardous material) and to predict the damage (lethality, injury, material destruction, and other property damage). The risk assessment modeling can be roughly divided into three groups:

- Determination of source strength parameters;
- Determination of consequential effects;
- Determination of damage or damage distances (with specific severity rates)

7.11.1 Weather Effect

The effect of ambient conditions on the impact of fire/heat radiation and GLC of hazardous/toxic material can be beneficial as well as harmful. A high wind (turbulence) can dilute the toxic material while stable environment can extend the reach of IDLH or IT (inhalation LC_{50} rats for products) concentration to long distance. Any inflammable gas/vapour release in turbulent weather will soon dilute the hazardous gases below LEL and thus prevent the disaster.

7.12 INCIDENTS IMPACTS

The identified failure scenarios **(Table 7.9)** have been analysed (Using ALOHA and EFFECT Modules) for the impact zones considering damage due to thermal and toxic impacts. Similar impacts are considered for expansion units. Each incident will have Impact on the surrounding environment which in extreme case may cross plant boundary. The impact zones for various scenarios are given in **Table 7.10.**

Table 7.10: Hazards Scenario Impact

Scenario No.	Scenario	Impact Zone (m)	Remarks
Scenario Raw Material			
Case-1	Liq. Iso. Butylene	❖ 27 ❖ 78	1st degree burn **Figure 7.1** Flammable area of Vapour Cloud Explosion **Figure 7.2**
Case-2	Liq. Ammonia	❖ 210 (IDLH) ❖ 420 (IDLH)	Stability Class-D **[Figure 7.3]** Stability Class-F **[Figure 7.4]**
Case-3	Liq. Bromine	❖ 616 (IDLH)	Stability Class-D **[Figure 7.5]**

Scenario No.	Scenario	Impact Zone (m)	Remarks
Scenario Raw Material			
		❖ 1300 (IDLH)	Stability Class-F **[Figure 7.6]**
Case-4	Hydrogen	❖ < 10 ❖ 10	1st degree burn Flammable area of Vapour Cloud Explosion
Case-5	Toluene	❖ 10 (IDLH)	Stability Class-D
Case-6	Hexane	❖ 35	1st degree burn; **Figure 7.7**
Case-7	Chloro Benzene	❖ 10 (IDLH) ❖ 15	Stability Class-D 1st degree burn; **Figure 7.8**
Case-8	Dimethyl Sulfate	❖ 100 (IDLH)	Stability Class-D; **Figure 7.9**

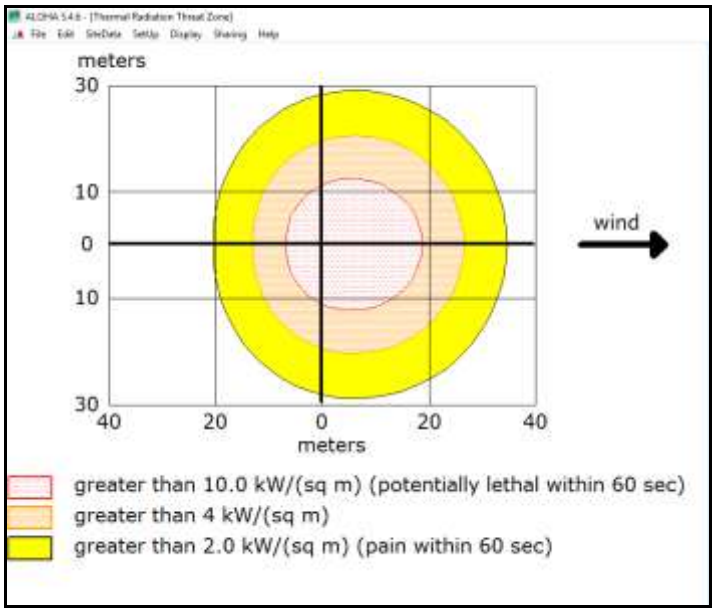

Figure 7.1 Isobutylene Spillage & Fire - Thermal Impact Zone

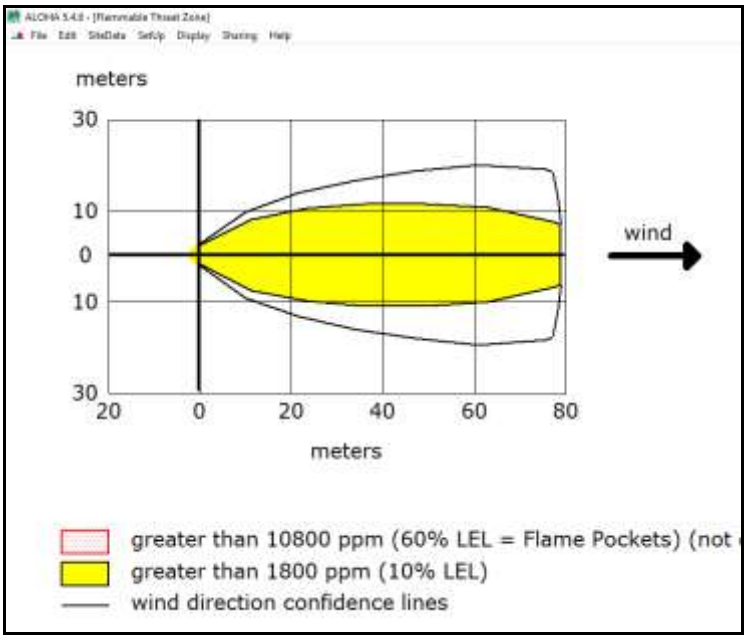

Figure 7.2 Isobutylene Spillage & Evaporation - Flammable Area of Vapor Cloud

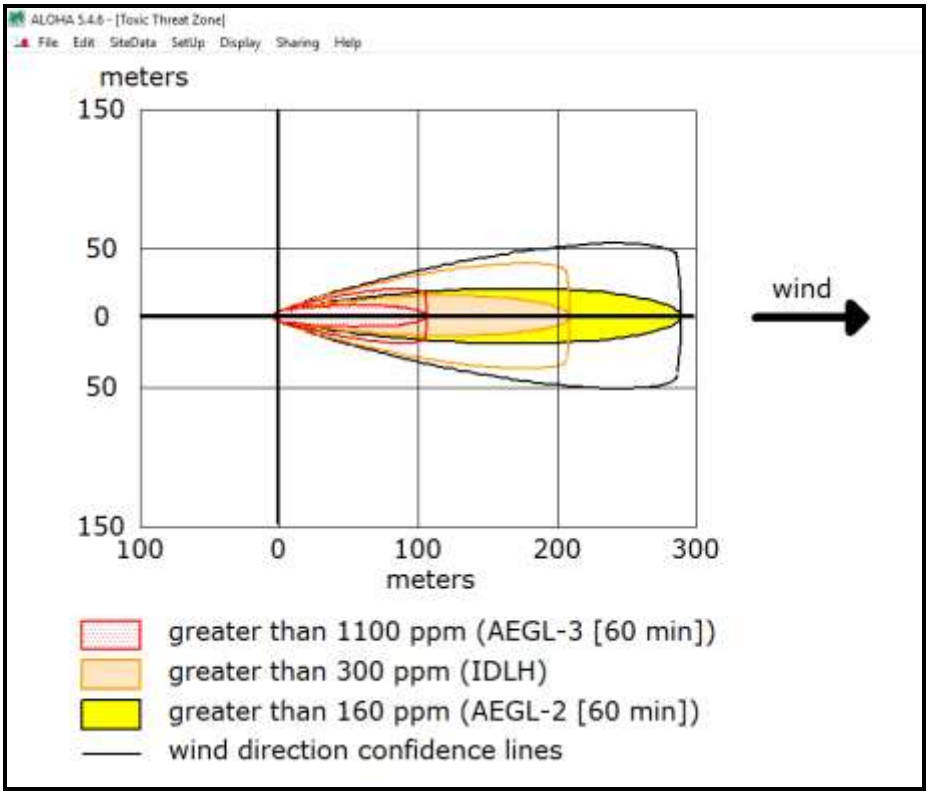

Figure 7.3 Liquid Ammonia Spillage & Evaporation—Toxic Impact Zone (Stability Class-D)

