6. RISK ASSESSMENT& DISASTER MANAGEMENT PLAN

6.1. 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.

6.2. Risk Assessment

A three 'levels' risk assessment approach has been adopted for the M/s BSCLLP proposed expansion project to be set up at C-6, 7 & 8 UPSIDC Industrial Area, Phase-2, Gajraula, J P Nagar, Uttar Pradesh. 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 are obtained from plant. The results provide a relative indication of the extent of hazards and potential for risk exposure.

- **Level 2 – MajorRisk 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:

i. Hazards identification utilising formal approach (Level 2, HAZOP etc.);

ii. Frequency Analysis. Based on past safety data (incidents / accidents); Identifying likely pathway of failures and quantifying the toxic / inflammable material release;

iii. 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.

iv. 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 analysed 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.

BSCLLP shall manufacture pesticides chemicals at the proposed site. **Table in Chapter 2** gives the list of raw materials. Solid raw materials are stored in ware house while liquid and gaseous raw materials are stored in tank farms and covered area. The list of bulk liquid storages of raw materials are as given below:

Table 6.1: Liquid/Gaseous Bulk Storages

S.No.	Name	Quantity (Kg/Day)	Means of Storage	Storage Quantity	Safety Features of Storage
1	H_2SO_4	3197	Above ground ms tank	22000 kg (~12600 L)	The tank will be placed in a concreted, dyke-walled

S.No.	Name	Quantity (Kg/Day)	Means of Storage	Storage Quantity	Safety Features of Storage
					storagearea with acid-proof tiling. The vent line will be connected to tanker while unloading to prevent escape of fumes into the atmosphere.
2	CAUSTIC LYE	4931	Above ground ms tank	34500 kg (~23000 L)	The tank will be placed in a concreted, dyke walled storage area.
3	HCl 30%	5079	Above ground hdpe tank	25000 kg (~23000 L)	The tank will be placed in a concreted, dyke-walled storage area with acid-proof tiling. The vent line will be connected to a scrubber.
4	CHLOROETHANE	225	Cylinder	2000 kg (10 Cylinders)	The cylinders will be stored in a well-ventilated shed away from direct sun light and having flame proof lighting.
5	ACETIC ANHYDRIDE	826	Above ground ss tank	12390 kg (11500 L)	The tank will be placed in a concreted, dyke walled storage area. The vent line of tank and dozing vessel will be connected to prevent escape of vapour to atmosphere. Additionally any vapour escape will be contained by a scrubber.
6	BROMINE (Br_2)	2095	Glass bottles	10000 kg (~4600 L)	The glass bottles will be stored in crates filled with saw-dust to prevent breakage and contain leakage, if broken. The bottles will be cooled before emptying into dozing vessel to reduce vapour escape and whatever vapour escaping will be

S.No.	Name	Quantity (Kg/Day)	Means of Storage	Storage Quantity	Safety Features of Storage
					extracted and scrubbed.
7	CARBON DISULFIDE (CS_2)	1450	Ms storage tank in concrete pit	14500 kg (~11500 L)	The material will be stored in a tank filled with water and the tank will be placed in a concrete pit with a layer of water so that if any leakage the heavy material will sink safely in water. The material will be transferred by hydraulic pressure.
8	CHLORINE	191	Tonners	2700 kg (3 tonners)	The tonners will be placed in a shed with provision to extract the gas and scrub in alkali in case of any leakage.
9	ETHYLENE OXIDE **(EPOXY ETHANE)**	917	Insulated MS bullet type tank with chilled brine cooled vent condenser.	9100 kg (~10500 L)	The tank will be placed in a dyke walled concreted storage in a safe area away from sources of ignition. Automatic water sprinkler will be provided around and on the tank.
10	PCl3	855	Above ground ms lead-bonded tank	8000 kg (~5500 L)	The tank will be placed in a concreted, dyke-walled storage area with acid-proof tiling. The vent will be connected to a scrubber to prevent escape of vapour to atmosphere.
11	AMMONIA GAS	423	Cylinders	2000 kg (20 cylinders)	The cylinders will be stored in a well-ventilated shed away from direct sun light and having flame proof lighting.
12	Dimethyl sulphide (DMS)	186	Insulated MS bullet type tank	2500 kg (~3000 L)	The tank will be placed in a dyke walled concreted storage in a safe area away from sources of

S.No.	Name	Quantity (Kg/Day)	Means of Storage	Storage Quantity	Safety Features of Storage
			with chilled brine cooled vent condenser		ignition. Automatic water sprinkler will be provided around and on the tank.

Table 6.2: Solvent Bulk / Fuel Storages

S. No.	Raw Material	Max. storage	Means of Storage	Dimensions/shape
1	TOLUENE	18 KL	20 KL UG, MS storage tank	3 m dia* 3.5 m height, Horizontal cylindrical tank with flat ends
2	METHANOL	7 KL	20 KL UG, MS storage tank	3 m dia * 3.5 m height, Horizontal cylindrical tank with flat ends
3	DMF	20 KL	25 KL ABOVE GROUND MS TANK	2.77 m dia *4 .5 m height , Vertical cylindrical tank with conical top and flat bottom
4	MDC	25 KL	25 KL ABOVE GROUND MS TANK	2.77 m dia * 4.5 m height , Vertical cylindrical tank with conical top and flat bottom
5	XYLENE	15 KL	25 KL ABOVE GROUND MS TANK	2.77 m dia * 4.5 m height , Vertical cylindrical tank with conical top and flat bottom
6	HEXANE	16 KL	20 KL UG, MS storage tank	3 m dia* 3.5 m height, Horizontal cylindrical tank with flat ends
7	MCB	4 KL	Drums	--
8	1,2 DICHLORO ETHANE	3 KL	Drums	--
9	ISOPROPYL ACETATE	2 KL	MS DRUMS	--
10	DMS	3 KL	20 KL UG MS TANK	3 m dia* 3.5 m height, Horizontal cylindrical tank with flat ends
11	DMSO	3 KL	DRUMS	--
12	IPE	1 KL	DRUMS	--
13	PE		DRUMS	--
14	O-XYLENE	12 KL	25 KL ABOVE GROUND	2.77 m dia * 4.5 m

S. No.	Raw Material	Max. storage	Means of Storage	Dimensions/shape
			MS TANK	height , Vertical cylindrical tank with conical top and flat bottom
15	BUTANOL	3 KL	MS DRUM	--
16	ACETONE	15 KL	20 KL UG, MS storage tank	3 m dia* 3.5 m height, Horizontal cylindrical tank with flat ends
17	ETHANOL	6 KL	Drums	--
18	ISOPROPYL ALCOHOL	2 KL	DRUMS	--
19	HSD	--	15 KL	MS Tank
20	LDO	--	15 KL	MS Tank

6.3. Risk Screening Approach

Proposed Plant: Risk screening of BCSLLP proposed project was undertaken through data / information provided by BCSLLP. 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. BCSLLP plant will be using number of hazardous chemicals and also producing pesticides chemicals – all hazardous in nature. The chemicals stored in bulk (liquid or gaseous) and defined under MSHIC Rule will be considered for detailed analysis.

Hazardous materials have been defined under MSIHC Rules (1989) - 2 (e) which means.

(i) Any chemical which satisfies any of the criteria laid down in Part I of Schedule I and is listed in Column 2 of Part II of this Schedule;

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:

S. No	Toxicity	Oral Toxicity LD_{50} (mg/kg)	Dermal Toxicity LD_{50} (mg/kg)	Inhalation Toxicity LC_{50} (mg/l)	Remarks
1	Extremely Toxic	>5	< 40	< 0.5	
2	Highly Toxic	>5 – 50	> 20 – 200	< 0.5 – 2.0	
3	Toxic	>50 - 200	> 200 - 1000	> 2 – 10	

6.3.1 Flammable Chemicals

(i) **Flammable gases**; 20 ^{0}C and at standard pressure of 101.3 KPa are:

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

(ii) **Extremely flammable liquids**: chemicals which have a flash point lower than or equal to 23 ^{0}C and the boiling point less than 35 ^{0}C;

(iii) **Very Highly flammable liquids**: chemicals which have a flash point lower than or equal to 23 ^{0}C and the boiling point higher than 35 ^{0}C;

(iv) **Highly Flammable Liquid**: Chemicals, which have a flash point lower than or equal to 60 ^{0}C but higher than 23 ^{0}C.

(v) **Flammable liquids**: chemicals, which have a flash point higher than 60 ^{0}C but lower than 90 ^{0}C.

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

a) 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 surroundings;

b) 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.