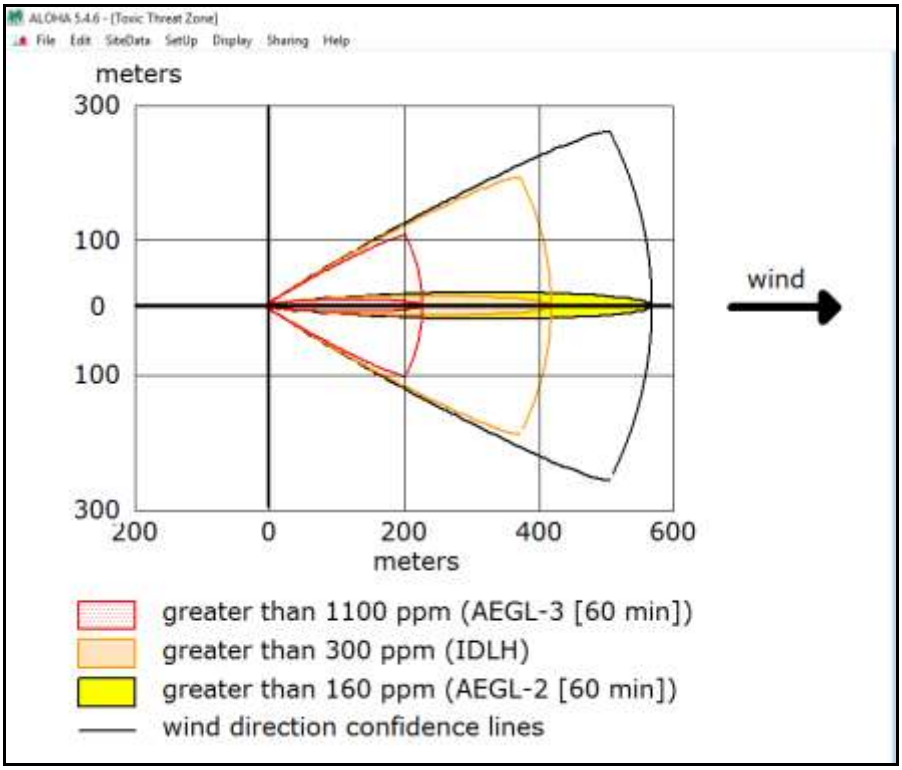

Figure 7.4 Liquid Ammonia Spillage & Evaporation—Toxic Impact Zone (Stability Class-F)

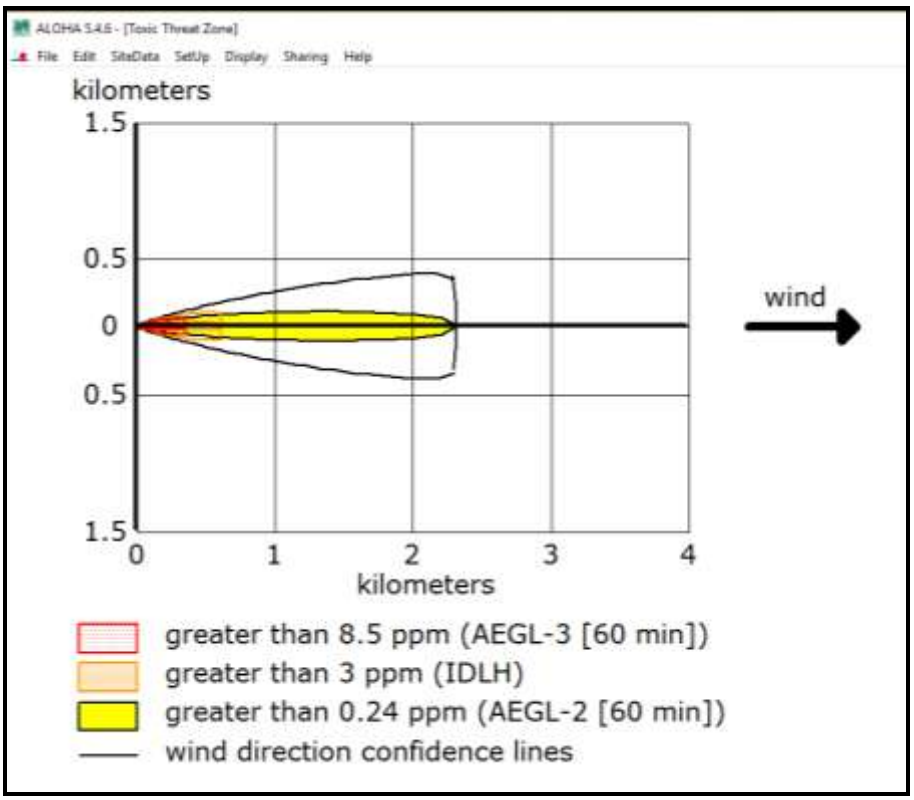

Figure 7.5 Bromine Release Impact Zone (Stability Class D)

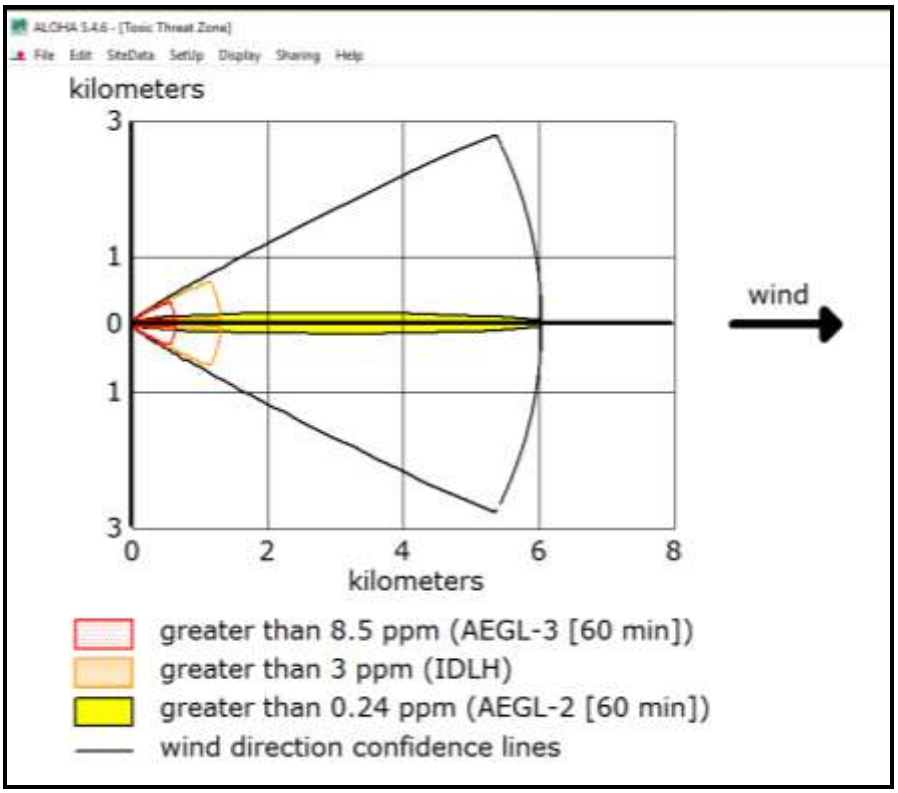

Figure 7.6 Bromine Release Impact Zone (Stability Class F)

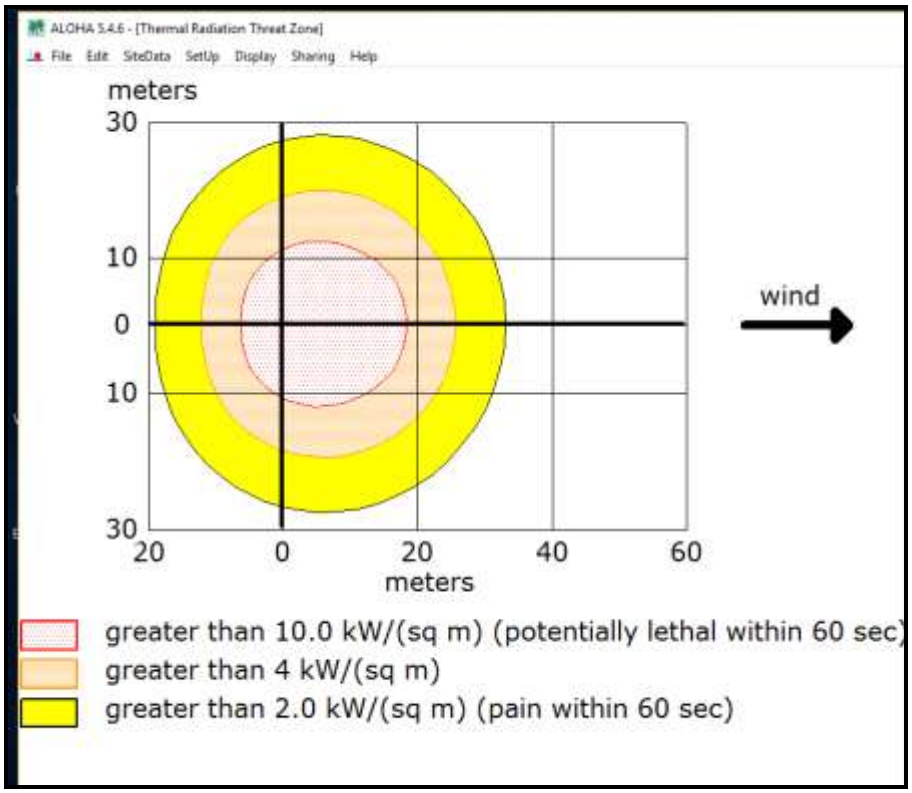

Figure 7.7 Hexane Burning Puddle-Thermal Radiation Impact Zone

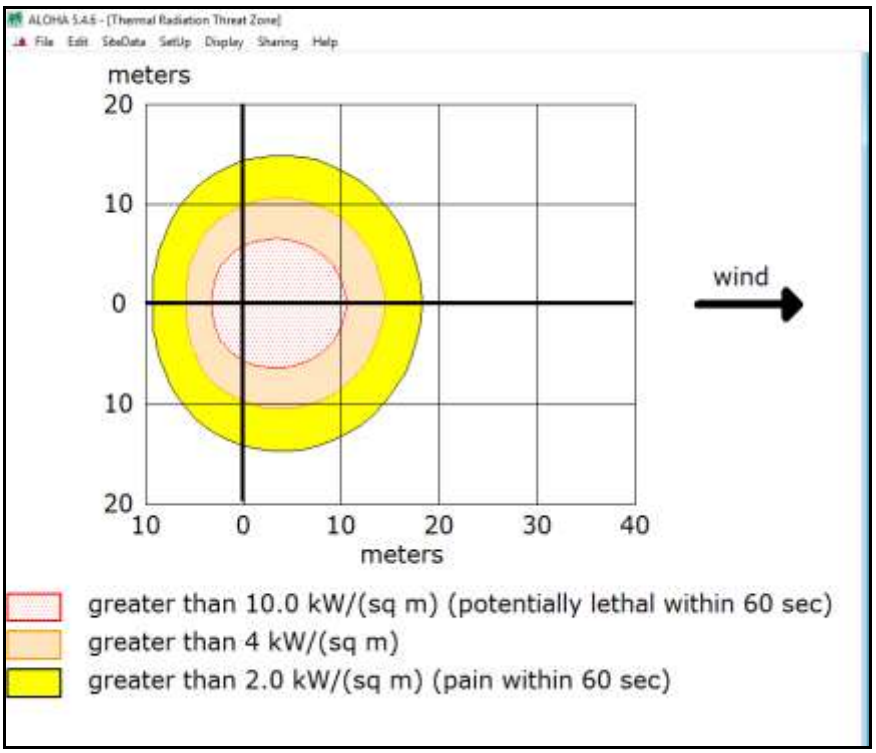

Figure 7.8 Hexane Burning Puddle-Thermal Radiation Impact Zone

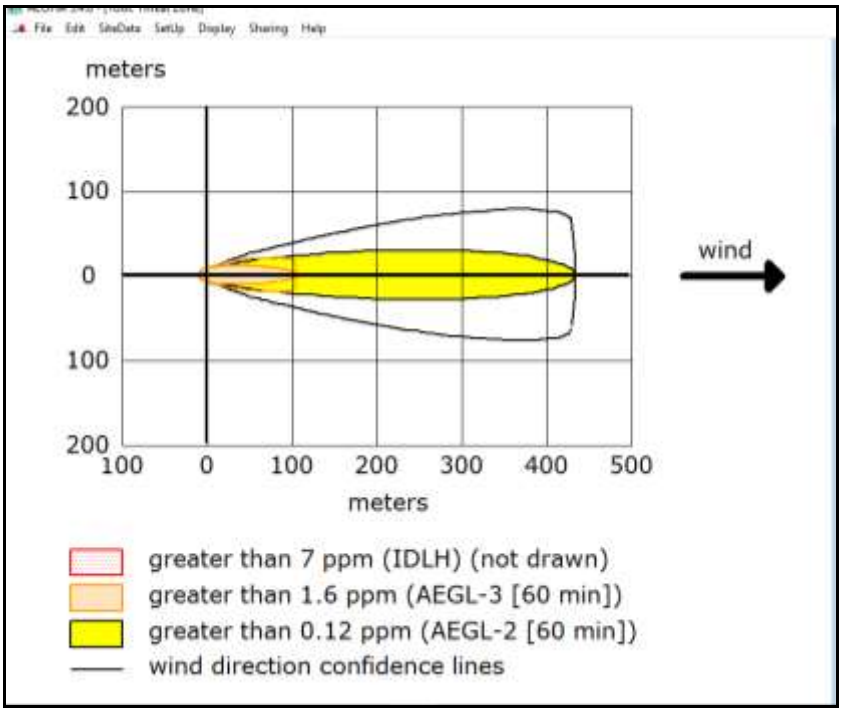

Figure 7.9 Dimethyl Sulfate Spillage-Toxic Impact Zone

7.13 CONSEQUENTIAL IMPACTS

The consequential impacts from each incident scenarios can be though thermal and toxic route. The damage can be on plant personnel (and neighboring residents in case incident crosses boundary), property and also loss in production. The impact zones for some of the hazards are shown in the **figure 7.1 to 7.9.**

7.13.1 Thermal and Explosion Hazards

Incidents involving thermal hazards are mainly due to raw material fire (in tank farms). The impact (1^{st} degree burn) is limited to 27 m only (i.e. within plant boundary). However the consequences can go to worse if the incidents lead to domino effect to other tanks.