I. any chemical listed in Column 2 of Schedule 2;

II. any chemical listed in Column 2 of Schedule 3;

Table 6.3: Hazardous Analysis Raw Materials Stored in Bulk

S. No.	Material	S. No & Threshold Quantity (TQ in Kg) as per MSHIC Rules			Chemicals Hazards Potential		Remarks
		Schedule-1, Part-II	Schedule-2, Part-I	Schedule-3, Part-I	Hazards	Toxic	
RM-1.	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	
RM-2.	Caustic (Sodium Hydroxide)	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	
RM-3.	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	
RM-4.	Chloroethane CAS No: 75-00-3 UN--1037 Flammable Gas; BP- 12.3^{0}C Flash Point: -50^{0}C	---	---	---	Flammable Gas Extremely hazardous in case of inhalation. Very hazardous in case of eye contact (irritant). Slightly hazardous in case of skin contact (irritant), of ingestion. Severe over-exposure can result in death.	LC 50—80 ppm (4 hrs)	
RM-5.	Acetic anhydride CAS No: 108-24-7 UN No: 1715	3			Flammable; Dangerous when exposed to heat or fire; Irritating vapours are generated when heated; Health Hazards: Liquid is volatile and causes little irritation on uncovered skin. However, causes severe	ERPG-1: 0.5 ppm-	

S. No.	Material	S. No & Threshold Quantity (TQ in Kg) as per MSHIC Rules			Chemicals Hazards Potential		Remarks
		Schedule-1, Part-II	Schedule-2, Part-I	Schedule-3, Part-I	Hazards	Toxic	
					burns when clothing is wet with the chemical or if it enters gloves or shoes. Causes skin and eye burns and irritation of respiratory tract. Nausea and vomiting may develop after exposure. Acetic Anhydride reacts violently on contact with water, steam, methanol, ethanol, glycerol and boric acid. Reaction with water is particularly dangerous in presence with mineral acids (e.g., nitric, perchloric, chromic, sulfuric acid)		
RM-6.	Bromine CAS No:7726-95-6 UN No:1744	84	17 TQ-1: 10 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		
RM-7.	CARBON DISULFIDE (CS_2) CAS No: 75-15-0 Flammable Liquid BP-46.3^{0}C	110			Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Very hazardous in case of skin contact	ORAL (LD50): Acute: 3188 mg/kg [Rat]. 2780 mg/kg [Mouse]. VAPOR (LC50): Acute: 12500 ppm 4 hour(s) [Rat].	Flammable in presence of open flames and sparks, of oxidizing materials. Explosion Hazards in Presence of Various

S. No.	Material	S. No & Threshold Quantity (TQ in Kg) as per MSHIC Rules			Chemicals Hazards Potential		Remarks
		Schedule-1, Part-II	Schedule-2, Part-I	Schedule-3, Part-I	Hazards	Toxic	
					(permeator). Inflammation of the eye is characterized by redness, watering, and itching.		Substances .
RM-8.	Chlorine CAS No:7782-50-5 UN No:1017 A greenish yellow gas with a pungent suffocating odour. Toxic by inhalation.	119	5 TQ-1: 10MT TQ-2: 25 MT	108 TQ-1: 10MT TQ-2: 25 MT	(Gas); Non Combustible; May ignite other combustible materials (wood, paper, oil, etc.). Mixture with fuels may cause explosion. Health Hazards: Poisonous; may be fatal if inhaled. Contact may cause burns to skin and eyes. Bronchitis or chronic lung conditions	ERPG-1: 1.0 ppm ERPG-2: 3.0 ppm ERPG-3: 20 ppm IDLH: 10 ppm **[T]**	
RM-9.	Ethylene oxide **(epoxy ethane)** CAS No: 75-21-8 Extremely flammable gas with ether like odour BP-10.5 ^{0}C	269			Causes skin irritation; causes serious eye irritation; may cause an allergic skin reaction	LC 50-2920 ppm/1 hr	
RM-10.	Phosphorus Trichloride (PCl3) CAS No-7719-12-2 Nonflammable fuming liquid with pungent odour BP-76 ^{0}C	506			Very hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Hazardous in case of skin contact (corrosive, permeator), of eye contact (corrosive). Slightly hazardous in case of skin contact (sensitizer).	ORAL (LD50): Acute: 18 mg/kg [Rat]. VAPOR (LC50): Acute: 50 ppm 4 hours [Guinea pig].	
RM-11.	Ammonia	31	2	105	Fire Hazards: (Gas); Mixing	ERPG-1: 25 ppm	

S. No.	Material	S. No & Threshold Quantity (TQ in Kg) as per MSHIC Rules			Chemicals Hazards Potential		Remarks
		Schedule-1, Part-II	Schedule-2, Part-I	Schedule-3, Part-I	Hazards	Toxic	
			TQ-1: 60 MT TQ-2: 600 MT	TQ-1: 50 MT TQ-2: 500 MT	of ammonia with several chemicals can cause fire hazards, / or explosions; vapours are toxic- irritation to eyes and respiratory tract.	ERPG-2: 150 ppm IDLH: 300 ppm	
RM-12	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. If aspirated, causes coughing, gagging, distress, and rapidly developing pulmonary edema. If ingested causes vomiting, griping, diarrhea, depressed respiration.	ERPG-1: 50 ppm ERPG-2: 300 ppm ERPG-3: 1000 ppm IDLH: 500 ppm	
RM-13	Methanol CAS No:67-56-1 UN No:1230 A colorless fairly volatile liquid with a faintly sweet pungent odor like that of ethyl alcohol.	377			Highly Flammable; Behavior in Fire: Containers may explode. Health Hazards: Exposure to excessive vapor causes eye irritation, head-ache, fatigue and drowsiness. High concentrations can produce central nervous system	ERPG-1: 200 ppm ERPG-2: 1000 ppm ERPG-3: 5000 ppm IDLH: 6000 ppm	

S. No.	Material	S. No & Threshold Quantity (TQ in Kg) as per MSHIC Rules			Chemicals Hazards Potential		Remarks
		Schedule-1, Part-II	Schedule-2, Part-I	Schedule-3, Part-I	Hazards	Toxic	
					depression and optic nerve damage. 50,000 ppm will probably cause death in 1 to 2 hrs. Can be absorbed through skin. Swallowing may cause death or eye damage.		
RM-14.	DMF Dimethyl formamide CAS No:68-12-2 UN No: 2265 A water-white liquid with a faint fishy odour. Flash point 136°F. Slightly less dense than water	---	---	---	Flammable. Water soluble. Fire Hazard Special Hazards of Combustion Products: Vapors are irritating (USCG, 1999) Health Hazard Irritation of eyes, skin and nose. May cause nausea.	ORAL (LD50): Acute: 2800 mg/kg [Rat]. 2900 mg/kg [Mouse]. 5000 mg/kg [Rabbit]. DERMAL (LD50): Acute: 4720 mg/kg [Rabbit]. cute toxicity of the vapor (LC50): 9400 1 hour [Mouse].	
RM-15.	MDC (Methylene Dichloride) CAS No-75-09-2 Colourless liquid BP-40 0C	--	---	--	Causes eye and skin irritation. Causes respiratory tract irritation. Harmful if swallowed. May be harmful if inhaled. May cause central nervous system effects	LC50 = 14400 ppm/7H; Inhalation, rat Oral, mouse: LD50 = 873 mg/kg	
RM-16.	Xylene CAS No; 1330-20-7 UN No:1307 A clear colorless liquid with a characteristic aromatic odor	442			Highly Flammable: Will be easily ignited by heat, sparks or flames. Vapors may form explosive mixtures with air. Vapors may travel to source of ignition and flash back. Health Hazards: May cause toxic effects if inhaled or	TEEL-1: 130 ppm TEEL-2: 920 ppm TEEL-3: 2500 ppm	Xylene CAS No; 1330-20-7 UN No:1307 A clear colorless liquid with a characteristic aromatic odor