7.13.2 Toxic Hazards

Toxic hazards are mainly due to ammonia and bromine gases leakage and their impact can cross the plant boundary (if not controlled in time). Toxic hazards are also possible in case of fire due to toxic gases generation from combustion of material (as generation of Phosgene and carbon monoxide due to Chloro Benzene combustion).

7.13.3 Other Hazards

The other hazards in the plant include (but not limited to):

- Other toxic hazards due to acids/other toxic spillages (mainly limited to spillage area only.).
- Mechanical hazards due to machines/equipment.
- Hazards due to individual soft spots like walking casually and not noticing a pit and falling or colliding/stumbling or slipping (not noticing a wet place etc.).

7.13.4 Other Toxic Hazards

Impact of acid spillage will be limited to spillage area. The spillage if comes in contact with metal parts will produce hydrogen which is highly flammable gas. Any person coming in contact with acid splash will receive chemical burns. In addition the spillage will cause pollution problem. The spillage is to be collected and neutralized for toxic contents before disposal.

7.14 OCCUPATIONAL HEALTH

PIL will have a well-equipped first aid post. It will also have staff personnel trained in first aid. Injured personnel will be immediately rushed to hospital after giving first aid. All employees will have regular medical checkup as per norms. An emergency vehicle/ambulance will always (round the clock) available for meeting any eventuality.

7.14.1 Treatment of workers affected by accidental spillage of chemicals

There is wide range of chemicals present in the Chemical plants. The safe cleanup of a chemical spill requires some knowledge of the properties and hazards posed by the chemical & any added dangers posed by the location of the spill. Employees must notify their immediate supervisor of injury by spillage of chemicals or exposure to hazardous materials. All injuries must be reported. Supervisor is responsible for reporting any injuries or occupational illnesses to the management.

Following steps will be immediate taken by the Supervisor.

- **Identify spillage/leakages of hazardous chemicals**
- **Chemical Exposure to Skin:**

Immediately flush with cool water for at least 15 minutes. If there are no visible burns, remove the cloth from burning part of body. Seek medical attention if exposure/spillages occur major possible problems.

- **Chemical Exposure to Skin – Serious:**

  Remove all contaminated clothing. Locate the nearest emergency shower and soak for at least 15 minutes. Have someone contact the Hospital for immediate medical attention.

- **Chemicals in Eyes:**

  Irrigate eyes for at least 15 minutes with tempered water from emergency eyewash station. Remove contact lenses if there is. Notify the management and immediate medical attention.

- **Acid Fumes:**

  Anyone overcome by fumes should be removed to fresh air. Never attempt to enter a location where potentially dangerous fumes might place you at risk. If someone is down, contact emergency personnel and let them enter. Self-breathing apparatus is required for persons entering the affected area. Seek medical attention for exposure as soon as possible.

- **Chemical Spills:**

  The safe clean-up of an acid spill requires some knowledge of the properties and hazards posed by the acid and any added dangers posed by the location of the spill. If you believe a spill is beyond your capacity to clean up, do not attempt to do so by your own, immediately contact to nearest fire/emergency station. Spill kits with instructions, absorbents, neutralizing agents if applicable, protective equipment, and sealable waste buckets should be present in plant area.

  Following Steps to be taken for ensuring health and safety of workers engaged in handling of Hazardous materials

  - Identify chemicals to be used, amounts required, condition followed as per the MSDS guideline.
  - Evaluate the hazards posed by the chemicals and the process conditions. The evaluation should cover toxic, physical, reactive, flammable, explosive as well as any other potential hazards posed by the respective chemicals.
  - Select appropriate controls to minimize risk, including use of engineering controls, administrative controls, and personal protective equipment (PPE) to protect workers from hazards. The controls must

ensure that OSHA's Permissible Exposure Limits (PELs) are not exceeded.

- Avoid Underestimation of Risk of handling and its reaction.
- Before working with chemicals, know the facility's policies and procedures for how to handle an accidental spill or fire. Emergency telephone numbers should be posted in a prominent area. Know the location of all safety equipment and the nearest fire alarm and telephone.
- Provide popper Ventilation in the plant/process area.
- Corrosive chemicals that require vented storage should be stored in vented cabinets instead of in a chemical hood.
- Local exhaust ventilation devices should be appropriate to the operations in the plant.
- Chemicals should be separated and stored according to hazard category and compatibility.

7.15 CONCLUSION & RECOMMENDATIONS

The hazard analysis and risk assessment of few possible selected incident scenarios indicates that such incidents mostly are not limited to plant battery limits and have impact on adjoining plants. Only one scenario (specifically toxic hazards scenario due to Ammonia leakage) is crossing the PIL plant boundaries. The direction of impact will be in down wind direction (wind direction and speed varies with season). Some of the recommendations for Tank farm storage system are as given below:

- Provision of flame detectors/ thermal sensors at strategic locations in the tank farm area.
- Auto water deluge system on each bulk storage tank for inflammable liquids. The system should automatically start taking signal from flame detectors or thermal relay.
- Fixed foam system with adequate capacity.

Toxic Hazards are due to Ammonia, Bromine and other hazardous raw materials all liquid products. Regular 'Hazard Survey' ensures the detection of leakage in the plant.

In house 'capability building' to attend hazardous scenarios is to be taken up through mock drills.

- Train staff in attending such scenarios.

Human Factors: PIL should have well equipped Toxic and fire handling system and also safety department – safety practices. Human factors role in safety cannot be ignored. Odd hours working and over/long hours work can drain out individual. It shows in lack of efficiency and also the lack of apt attention the modern chemical complex demand. They are to be closely looked into and avoided. Safety' has unique features:

a. If no accident has happened so far probability of incident/accident occurring increases.
b. 'No accident' / good safety record develops complacency inertia/over confidence in the team. This attitude gives rise to gaps/soft spots in the system giving chances to incidents/accidents.
c. Safety requires novelty. Routine training practices get stale with no positive results. Look for novel scheme of training/ safety practices to build up fresh impetus in safety. Involvement of employees with refreshed outlook for safety is to be achieved.

7.16 ACTION PLAN FOR HANDLING & SAFETY SYSTEM OF HAZARDOUS CHEMICALS

Flammable chemicals will be stored in open area outside the process plant with all the safety measures. Hazardous chemicals will be stored and handle in dispensing room for taking out sample from the container for quality check-up purpose or for the partial use. This activity for Hazardous material handling will be carried out by using all PPEs with proper ventilation & under supervision.