S. No.	Material	S. No & Threshold Quantity (TQ in Kg) as per MSHIC Rules			Chemicals Hazards Potential		Remarks
		Schedule-1, Part-II	Schedule-2, Part-I	Schedule-3, Part-I	Hazards	Toxic	
					absorbed through skin. Inhalation or contact with material may irritate or burn skin and eyes. Fire will produce irritating, corrosive and/or toxic gases. Vapors may cause dizziness or suffocation. Any cause toxic effects if inhaled or absorbed through skin. Inhalation or contact with material may irritate or burn skin and eyes. Fire will produce irritating, corrosive and/or toxic gases. Vapors may cause dizziness or suffocation.		
RM-17	Hexane CAS No:110-54-3 UN No:1208 Clear colorless liquids with a petroleum-like odor. Flash points -9°F	306			Highly flammable; Vapours may explode; Health Hazards: Inhalation causes irritation of respiratory tract, cough, mild depression, cardiac arrhythmias. Aspiration causes severe lung irritation, coughing, pulmonary edema; excitement followed by depression. Ingestion causes nausea, vomiting, swelling of abdomen, headache, depression.	TEEL-1: 400 ppm TEEL-2: 3300 ppm TEEL-3: 8600 ppm IDLH 1100 ppm	
RM-18	DMS [Dimethyl Sulfide]	213	--	--	Colorless Flammable Liquid and Vapor with stench odour	Oral LD-50 (mouse): 3,700 mg/kg	Inhalation: High vapor concentration may cause

S. No.	Material	S. No & Threshold Quantity (TQ in Kg) as per MSHIC Rules			Chemicals Hazards Potential		Remarks
		Schedule-1, Part-II	Schedule-2, Part-I	Schedule-3, Part-I	Hazards	Toxic	
	CAS No.:71-58-5				Flash Point: -48°C (-54°F) Lower Explosive Limit: 2.2% Upper Explosive Limit: 19.7% Ignition at remote sources and flash back are potential hazards. It may also explode. Combustion products include highly toxic sulfur oxide vapors.	Inhalation LC-50 (rat 4-h): 40,250 ppm (102 mg/L) Dermal LD-50 (rat): 10,200 mg/kg	headache, memory loss, confusion, convulsions, unconsciousness (lethal concentration rats (LC50), 40,250 ppm). Eyes: Can cause irritation or inflammation. Skin: Can cause stinging on contact with subsequent reddening and removal of skin oils. Ingestion:
RM-19	Acetone [C3 H6 O] CAS No: 67-64-1 Colourless liquid; Pleasant Etheral odour BP-56.2 ^{0}C	4	--	--	Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (permeator). Flammable: Limits- Lower- 2.6%; Upper- 12.8%	ORAL (LD50): Acute: 5800 mg/kg [Rat]. VAPOR (LC50): Acute: 50100 mg/m 8 hours [Rat].	

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)

Note:

1. Oral Toxicity (OT) in LD_{50} (mg/kg)
2. Dermal Toxicity (DT) in LD_{50} (mg/kg)
3. Inhalation Toxicity in LC50 (mg/l) [4 hrs.]

BCSLLP all 57 products and 12 by products consisting of 16 Herbicides, insecticides -24 and fungicides – 16, plant growth regulator -1 and R&D product.. Products are hazardous in nature and limited data are available for these. However hazards potential (for damage) of products and other materials to plant personnel, environment and off-site area is different for different materials. BCSLLP will be storing nearly 14 liquid raw materials (in bulk) and 5 gaseous. Three of the raw materials are not listed in under "List of hazardous and Toxic Chemicals" category under MSIHC Rules, 1989.The raw materials coming under hazardous category as specified by MSIHC Rules, 1989 (including subsequent amendments) is given in **Table 6.3** above.

All pesticides products are hazardous in nature and many of them are new compounds with little data available. The products are produced as per market demand and packed and stored in saleable packing.

6.4. Hazardous Materials Storage

The solid raw materials will be received in bags or drums and will be stored in chemicals go-downs. The products (liquid or solid) will be packed in drums and stored in product go-downs as per market demand. The bulk storages of liquid hazardous materials are given in the **Table 6.1.**

The solid materials 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. Some of the raw materials are though stored in bulk (quantity) but in drums only.

The pesticide product will be both as liquid and solid. The product storage for liquid will be in drums and ISO containers and for solid in bags depending upon client requirement

The risk is through liquid and gaseous materials (Chlorine/Bromine/Ammonia/ Chloroethane/ Ethylene oxide) which are volatile/gaseous material (toxic) and inflammable/explosive materials. The toxic vapours due to spillage of such material can travel to some distance (as they are stored in covered go-downs) and cause damage. The liquid products will be packed in drums (50 litres drums).

6.5. 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 below as **Table 6.4:**

Table 6.4: Risk Classification

Stage	Description
High ($> 10^{-2}$/yr.)	A failure which could reasonably be expected to occur within 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	A failure or sequence of failures which has a low probability of occurrence

Stage	Description
(10^{-2} --10^{-4}/yr.)	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.

6.6. 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 6.5,Table 6.6** and **Table 6.7** (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 vaporisation of large fraction of its vapour contents; possibly followed by combustion or explosion of the vaporised cloud if it is combustible range.

Thermal hazards have been considered for various scenarios including:

Fire in inflammable chemicals storage tanks.

Table 6.5: 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.

Incident Radiation kW/m^2	Damage Type
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 6.6: Thermal Radiation Impact to Human

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

Table 6.7: 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 sec.)
6	Personnel in Emergencies	3 (up to 30 sec.)
7	Plastic Cables	2
8	Stationary Personnel	1.5

6.7. 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.

As a safety measure BCSLLP is storing highly hazardous raw materials in isolated places with full safety measures. Damage estimates based on overpressure are given in **Table 6.8** below:

Table 6.8: Damage due to Overpressure

Sl. 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 BCSLLP case explosion not likely.

6.8. Toxic Release

Hazardous materials handled and stored in bulk in BCSLLP complex are toxic gases i.e. Chlorine and bromine and liquids (as detailed in **Table 6.1/ 6.2**) and other raw materials as defined in MSHIC rules and indicated in **Table 6.3** and **Table 6.4**. Some of these chemicals are stored in bulk (in tank farm).

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 the products as IDLH are not available for these chemicals.

6.9. Data Limitations

It is also observed that very little data or information (regarding physical properties required for modelling) is available about the products.

6.10. 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 6.9** below:

Table 6.9: Different Failure Scenarios

S. No.	Scenario	Remark
Raw materials		
RM-6	Bromine Bottle Leakage	Toxic Impact
RM-7	Carbon Disulfide Tank Leakage	Toxic Impact
RM-8	Chlorine Cylinder leakage	Toxic Impact
RM-9	Ethylene Oxide Tank Leakage	Thermal Impact
RM-10	PCl3 Tank Leakage	Toxic Impact
RM-18	DMS Tank Leakage	Thermal Impact
RM-17	Hexane Tank Leakage	Thermal Impact

6.11. 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 LC50 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 save the disaster.

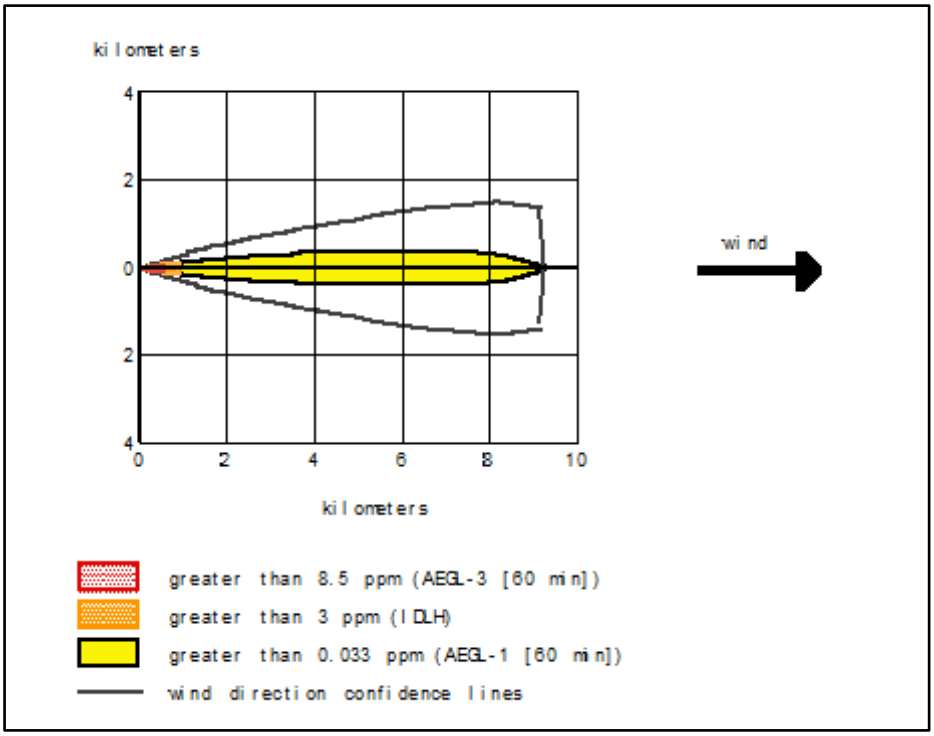
6.12. Incidents Impacts

The identified failure scenarios (Table 6.10) 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 6.10**.