7.16.1 Safety Measures for Transportation and Unloading of Hazardous Chemicals

- Solvent unloading standard procedure will in place and will be implemented for safe unloading of road tanker.
- Static earthing provision will be made for tanker unloading.
- Drum handling trolleys will be used for transportation of drums up to plant and internal handling from storage to process area.
- Display Boards will be provided on all storage tanks which include the name of the chemicals and its major hazardous characteristics.
- Fire extinguishers will be provided as required.

- First aids boxes will also be provided at different places wherever required.
- Water showering system will be provided to the flammable chemicals storage area.
- Area will be declared as "NO SMOKE ZONE".

7.16.2 Safety Measures for Storage/Handling of Hazardous Chemicals

All Hazardous and flammable chemicals will store separately and away from the strong oxidant & kept it in well ventilated room. Adequate firefighting system will be installed. Safety shower and eye washer will be installed near storage area. Flame proof light fitting will be provided at storage area. Sprinkler system will be installed near storage area. Safety permit system will be followed for loading and unloading. Isolate storage will be provided with wire fencing under lock and key. Caution note, hazardous identification board will be provided. Only authorized person will be permitted in storage area and register will be maintained. "NO SMOKING" board will be displayed and Wind Indicator and siren will be provided.

7.16.3 Safety Measures for Process Units

Safety measures are the most important aspect of selection of process technology to ensure safety in production unit. For the safety in production area some important critical safety measures will be provided within the process technology/equipment itself & will put continue efforts for developing new technology/equipment. Company will ensure such provision in the technology/equipment/machineries at time of purchase. The details of the critical safety measures for process unit are as below; any reaction upsets will be confined to the reaction vessel itself as defined quantity of raw materials will be issued to the reaction vessel by metering pumps/load cells. Process parameters control will be provided as per SOP- Standard Operating Procedures. Materials will be transferred by pumping through pipeline or by vacuum from drums. All reaction vents will be connected to vapor condensers system. Hazardous materials will be transferred by pipelines in a controlled manners. Trained person will be engaged for handling of hazardous materials. Proper safety precautions will be taken during handling of hazardous materials. All

solvents and flammable material with required quantity will be charge in reactor by pump or by gravity. All the vessels will be examined periodically by a recognized competent person. All the vessels and equipments will be well earthed appropriately and well protected against Static Electricity. Temperature indicators will be provided near all reactor and distillation systems. Flame proof light fittings will be installed in the plant. All the Plant Personnel will be provided with Personal Protection Equipments to protect against any adverse health effect during operations, leakage, spillages or splash. PPE like Helmets, Safety Shoes and Safety Glasses will be provided to the employees.

7.16.4 Safety Measures for Preventive Maintenance

The safety measures in the form of the general Do's & Don'ts for safety in process & other plant area are as below:

- Do not work on equipments without permission from plant head and maintenance head.
- Make sure equipment is empty and flushed with nitrogen and air.
- Check VOC content for flammable and make sure that no flammable vapour contents.
- Keep proper and adequate fire extinguisher near work area.
- Use proper PPE.
- Do not allow any employment without pre-medical check-up or without checking fitness.
- Work in any equipment must be conducted in presence of supervisor.
- Additional safety measures in form of the checklist covering Do's & Don'ts of preventive maintenance, manufacturing utility staff for safety related measures will be updated timely and will be made available to all concern department & personnel.

7.16.5 Safety measures to prevent spillage/leakage of toxic chemicals

The preventive maintenance will be planned and carried out as per plan to avoid the failure of valve, pipelines and other component of transferring line. The spillage will be confined to the dyke area underneath the vessel. The resultant splash of such chemicals will result in exposure of toxic chemicals to employees. Decontamination facilities (Safety shower and eye wash fountains) will be provided in the plant

area, which can be used to decontaminate the affected employees. Suitable decontamination procedure will be used to decontaminate the spilled or leaked material. The SOP for decontamination will be available with all related department.

7.17 ARRANGEMENTS FOR ENSURING HEALTH AND SAFETY OF WORKERS ENGAGED IN HANDLING OF TOXIC MATERIALS

The significance of Safety & Health in plant has been a vital issue in achieving productivity and quality standard. Following is an effort for safety & health of workers working in the plant. Numbers of chemicals are used in plant have specific health hazards in nature. Following are basic fundamental principles properly underlie all the workers working in the plant. Occupational health and safety is about preventing people from being harmed by work or becoming ill from work by taking adequate precautions and providing a safe and healthy work environment. Consideration of each should be encouraged before beginning work as part of the culture of safety within the plant.

- **Plan ahead.** Determine the potential hazards associated with production.
- **Minimize exposure to chemicals.** Do not allow toxic chemicals to come in contact with skin. Provide proper ventilation devices to prevent/minimize airborne.
- **Do not underestimate hazards or risks.** Assume that any mixture of chemicals will be more toxic than its most toxic component. Treat all the chemicals as toxic substances.
- **Be prepared for accidents.** Before beginning of any batch reaction, know what specific steps to take which cause to accident if any hazardous substance release accidently. Proper follow SOP- Standard Operating procedure to take batch reaction.

Unit will assess is careful examination of what, at work, could cause harm to workers, accidents and ill health. All risks in the workplace must be identified and assessed for control measures to be put in place.

Follow the five steps of hazard identification will be taken by unit namely;

- Identify the hazards
- Decide who might be harmed and how

- Evaluate the risks and decide on precaution
- Record your findings and implement them
- Review your assessment and update if necessary

Following Information workers should know regarding hazardous chemicals

Unit shall ensure that the employee is adequately trained with regard to:

- The contents of the hazardous chemical substances
- Potential source exposure to chemicals
- Measures taken by the employer to protect employees against any risk from exposure
- Precautions to be taken by an employee to protect himself against the health risks associated exposure
- Correct use, maintenance of safety equipment, facilities and engineering controls
- Importance of good housekeeping at the workplace and personal hygiene
- Safe working procedures
- Procedures to be followed in the event of spillages or leakages.

7.18 DISASTER MANAGEMENT PLAN (DMP)

Disaster/Emergency Management Plan is essential for a chemical plant as the processes adopted for manufacturing are classified under Factory Act as Hazardous due to handling and storage of toxic, flammable and explosive hazardous materials. Over the years, the chemical process plant has created adequate infrastructure and adopted risk mitigation measures to tackle any emergency that may arise during the manufacturing process. The important aspect in emergency planning is to control an emergency by technical and organizational means, minimize accidents and consequent losses. Emergency planning also brings to light deficiencies, such as, lack of resources necessary for effective emergency response. It also demonstrates the organization's commitment to safety of employees and physical property as well as increases the awareness among management and employees. Disaster Management Plan for the plant is necessarily a combination of various actions which are to be taken in a very short time but in a pre-set sequence to deal effectively

and efficiently with any disaster, emergency or major accident with an aim to keep the loss of men, material, plant/machinery etc. to the minimum. A major emergency in a hazardous chemical plant is one, which has the potential to cause serious injury or loss of life. It may cause extensive damage to property and serious disruption of both inside and outside the plant. Sometimes, it would require the assistance of outside emergency services to handle it effectively. Although the emergency at the plant may be caused by a number of different factors, e.g. leakage of toxic and flammable materials from piping/tanks, total/partial power failure, earthquake or sabotage, it will normally manifest itself in fire/toxic release.