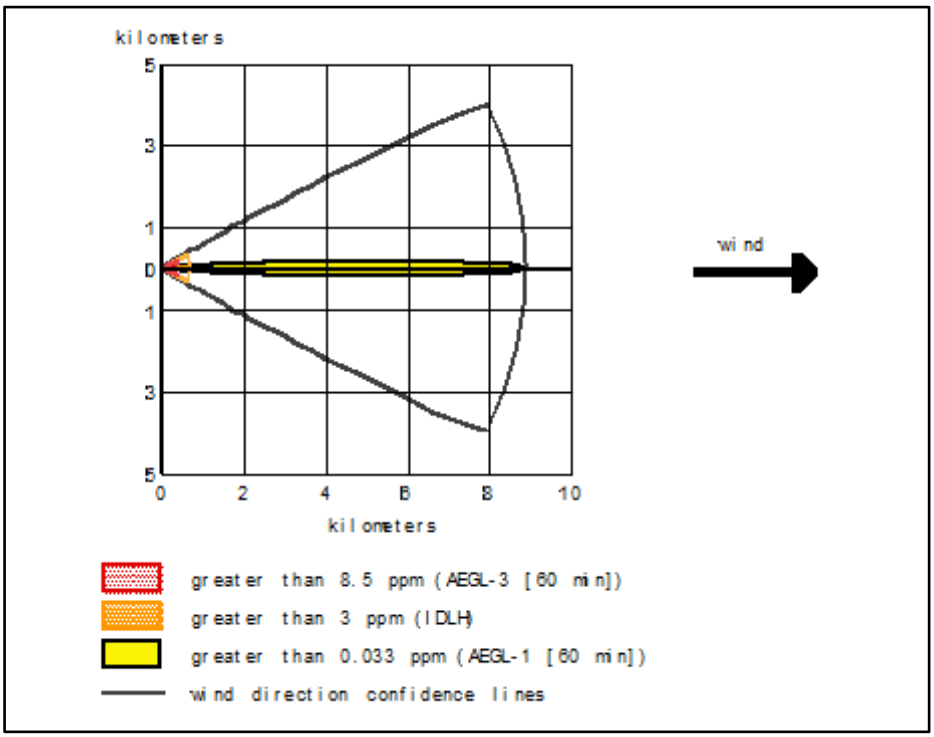
Table 6.10: Hazards Scenario Impact

Scenario No.	Scenario	Impact Zone (m)	Remarks
Scenario Raw Material			
RM-6	Bromine Bottles Leakage	❖ < 897 ❖ <711	IDLH; Stability Class D;Template-1 IDLH; Stability Class 2;Template-2
RM-7	Carbon Disulfide Spillage	❖ <25	IDLH; Stability Class D;Template-3
RM-8	Chlorine Cylinder leakage	❖ <1000 ❖ <1200	IDLH; Stability Class D;Template-4 IDLH; Stability Class 2;Template-5
RM-9	Ethylene Oxide Tank Leakage	❖ < 12	Thermal Impact; 1st degree burn Template-6
RM-10	PCl3 Tank Leakage	❖ < 101	IDLH; Stability Class D;Template-7
RM-18	DMS Tank Leakage	❖ <104	ERPG-2; Stability Class D;Template-8
RM-17	Hexane Tank Leakage	❖ <14	Thermal Impact; 1st degree burn Template-9
Fuel	HSD/LDO Pool Fire	❖ <18	Thermal Impact; 1st degree burn

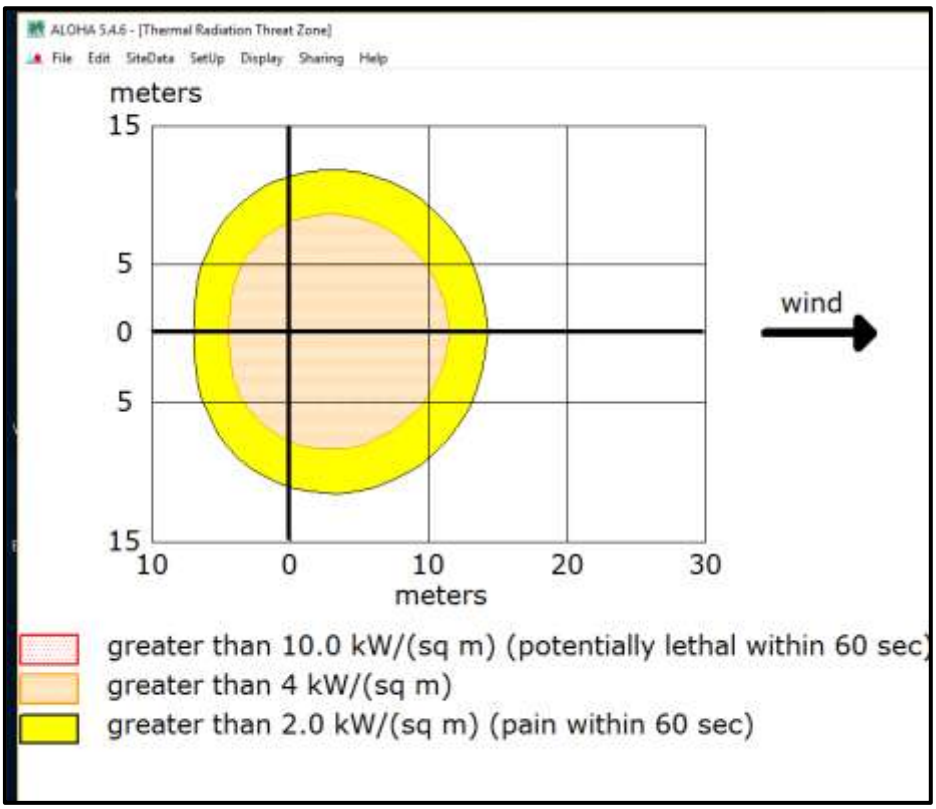
Templates of Scenario



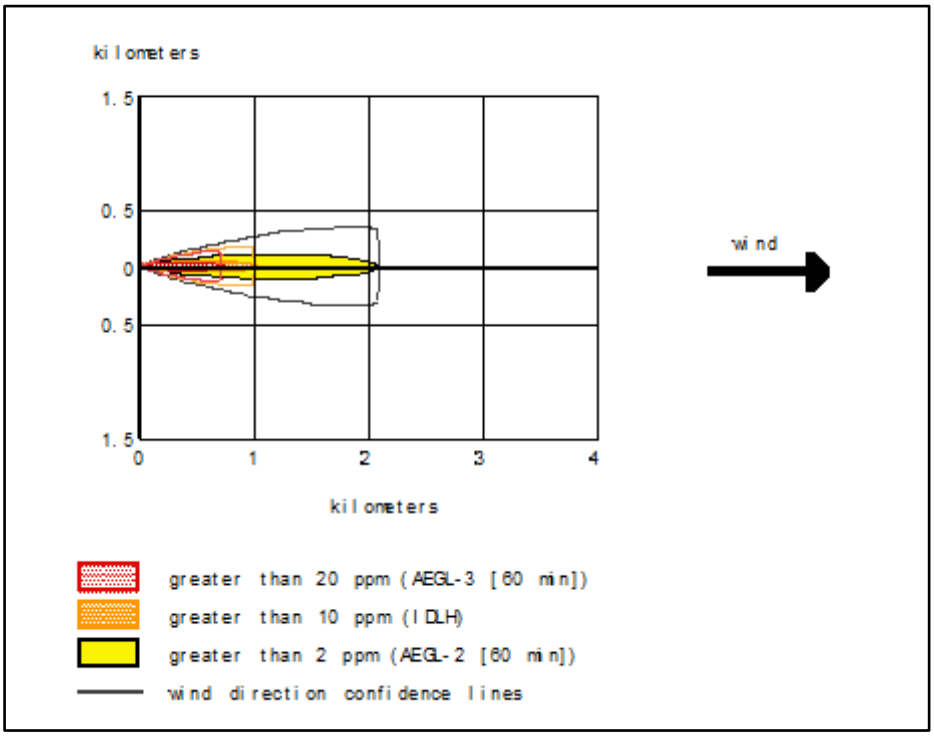
Template 1. Toxic Impact Zone Bromine Bottles Leakage; Stability Class D



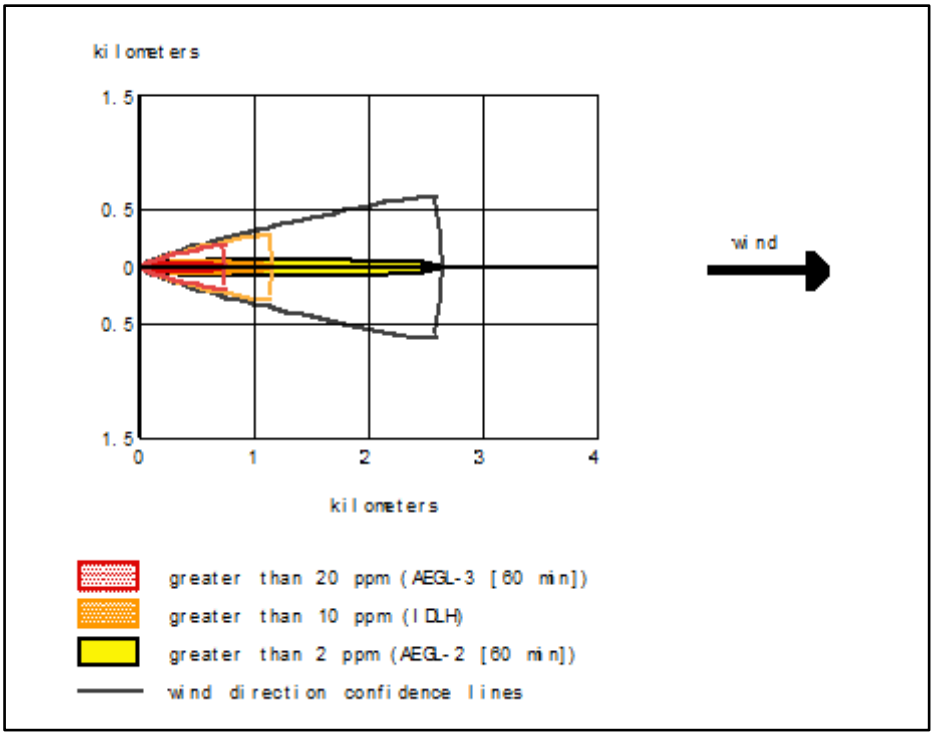
Template 2. Impact Zone Bromine Bottles Leakage; Stability Class F



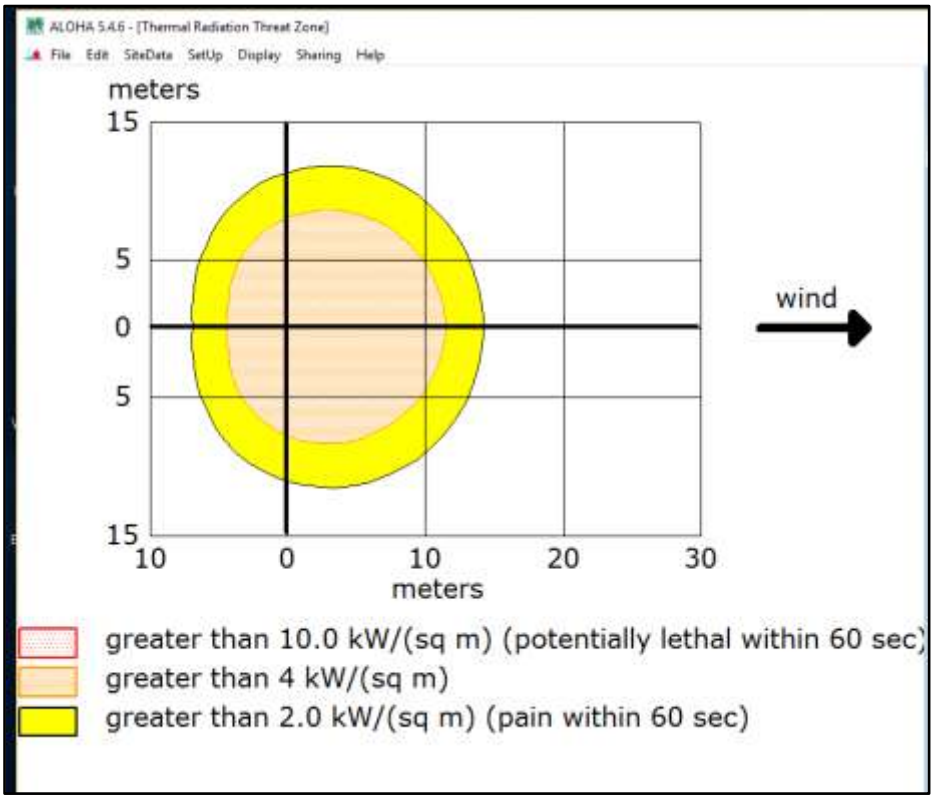
Template 3. Toxic Impact Zone Carbon Disulfide Vessel Leakage; Stability Class D



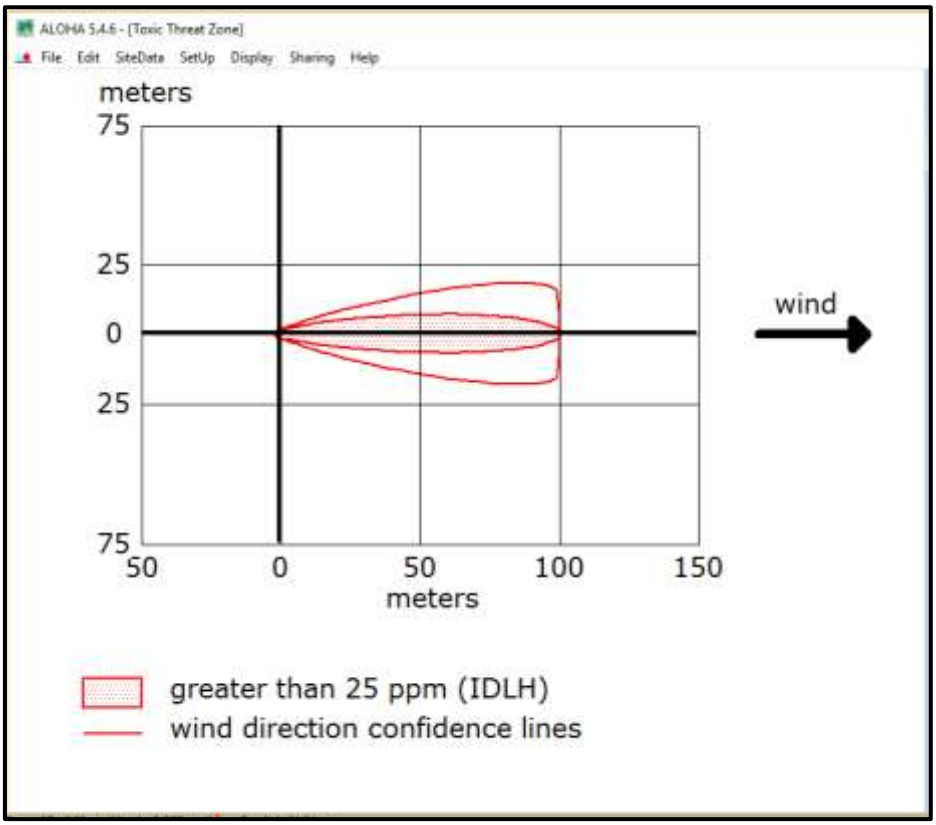
Template 4. Toxic Impact Zone Chlorine Tonner Leakage; Stability Class D