Primarily, DMP is prepared to furnish details which may require at the time of the emergency, to delegate responsibility, to estimate the consequences in advance and to prepare ourselves to control any type of emergency. The plan explains basic requirements as follows:

- Definition,
- Objectives,
- Organization set up,
- Communication System,
- Action on site,
- Link with Off-site Emergency Plan,
- Training rehearsal and record aspect.

7.18.1 Definitions

Various definitions on different analogy used on On-site & Off-site Emergency Plan are as follows:

Accident: An accident may be defined as "an undesirable and unplanned event with or without or major damage consequence of life and /or property.

Major Accident: It is a sudden, unexpected, unplanned event resulting from uncontrolled developments during an industrial activity, which causes or has the potential to cause, death or hospitalization to a number of people, damage to environment, evacuation of local population or any combination of above effects.

Emergency: This can be defined as any situation, which presents a threat to safety of person's or/and property. It may require outside help also.

Major Emergency: Occurring at a work is one that may affect several departments within and/or may cause serious injuries, loss of life, extensive damage to properly or serious disruption outside the works. It will require the use of outside resources to handle it effectively.

Disaster: Disaster is a sudden calamitous event, bringing great damage, loss or destruction.

Hazards: Hazard may be defined as "the potential of an accident". Hazard exists in man and the system of materials and machines.

Chemical Hazards: It is a hazard due to chemical(s) (including its storage, process, handling, etc.) and it is realized by fire, explosion, toxicity, corrosively, radiation, etc.

Risk: Risk may be defined as the combination of consequence and probability or likelihood of an accident being caused in a given man-material – machine system.

On-Site Emergency plan: It deals with measures to prevent and control emergencies within the factory and not affecting outside public or environment.

Off-Site Emergency plan: It deals with measures to prevent and control emergencies affecting public and the environment outside the premises.

7.18.2 Objective of the Disaster Management Plan

The primary purpose of this Disaster Management Plan is to equip the Plant with required resources and information for prompt implementation of the set of actions to be undertaken in the event of an accident posing hazards to the people and community after commissioning of the plant.

The objective of Disaster Management Plan (DMP), for the plant is to be in a state of perceptual readiness through training, development and mock drills, to immediately control and arrest any emergency situation so as to avert a full fledge disaster and the consequence of human and property damage and in the event of a disaster still occurring, to manage the same to that the risk of the damage consequences to life and

property are minimized and thereafter, proper rehabilitation, review and revisions of the DMP to overcome the shortcomings noticed are undertaken. The DMP document is prepared keeping in view and to confirm the requirements of the provisions of The Factories Act, 1948 under section 41 B (4), Guidelines issued by the Ministry of Environment and Forests, Govt. of India and Manufacture, Import and Storage of Hazardous Chemicals Rules, 1989 amended in 2000, Schedule 11 under Environmental Protection Act, 1986.

Following are the main objectives of the plan to:

- Defined and assess emergencies, including hazards and risk
- Control and contain incidents.
- Safeguard employees and people in vicinity.
- Minimize damage to property and/or the environment.
- Minimization of risk and impact of event accident.
- Preparation of action plan to handle disasters and to contain damage.
- Inform employees, the general public and the authority about the hazards/risk assessed and to provide safeguard, and the role to be played by them in the event of emergency.
- Be ready for 'mutual aid' if need arises to help neighbouring unit.
- Inform authorities and mutual aid centres to come for help.
- Effect rescue and treatment of casualties.
- Effective rehabilitation of the affected persons and prevention of damage to the property.
- Identify and list any fatalities.
- Inform and help relatives.
- Secure the safe rehabilitation of affected areas and to restore normalcy.
- Provide authoritative information to the news media.

7.19 ONSITE EMERGENCY PLAN

7.19.1 Incident Controller

Incident Controller's role is to control the emergency at the incident site.

7.19.1.1 Duties of Incident Controller

Incident Controller will proceed to the place of emergency after hearing siren/announcement. He will:

- Assess the scale of emergency and decide if a major emergency exists or is likely, accordingly activate emergency procedure.
- Immediately give his feedback to Emergency Control Centre (ECC) regarding emergency.
- Direct all operations within the area with following priorities.
  - Secure the safety of personnel
  - Minimize damage to plant property and environment.
  - Minimize loss of material.
- Direct rescue and firefighting operations till the arrival of the outside Fire Brigade, he will relinquish control to Sr. Officer of Fire Brigade.
- Ensure that the affected area is searched for causalities.
- Ensure that all non-essential workers in the affected area evacuate to the appropriate assembly point.
- Set up communication point to establish Radio/Telephone/Messenger contact as with emergency control centre.
- Pending arrival of works site controller, assume the duties of the post in particular to:
  - Direct the shutting down and evacuation of plant and areas likely to be threatened by emergency.
  - Ensure that the outside emergency services have been called in.
- Ensure that the key personnel have been called in.
- Report all significant development to the Site Main Controller.
- Provide advice and information, as required to the Senior Officer of the Fire Brigade.
- Preserve evidence that would facilitate any subsequent inquiry into the cause and circumstances of emergency.

Dy. Incident Controller will carry out above said duties in absence of Incident Controller.

7.19.2 Site Main Controller

Site Main Controller will be overall in-charge of emergency organization

7.19.2.1 Duties of Site Main Controller:

- Relieve the Incident Controller of responsibility of overall main control.
- Co-ordinate ECC or if required, security for raising evacuation siren and also all clear siren, in case emergency is over.

- Declaration of major emergency ensures that outside emergency services will be called and when required nearby firms will be informed.
- Ensure that key personnel will be called in.
- Exercise direct operational control on parts of the works outside the affected area.
- Maintain a speculative continuous review of possible development and assess these to determine most possible cause of events.
- Direct the shutting down and evacuation of plants in consultation with key personnel.
- Ensure causalities are receiving adequate attention; arrange for additional help if required. Ensure relatives are advised.
- Liaison with Chief Officers of the Fire and Police services for providing assistance in tackling the emergency.
- Ensure the accounting of personnel.
- Control traffic movement within the work.
- Arrange for a chronological record of the emergency to be maintained.
- During prolonged emergency, arrange for the relief of the personnel and provision of catering facilities.
- Contact the local office to receive early notification of impending changes in weather conditions, in case of prolonged emergency.
- Issue authorized statements to the news media and informs H.O.
- Ensure that proper consideration is given to the preservation of evidence.
- Control rehabilitation of affected areas after control of the emergency.

7.19.3 Other Key Personnel

The key personnel required for taking decision about further action for shutting down the plant, evacuate the personnel, and carry out emergency engineering works in consultation with Site Main Controller in light of the information received.

HOD's /Senior Managers/ Section Heads will be responsible for safety, security, fire, gas and pollution control, spillage control, communication system including telephone, wireless etc. Also medical services,

transport, engineering, production, technical services, will form part of advising team.

7.19.3.1 Emergency Response Team

The role of Emergency Response Team members is to actually combat the emergency at the site and control the emergency situation and carry out rescue operations. All team members will be thoroughly trained to deal with fires, explosions, chemical spills and atmospheric releases, first aid. As per priority list during emergency, the activities will be carried out as per emergency control plan.

7.19.3.2 Emergency Personnel's responsibilities Outside Normal Working Hours of the Factory.

The duties of Shift In-charge & **team members** have been brought out in emergency control plan. **All team members** after evacuating the area shall report to ECC/ Incident Place. The non-essential workers shall be evacuated from the plants if need arises and this will be determined with the forcible rate with which incident may escalate. Non-essential workers shall assemble at the earmarked/specified point of assembly.