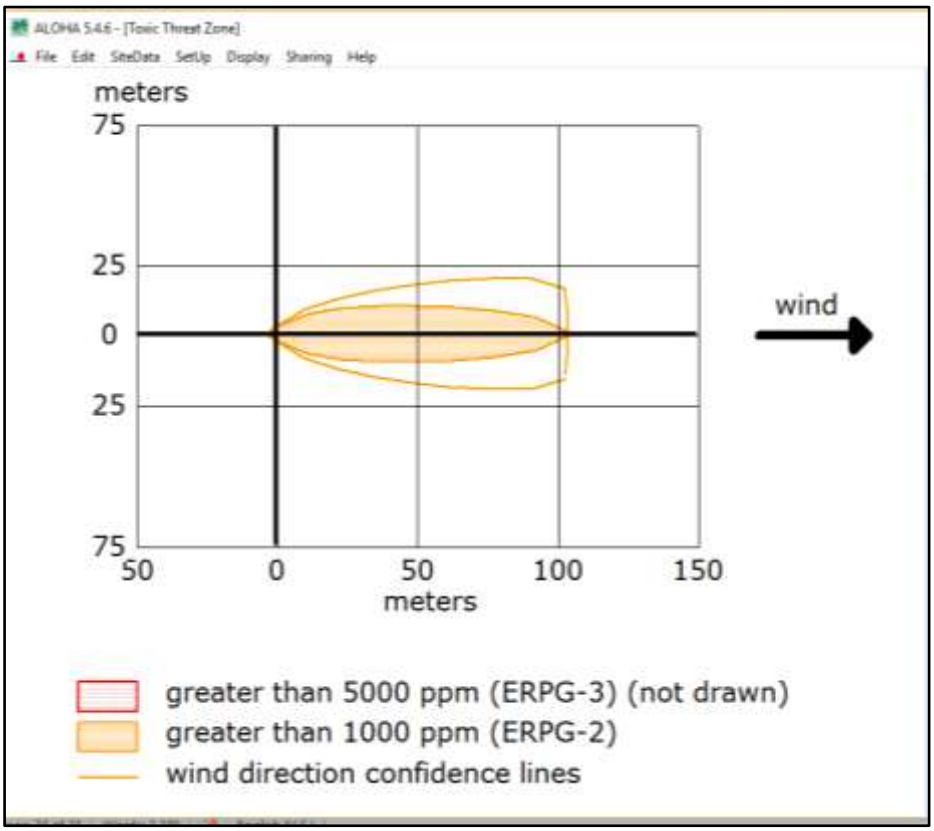
Template 5. Toxic Impact Chlorine Tonner Leakage; Stability Class F



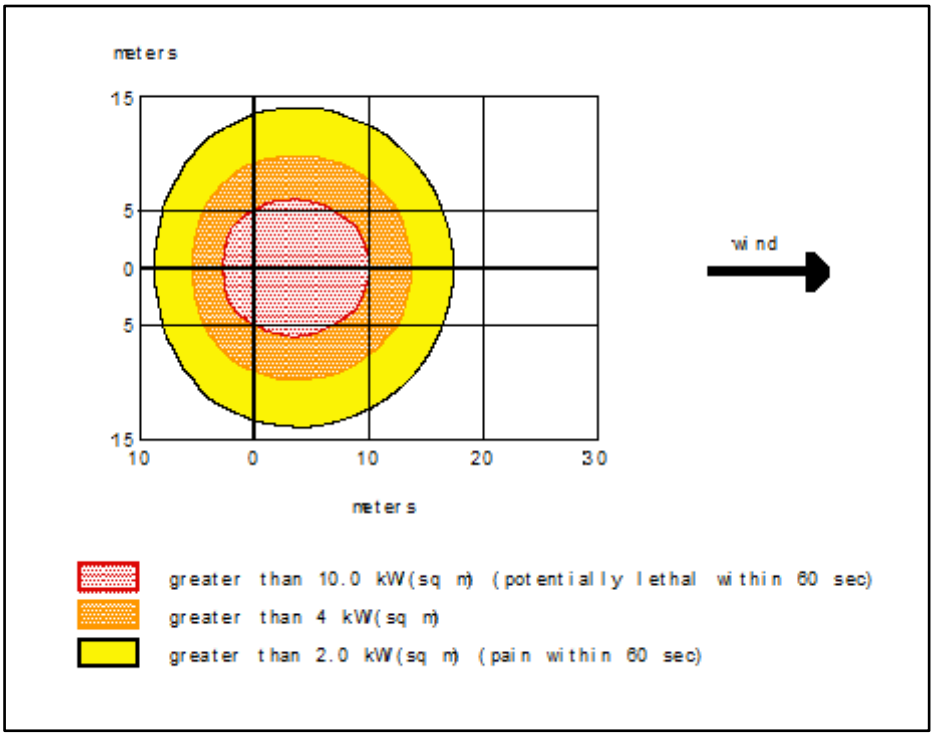
Template 6. Thermal Impact- Ethylene Oxide Tank Leakage Burning Puddle



Template 7. Toxic Impact—Phosphorus Trichloride Tank Leakage Stability Class D



Template 8. Toxic Impact DMS Tank Leakage Stability Class D



Template 9. Thermal Impact-Hexane Tank Spillage Puddle Fire

6.13. Consequential Impacts

The consequential impacts from each incident scenario can be though thermal, over pressure wave and toxic route. The damage can be on plant personnel (and neighbouring residents in case incident crosses boundary), property and also loss in production.

6.14. Thermal and Explosion Hazards

Incidents involving thermal hazards are mainly due to raw material fire (due to spillage/ BLEVE). The impact (1st degree burn) is limited to 14 m / 18 m (fuel case) only (i.e. within plant boundary). However the consequences can go to worse if the incidents lead to domino effect to other tanks.

6.15. Toxic Hazards

Toxic hazards are mainly due to Chlorine and Bromine gas and other toxic chemicals leakage and its impact can cross the plant boundary (if not controlled in time). The impact due to Chlorine /Bromine can go up to 1200 m i.e. it may cross the plant boundary limit and affect larger area / nearby populace depending upon wind direction.

BCSLLP is using Chlorine /Bromine as basic raw material and shall provide following emergency safety measures:

- Caustic drum shall be provided adjoining to Chlorine/ bromine storage for any emergency.
- Alternatively hood shall be provided that covers the Chlorine/ bromine vessels in emergency and necessary connections provided directly connecting to the scrubbing system.
- Emergency kit and two sets of breathing apparatus provided to meet any emergency.

6.15.1 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 noticing a pit and falling or colliding/ stumbling or slipping (not noticing a wet place etc.).

6.15.2 Other Toxic Hazards

Other hazardous chemicals including products their impact will be limited to spillage area. The acid spillage if comes in contact with metal parts will produce hydrogen which is highly flammable gas. Any person moving in area and getting splash will get the injury. In addition the spillage will cause pollution problem. The spillage is to be collected and neutralized for toxic contents before disposal.

6.16. General Control Measures

Since some of the substances in use at BCSLLP are hazardous with fire potential and also toxic in nature, it is necessary to use appropriate control measures recommended for such substances:

6.16.1 Flammable Gas Fires

Fire control generally consists of directing, diluting and dispersing the inflammable gas/ vapor to prevent contact with persons, to prevent it from infiltrating structures if the leak is

out door, and to avoid its contact with ignition sources while, if possible, simultaneously stopping the flow of gas. Water in the form of spray, applied from hoses or monitors nozzles or by fixed water sprays system cools the burning vapours / gas.

6.17. Process Safety System to be Developed at BCSLLP

Process & Plant Safety:

Conducting Preliminary Safety Analysis (A1), Basic Safety Review (A2), Detailed Safety Review (A3), Pre Start-Up Safety Review (A4) & Pre Start-Up Safety audit according to PPS directive (details mentioned in following flow diagram)

- Every change in the process, procedure, equipment, etc. will be done through robust management of change (MOC) procedure
- Pre-Start up Safety Reviews for all modification
- Pressure testing of pipelines and replacement of fragile pipelines and tanks by prevention project
- Hazardous area classification
- Internal safety rounds for P&PS
- Control P&IDs, and Lock opened (LO)/ Lock closed (LC) procedures are in place
- TOPPS (Top Performance in Process & Plant Safety) training to all employees
- Root Cause Analysis of all incidents
- Pre-Start up Safety Reviews for all modification

Occupational Safety:

- Permit to Work procedure and Monthly monitoring of all filled permit for continual improvement
- Mobilized Near- Miss Reporting and award scheme
- HSE rounds: PMT (Plant Management Team) of one plant takes HSE round of another plant. Exchange of best practices among plants
- MSDS Management
- Tool Box talk with contractors
- Central Safety Committee
- Departmental Safety Committees
- HSE Coordinator and Monitor program: Shop floor employees' participation in Safety activities
- Celebration of theme based Safety days/ weeks at site
- Safety Induction program for new joiners (both company & contract employees)

Emergency Preparedness:

- On-Site Emergency Plan for the site
- Training on On-Site Emergency Action Plan
- Regular Site level Mock drills and Plant specific Fire Drills and Leak, spill drills
- Availability of First aiders, Fire Fighters and Rescue members in each shift

- Maintenance of Fire hydrant system, sprinkler system and portable fire extinguishers
- Periodic testing of fire hydrant and sprinkler systems
- Three Fire Tenders and Two Ambulances

Occupational Health:

- Pre-employment & Annual Medical Examination
- Quarterly/Periodical Physical Examinations
- Canteen Employees Examination
- Fork lift operators Examination
- Recall services & Follow-Up
- Return to work assessment
- Exit Examination
- Training on Counselling, Hearing Conservation Program, Hazardous Chemical Awareness Program, Shop floor training, First-aid (138Nos. Certified First Aiders), etc.
- Legal records: All medical records of employees to be maintained.
- Emergency Medical services: Ambulance services, First-aid boxes, Decontamination facility etc.
- Health Promotional Activities: Awareness on Medical issues, Ergonomics awareness programs, Stress management, De-addiction program, etc.

6.17.1 Safety System for Toxic Material Handling

Following precaution Taken while handling Toxic materials

- ❖ Highly Toxic chemical is stored in storage room with lock and key.
- ❖ Inventory records are maintained.
- ❖ Toxic material is stored in well ventilation and out of sunlight
- ❖ It is stored away from incompatible chemicals.
- ❖ Keeping containers tightly & securely closed when not in use
- ❖ Toxic chemical charging is done inside the closed room in presence of shift in-charge.
- ❖ Local Ventilation system is provided to avoid exposure at work place.
- ❖ Vent gas is passing through scrubber system for absorption & reduction of pollution.
- ❖ Standby pump provision is available for LEV & scrubber system.
- ❖ Decontamination facility is provided
- ❖ Safety PPE's is providing during charging.
- ❖ Breathing air provision is provided at toxic chemical handling area.
- ❖ Training to employees is providing for manual handling of toxic chemicals.
- ❖ First aid training also provided to concern employees.

- Antitoxic kit is maintaining inside OHC.
- First aid kit provision is available at work place area.
- Eye wash/Safety shower stations are readily available nearby and are tested regularly
- To avoid fire and explosion nitrogen blanketing, earthing & bonding, electrical flame proof equipment's, pressure rated equipment' are provided.
- Suitable fire extinguisher and spill cleanup equipment are maintained.
- Dyke provision is available where liquid toxic chemicals are stored.
- Appropriate spill control equipment and procedures is available.
- MSDS is maintained inside the concern plant / department.
- Precautionary placard is displayed nearby the work place.
- Toxic chemicals sign board is displayed on container.
- Avoiding any welding, cutting, soldering or other hot work on an empty container of toxic chemicals.
- Good housekeeping is maintaining.
- Toxic gas detector also provided at workplace.
- Toxic chemical waste is collecting in separate pit and transferring to ETP for its treatment.
- Always ensuring that the waste container used is compatible with the waste material
- Ensuring that the waste container is properly and accurately labelled.
- Unauthorized person entry is restricted.
- Restricted for eating, drinking & smoking at work place.
- Employees are trained for emergency of toxic chemicals.
- Toxic chemical spill, leak drills are conducting for awareness, preparedness & response during an emergency.
- Work place area monitoring is to be carried out for ensuring exposure at workplace.
- Process is performed in closed conditions.
- Regular pressure testing for pipelines and equipment to ensure tightness

6.17.2 Work Place Monitoring Plan

Work zone monitoring is carried out by HSE department every month for gaseous pollutants and dusts. Records are to be kept in standard Form as per Factories Rules. Location for samplings shall be identified. Samples are analyzed for Air borne concentration of hazardous chemicals in ppm.

The analyzed results are compared with the threshold limit values (TLV) of international organizations. The monitoring program is based on the Action level Concentration (ALC) which is 50% of the TLV. If the analyzed concentration is < ALC, no regular monitoring is required, only occasional checks (once in a year) to ensure the acceptability of the system.

If the analyzed concentration is > ALC < TLV then the monitoring is carried out at regular interval (once in two months). Incase analyzed concentration is > TLV then corrective actions are decided by Plant Manager, General Manager - works and Engineering Manager and they are implemented. After implementation again monitoring is carried out.

The sampling for gaseous pollutants and air pollutants are done by Air sampling pump. A sample report of work area monitoring is attached as Annexure V.

6.17.3 Arrangement for ensuring health and safety of workers engaged in handling of toxic materials

All persons working in manufacturing units are surveyed by regular medical examinations.

Pre-employment Medical examination to be carried out for all employees prior to employment at well-known multispecialty hospital.

Checkups & tests carried out as per Factory rules / SPCB guidelines.

6.18. Safety Recommendations

6.18.1 Commonly Recommended Control Measures

A number of preventive control measures for hazardous occurrences have been analysed and discussed above. Some more salient points are enumerated below:

- All storage tanks in the tank farm should be dyked. Other operation and maintenance features shall be based on established best safety practices.
- Concentration detectors for hazardous chemical vapours (e.g. Chlorine/ bromine/ other chemicals etc.) fire Smoke / heat detectors and fire alarm should be installed at all strategic locations in the plant.
- A schedule for preventive maintenance including health survey of all plant equipment should be adhered to as far as possible.
- Ensure the absence of ignition sources in storage area.
- Ensure placement of firefighting facilities, such as, carbon dioxide, dry chemical powder and foam type fire extinguishers in addition to fire hydrant system, at strategic locations. Spill control measures, such as, removal of all ignition sources from the spill area and ventilating the area as well as soaking the spilled material with paper, towel or mud and letting the volatile substance evaporate slowly in a safe area.
- Compulsory use of protective clothing, non-sparking tools and warning signs during critical operations and maintenance.
- Training / refresher courses on safety information’s / norms.
- Eyewash and showers should be put up at strategic places for use during emergencies.

A group of plant personnel should be trained in first aid, rescue, firefighting and emergency control measures. These personnel will form core group/emergency squad who will fight the emergency and also act as rescue and first aid team.

In order to ensure communication from isolated places/locations Walkie-Talkie be made available to persons working in these areas. This will considerably improve the effectiveness of emergency management.

There is no substitute for training-mock drills and these must be held at regular interval keeping the following objectives in mind:

Real time mock-drill should be carried out for probable/likely hazardous situation (after the plant is successfully commissioned).

Target to be set up for various tasks and events during an emergency.

Weak links should be marked and corrective action taken to improve effectiveness during emergency.

BCSLLP team already understand the implication and hazards in fertiliser industry and has implemented most of the measures in the sister organisation existing plants.

6.19. Occupational Health and Safety

Occupational Health and Safety (OHS) are of prime importance more so in hazardous industries. Industries have various types of hazards and QRA is carried out to understand the hazards potential from various incidents. Pre-emptive steps can be planned to safeguards from likely causes. Some of the

Frequent causes of accidents

- Fire and explosion: explosives, flammable material
- Hazards from Toxic Materials
- Mechanical Hazards such as:

  Being struck by falling objects

  Caught in between machine parts

  Snapping of cables, ropes, chains, slings

  Handling heavy objects
- Electricity Hazards
  - Electrocution
  - Short circuits and consequential fire.
  - Poor illumination etc.
- Other Hazards:

  Falls from height inside industrial units or on the ground

  Struck by moving objects; Slipping on wet surfaces

  Sharp objects

Oxygen deficiency in confined spaces; Lack of personal protective equipment (PPE), housekeeping practices, safety signs

- Consequential hazards due to extreme Temperatures;
- Consequential hazards due to vibration
- Consequential hazards due to radiation;
- Many more hazards.

Hazardous substances and wastes

- Heavy and toxic metals
- Lack of hazard communication (storage, labeling, material safety data sheets)
- Batteries, fire-fighting liquids

- Welding fumes
- Volatile organic compounds (solvents)
- Inhalation in confined and enclosed spaces

Ergonomic and psychosocial hazards

- Many of the hazards are as result of working environment.
- Repetitive strain injuries, awkward postures, repetitive and monotonous work, excessive workload
- Long working hours, shift work, night work, temporary employment (Long working hours, shift work, night work, temporary employment, Mental stress, human relations) which results in less attention at work place and consequential incidents and accidents.
- Lack of education and training / awareness is another prime cause of accidents.

Considering above, QRA analysis and also the nature of activities at BCSLLP the following steps for OHS activities have been suggested:

- Employee's health check-up: pre-employment and periodic check-up during employment. The health check-up observations should be informed to employees.
- The health should include any impact due to hazards at work place including (but not limited to) due to noise, heat, illumination, dust, any other chemicals, metals being suspected in environment and going into body of workers either through inhalation, ingestion or through skin absorption and steps taken to avoid musculo-skeletal disorders (MSD), backache, pain in minor and major joints, fatigue etc.
- Training and refresher courses on safety to all employees.
- Employees should be made aware of the hazards in the plant and the preventive actions to be safe from such hazards.

Response to Injuries: Based on a survey of possible injuries, a procedure for response to injuries or exposure to hazardous substances should be established. All staff should have minimum training to such response and the procedure ought to include the following:

- Immediate first aid, such as eye splashing, cleansing of wounds and skin, and Bandage etc.
- Immediate reporting to a responsible designated person
- If possible, retention of the item and details of its source for identification of possible hazards.
- Medical surveillance
- Recording of the incident
- Investigation, determination and implementation of remedial action

6.20. Emergency Management Plan

BCSLLP should develop an Emergency Management Plan (EMP) and regularly carry out Mock drills to check the effectiveness of the EMP. For reference and review key features of standard EMP are given below.