7.19.3.3 Assembly Points

At the proposed plan, at least 2 assembly points will be identified and marked properly.

7.19.4 Emergency Control Centre

It will be headed by Site Main Controller, HOD – PD, HOD- P&A and it is sited in **Office of Site Main Controller in Admin Building & New security office** (after office hours), which is readily accessible & with minimum risk, equipped with telephone facilities and other announcements extra communications facilities needed. It has enough means to receive and transmit information and directions from site main controller to incident controller and other areas. In emergency control centre due to its safer location and advantage of easier accessibility, all necessary personnel protective equipment's fire-fighting extinguishers will be stocked in sufficient quantity.

7.19.4.1 Role of Emergency Control Centre

In case of mishap or accident like fire, toxic gas leakage, explosion in the factory, The Emergency Control Centre will be Office of Head- Operations.

- The plot plan indicating all the activities in the factory premises including that of storage's utility services, production area, administration, will be kept for ready reference, showing the location of fire hydrant and fire-fighting aids.
- Normal roll of employees, work permits, gate entries and documents for head count, employees blood group, other information and addresses will be available and the person, who will handle this operation will HOD P & A.
- Stationery required is available in the Control Centre (ECC) and HOD (P & A) looks after it.
- The requirement of personnel protective equipment and other material, like torches, have been worked out and the quantity required during emergency will be kept in the Control Room (ECC). The responsible person for maintaining the said requirement/inventory will be HOD-HSE.

7.19.5 Fire & Toxicity Control Arrangements

The plant will be well equipped with suitable numbers of fire-fighting and personnel protective equipment. The staff will be trained regularly to handle the various emergency situations.

7.19.6 Medical Arrangements

Availability of first aid facilities in sufficient quantity will be always ensured. In case of emergency arrangements will be made to avail outside medical help immediately. Emergency transport facility will be available.

7.19.7 Transport & Evacuation, Mutual Aid Arrangements

Transport & Evacuation and Mutual Aid arrangements will be available in the factory.

7.20 COMMUNICATION SYSTEM

7.20.1 Declaring the Emergency

In case of any emergency in the plant, speedy and effective communication of the same to all concerned in least possible time is the most important aspect of any emergency-handling plan. An early communication increases the chances of control of emergency in the bud

stage. Blowing siren will be adopted as method of communication of emergency, to all employees in the plant.

7.20.1.1 Type of Sirens

Three different types of sirens have been identified for communication of emergency.

Alert Siren: <u>Single Continuous Siren for One Minute</u>. This indicates that there is some accidental happening in the plant. All have to become alert. Incident controller will be rush to the site of emergency. Plant area people have to start safe shut down. Rescue team and other emergency control teams have to reach at the site of emergency.

Siren for evacuation: <u>wailing & waning siren for three minutes</u>. This siren indicates that emergency is of serious proportion and everybody has to leave his work place. All people having their role in emergency control have to assume their assigned role. All non-essential workers have to proceed immediately to assembly area and wait for further instruction.

All clear siren: <u>Long continuous siren for two minutes</u>. This is a sign of return of normalcy. On hearing this siren everybody should go back to his or her respective workplace.

7.20.1.2 Location of Siren

Siren will be located in centre of the pant for wide coverage of the whole campus. Switch for siren will be provided at security gate. The switch at Security gate should be operated only as a general rule.

Emergency manual call bell will be installed which will be used in case of total failure of electricity. It is responsibility of HOD (HSE) to maintain the upkeep of electric call bell and HOD- Security and administration to maintain manual and Hand operated siren.

7.20.1.3 Raising Alarm

Any person noticing any emergency situation in the plant should immediately call security gate with following information:

- Identify oneself
- State briefly the type of emergency i.e. whether fire, explosion, toxic gas release etc.
- Give the location of the incident

- Estimated severity of the incident

Security personnel after ensuring genuineness of the call shall raise the ALERT SIREN. At the same time he will also contact the incident controller and ECC in order and inform about the incident. He will keep the gate open and rush his two security personnel at the site of emergency with appropriate PPEs. ECC will be located at the office of Head-Operations on normal working hours and at Security gate after normal working hours (during night). ECC shall be immediately manned on hearing alert siren. If the authorized people to handle ECC are not available, any senior most people out of the available person nearby shall occupy ECC till authorized person comes. Incident controller, on hearing alert siren or by any other way of information of the emergency, will immediately reach at the site of incident and assess the situation. He will immediately give his feed back to ECC. ECC shall direct security gate to raise evacuation siren, if the need arise. SIREN FOR EVACUATION shall be raised on instruction from Site Main Controller or any Manager of the plant in the ECC. Security gate person will be authorized to raise ALL CLEAR SIREN on instruction from Site Main Controller or ECC, after the emergency is over. Incident controller shall assume the responsibility of site main controller in his absence.

7.20.2 Internal Communication

It shall be responsibility of ECC to communicate to all employees in the plant. They may take help of telephone operator for such communication. However, telephone operator can directly communicate information about emergency to all internal departments, if such message comes from incident controller or site main controller. Telephone operator will continue to operate the switchboard advising the callers that staffs are not available and pass all calls connected with the incident to ECC.

7.20.2.1 Availability of Key Personnel outside Normal Working Hours

The details of key personnel availability after working hours will be made available at Security Gate, ECC, telephone operator as well as production units. Security personnel shall call required key personnel from their residence in case emergency occurs outside normal working hours. Availability of emergency vehicle/Ambulance will be ensured to fetch the

key personnel residing outside. It will be the responsibility of HOD (P & A) to maintain it.

To the Outside Emergency Services

Decision to call outside help to deal with emergency like fire brigade, ambulance, police, etc., shall be taken by Site Main Controller. However, in absence of Site Main Controller, if the incident controller realizes the situation going out of control, he may ask for immediate help from outside. ECC will be responsible for calling help from outside. A list of emergency services available in the area with their telephone numbers will be provided at ECC, at Security gate and with telephone operator. Facilities such as phones, emergency vehicle, and security personnel will be available to help calling outside emergency services and authorities.

7.20.3 Communication to the Authorities

The emergency will be immediately communicated to the government officers and other authorities such as SPCB, police, district emergency authority, Factory Inspectorate, hospital etc. by Emergency Control Centre.

Communication to Neighboring Firms & the General Public

In case of emergency having its outside impact, public will be cautioned regarding the same. Co-ordination of police will be sought for speedy action. This is to be ensured by ECC.

7.21 Pre-emergency activities

Internal Safety survey with regard to identification of hazards, availability of protective equipment's, checking for proper installation of safety devices will be carried out periodically.

- Periodic pressure testing of equipment
- Periodic pressure testing of lines
- Periodic safety/relief valve testing
- Periodic fire hydrant system testing
- Mock drill to check up level of confidence, extent of preparedness of personnel to face emergency is being contemplated
- Regular training is being imparted to all personnel to create awareness
- Adequate safety equipment will be made available
- Periodic check-up of emergency lights

- Safer assembly points will be identified
- Storage of adequate first aid treatment facilities

7.22 POST-EMERGENCY ACTIVITIES

Following post emergency actions will be carried out to study in detail and preventive measures to be taken

- Collection of records
- Inquiries
- Insurance claims
- Preparation of reports comprising suggestion and modification
- Rehabilitation of affected personnel
- Normalization of plant

7.22.1 Evacuation and Transportation

In case of emergency, evacuation and transportation of non-essential workers will be carried out immediately. The affected personnel will be transported for medical aid.

7.22.2 Safe Close Down

During emergency plant shut down will be carried out if situation warrants. This will be as per the instruction of site main controller under guidance of incident controller.

7.22.3 Use of Mutual Aid

Mutual aid agreement with nearby industries will be ensures to provide help to each other in the emergency,

7.22.4 Use of External Authorities

As and when necessary, statutory authorities, police, pollution control personnel, medical aid/center, ambulance etc. will be contacted.

7.22.5 Medical Treatment

The affected personnel will be brought to safer place immediately to give them first aid. Immediate medical attention will be sought.

7.22.6 Accounting for Personnel

Proper accounting for personnel will be laid down in all the shifts. The number of persons present inside the plant premises, their duty etc. will be available with the P & A. This record will be regularly updated and will be made available.

7.22.7 Access to Records

The relatives of affected personnel will be informed. The details regarding all employees will be made available to Administration building.

7.22.8 Public Relations

In case of emergency, Manager P & A will be available for official release of information pertaining to the incident.

7.22.9 Rehabilitation

The affected area will be cleared from emergency activities only after positive ascertaining of the system in all respects. The entry to affected area will have to be restricted until statutory authorities visit and inspect the spot of incident. Nothing should be disturbed from the area till their clearance. The site main controller will be in charge of the activities to be undertaken. The plan will cover emergencies, which can be brought under control by the works with the help of emergency team/fire services. The DISASTER CONTROL PLAN for gas leak and fire will be prepared for entire factory.

7.23 CAUSES OF EMERGENCY

7.23.1 Risk

7.23.1.1 Nature

In the plant, the nature of dangerous events could be of the following:

- Fire : Chemical/Electrical
- Toxic Release : From chemicals
- Leakages : Equipment, pipe lines, valves, etc.

7.23.1.2 Various Emergency Actions

a) Onsite

- Safe shut down of the plant and utilities
- Emergency control measures.
- To attempt with the help of trained crew in firefighting to contain the fire spread up/gas emission and limit within limited space.
- To cut off source of oxygen by use of firefighting appliances/to cut off source of gas emission.
- Cut off fall sources of ignition like electrical gadgets.
- To protect fire prone area from the fire.

- To remove material which can catch fire to the extent possible from fire prone area.
- Evacuation of non-essential persons.

b) Medical Facilities/Treatment

- The Plant will have a Health centre which is manned with trained male nurse on continuous basis who can render medical first aid. Doctor will visit two times a week for two hour each time. The Plant is searching for a full time medical officer and will appoint as and when available.
- Depending on seriousness the injured person shall be shifted to any other hospital.
- Vehicle will be available round the clock for transportation. Ambulance will be also made available in the campus on regular basis.

c) In the event of Fatal Accidents

The information shall be given to following authorities:

- Inspector of Police
- Inspector of Factories
- Mamlatdar
- Corporate Office
- Regd. Office
- Insurance of the plant
- Regional Officer, SPCB

d) Emergency Siren

Emergency siren shall be blown for announcing the emergency which shall have different sound for identification/differentiation than the normally used for commencement of factory working etc.

- Location of Siren Above Plant
- Type of Siren Industrial Siren
- Position of siren switch Located at Main Gate

e) Seeking help from neighboring industries/sources for fire engine

f) Advise for vacation of other areas

- Since the effect of fire/gas emission shall be contained within the area of the plant advice of vacation of other areas is not necessary

7.23.1.3 Response Time-Minutes

Hazard	Fire Fighting	Police	Medical Services
Fire & Explosion	Immediate with whatever facilities available with the plant	10 min.	10 minutes
	External Help within 15 minutes		

7.24 OFF-SITE EMERGENCY PLAN

7.24.1 Need of the Site Emergency Plan

Depending upon the wind direction and velocity of the effects of accident in factory may spread to outside its premises. To avert major disaster it is essential to seek guidance/assistance of statutory authorities, police and health department. The movement of traffic may have to be restricted. Required information will be given to the authority and consultation will be sought for remedial measures.

A purpose of the off-site emergency plan is:

- To provide the local/district authorities, police, fire, brigade, doctors, surrounding industries and public the basic information of risk and environmental impact assessment and appraise them of the consequences and the protection/prevention measures and to seek their help to communicate with public in case of major emergency.
- To assist district authorities for preparing the off-site emergency plan for district or particular area and to organize rehearsals from time to time and initiate corrective actions on experience.

7.24.2 Structure of the Off-Site Emergency Plan

Available with concerned authorities.

7.24.3 Role of the Factory Management

The site main controller will provide a copy of action plan to the statutory authorities in order to facilitate preparedness of district/area off-site emergency plan.

7.24.4 Role of Emergency Co-ordination Office (ECO)

He will be a senior police or fire officer co-ordination with site main controller. He will utilize emergency control centre.

7.24.5 Role of Local Authority

Preparation of Off Site Plan lies with local authorities. An emergency-planning officer (EPO) works to obtain relevant information for preparing

basis for the plan and ensures that all those organization involved in offsite emergency and to know their role and responsibilities.

7.24.6 Role of Fire Authorities

The fire authorities will take over the site responsibility from incident controller after arrival. They will be familiarized with site of flammable materials, water and foam applies points, fire-fighting equipment.

7.24.7 Role of the Police and Evacuation Authorities

Senior Police Officer designated, as emergency co-ordination officer shall take over all control of an emergency. The duties include protection of life, property and control of traffic movement.

Their functions include controlling standards, evacuating public and identifying dead and dealing with casualties and informing relatives of dead or injured. There may be separate authorities/agencies to carry out evacuation and transportation work. Evacuation depends upon the nature of accident, in case of fire only neighboring localities shall be alerted. Whole areas have to be evacuated in case of toxic release.

7.24.8 Role of Health Authorities

After assessing the extent of effect caused to a person the health authorities will treat them.

7.24.9 Role of Mutual Aid Agencies

Various types of mutual aid available from the surrounding factories and other agencies will be utilized.

7.24.10 Role of Factory Inspectorate

In the event of an accident, the Factory Inspector will assist the District Emergency Authority for information and helping in getting Neighbouring Industries/mutual aid from surrounding factories. In the aftermath, Factory Inspector may wish to ensure that the affected areas are rehabilitated safely.

7.25 MOCK DRILLS AND RECORDS

7.25.1 Need of Rehearsal & Training

Regular training and rehearsal program of emergency procedures shall be conducted with elaborate discussions and testing of action plan with mock drill. If necessary, the co-operation/guidance of outside agencies will be sought.

7.25.2 Some Check Points

- The extent of realistic nature of incidents.
- Adequate assessment of consequences of various incidents.
- Availability of sufficient resources such as water, fire-fighting aids, personnel.
- The assessment of time scales.
- Logical sequences of actions.
- The involvement of key personnel in the preparation of plan.
- At least 24 hours covers to take account of absences due to sickness and holiday, minimum shift manning.
- Satisfactory co-operation with local emergency services and district or regional emergency planning offices.
- Adequacy of site.

7.25.3 Records and Updating the Plan

All records of various on-site and off-site emergency plans of the factory will be useful alone with those of the factors by which statutory authorities draw a detailed plan for the whole area/district. The records of the activity will be updated regularly.