6.21. Ergonomic and psychosocial hazards

Many of the hazards are as result of working environment

- Repetitive strain injuries, awkward postures, repetitive and monotonous work, excessive workload
- Long working hours, shift work, night work, temporary employment (Long working hours, shift work, night work, temporary employment, Mental stress, human relations) which results in less attention at work place and consequential incidents and accidents.
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- Considering above, QRA analysis and also the nature of activities at BCSLLP the following steps for OHS activities have been suggested:
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- Training and refresher courses on safety to all employees.
- Employees should be made aware of the hazards in the plant and the preventive actions to be safe from such hazards.
- Response to injuries: Based on a survey of possible injuries, a procedure for response to injuries or exposure to hazardous substances should be established. All staff should have minimum training to such response and the procedure ought to include the following:
    - Immediate first aid, such as eye splashing, cleansing of wounds and skin, and Bandage etc.
    - Immediate reporting to a responsible designated person
    - If possible, retention of the item and details of its source for identification of possible hazards.
    - Medical surveillance
    - Recording of the incident
    - Investigation, determination and implementation of remedial action

6.21.1. Key Process Safety Measures

- Flameproof equipment's and fittings are provided for handling of hazardous chemicals.
- Tanks and all pump motors are earthed.
- Road tanker earthing lines have been provided near the unloading pumps.
- Dykes have been provided for hazardous chemicals storage to contain leakages. Floors of the dyke area have impervious finish.

- Housekeeping of the plant is as per prescribed norms. Floors, platforms, staircases, passages are kept free of any obstruction.
- All hazardous operations are explained to the workers. They are periodically trained on the hazardous processes.
- Dedicated supply of firewater is available in the plant.
- Only authorized persons are allowed inside the plant.
- All instrument and safety devices are checked and calibrated during installation. They are also calibrated, checked at a frequent interval. Calibration records are maintained.
- All electrical equipment's are installed as per prescribed standards.
- All the equipment's of the plant are periodically tested as per standard and results are documented. All equipment's undergo preventive maintenance schedule.
- Hydrant system is pressured with a Jockey Pump.
- Flame arrestor is provided on each tank.
- Pressure gauge is provided on each tank.

In addition to fire hydrant system, nos. of fire extinguishers is also installed at different locations within premises.

Retention basin is provided to collect the contaminated water used during firefighting.

6.22. Transportation:

- Class A petroleum products (equivalent raw materials) will be received through road tanker and stored in underground storage tank as per petroleum Act & Rules.
- Road tanker unloading procedure will be in place and will be implemented for safe unloading of road tanker.
- Static earthing provision will be made for tanker unloading.
- Earthed Flexible Steel hose will be used for solvent unloading from the road tanker.
- Fixed pipelines with pumps will be provided for solvent transfer up to Day tanks/reactors.
- Double mechanical seal type pumps will be installed.
- NRV provision will be made on all pump discharge line.

Table 6.11: Transportation, Unloading and Handling safety Measures

Sr.No.	Activity	Type of Possible Hazard	Mitigation Measures
1	Transportation of Chemicals like Chlorine, Bromine and acids & Solvents by road tanker	Leakage& Spillage Fire,& explosion,	• Check the source of leakage point. • Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. • Stop leak if you can do it without risk. • Use water spray to reduce vapors; do not put water directly on leak, spill area

Sr.No.	Activity	Type of Possible Hazard	Mitigation Measures
			or inside container. • Keep combustibles (wood, paper, oil, etc.) away from spilled material.
		Toxic release	• Isolate the area • Isolate the container • Training will be provided to driver and cleaner regarding the safe driving, hazard of Flammable chemicals, emergency handling. • TREM card will be kept with TL. • Fire extinguishers will be kept with TL. • Flame arrestor will be provided to TL exhaust. • Instructions will be given not to stop road tanker in populated area. • Clear Hazard Identification symbol and emergency telephone number will be displayed as per HAZCHEM CODE. • Appropriate PPEs will be kept with TL.
2	Acids, Bromine and & Solvents Road tanker unloading at project site.	Leakage& Spillage	• Check the source of leakage point. • Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. • Stop leak if you can do it without risk.
		Fire,& explosion,	• Use water spray to reduce vapors; do not put water directly on leak, spill area or inside container. • Keep combustibles (wood, paper, oil, etc.) away from spilled material.
		Toxic release	• Isolate the area • Isolate the container • Check the source of leakage point. • Spray the water on leakage • Priority will be given to Tanker to immediately enter the storage premises at site and will not be kept waiting near the gate or the main road. • Security person will check License, TREM CARD, Fire extinguisher condition; Antidote Kit, required PPEs as per SOP laid down. • Store officer will take sample as per sampling SOP from sampling point. • After approval of QC department unloading procedure will be allowed be started.

Sr.No.	Activity	Type of Possible Hazard	Mitigation Measures
			Following precautions will be adopted during unloading • Wheel stopper will be provided to TL at unloading platform. • Static earthing will be provided to road tanker. • Tanker unloading procedure will be followed according to check list and implemented. • Flexible SS hose connection will be done at TL outlet line. • The quantity remaining in the hose pipeline will be drained to a small underground storage tank, which will be subsequently transferred by nitrogen pressure to the main storage tank thus ensuring complete closed conditions for transfer from road tanker. • All TL valves will be closed in TL. • Only day time unloading will be permitted.
3	Chlorine, Bromine, fuels and acid & Solvents Storage tank safety	Leakage& Spillage, Fire, Explosion Toxic release.	• Check the source of leakage point. • Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. • Stop leak if you can do it without risk. • Use water spray to reduce vapors; do not put water directly on leak, spill area or inside container. • Keep combustibles (wood, paper, oil, etc.) away from spilled material. • Isolate the area • Isolate the container • Check the source of leakage point. • Spray the water on leakage • SS storage tank will be provided as per IS code. • Dyke wall will be provided to storage tank. • Level transmitter will be provided with low level high level auto cut-off provision. • Vent will be connected to water trap and vent of water trap will be provided with flame arrestor. • Water sprinkler system will be provided to storage tank. • Fire hydrant monitor with foam attachment facility will be provided.

Sr.No.	Activity	Type of Possible Hazard	Mitigation Measures
			• Dumping / Drain vessel/alternate vessel will be provided to collect dyke wall spillage material. • FLP type pump will be provided. • Nitrogen blanketing will be provided to storage tank. • Double static earthing will be provided to storage tank. Double Jumper clip will be provided to all Solvent handling pipeline flanges.
4	Bromine and acid & Solvents transfer from storage tank to Day tank.	Leakage& Spillage due to Line rupture, Flange Gasket failure, Fire, Explosion, Toxic release.	• Double mechanical seal type FLP type pump will be provided. • Double on / off switch will provided at tank farm and process area near day tank. Pump auto cut off with day tank high level will be provided. • Flame arrestor will be provided on day tank vent. • Over flow will be provided for additional safety and it will be connected to main storage tank. • NRV will be provided on pump discharge line. • Double Jumper clip will be provided to all solvent handling pipeline. Double static earthing will be provided to day tank.
5	Transportation of Chemicals transfer from Day tank to reactor.	Leakage, Spillage due to Line rupture, Flange Gasket failure, Fire, Explosion, Toxic release.	• Gravity transfer. • Total quantity of day tank material will be charged in to reactor at a time. • Static earthing will be provided to storage tank. • Double Jumpers will be provided to pipeline flanges.

6.23. Emergency Facilities

Emergency Management Planning (EMP) should be developed considering the likely hazards in the plant and sincerely implemented. Mock drills for various scenarios should be carried out and results of the drills should be recorded. Weal links in the mock drills should be strengthened.

Objectives

The Emergency Management Plan (EMP) is developed to make the best possible use of the resources available at BCSLLP and the nearby agencies to provide help/assistance in case of an emergency in the plant. The activities will include:

- Rescue the victims and give them the necessary medical attention in the shortest possible time.
- Safeguard other person (evacuate them to a safer place).

- Contain the incident and control it with minimum damage to human and life and property.
- Provide necessary information to families/relatives of affected persons, outside agencies including media and statutory bodies.

6.24. Emergency Management Plan [EMP]

An outline of EMP organizational set-up necessary for chain of commands during emergency situation in the plant is as given below. BCSLLP should develop EMP in the organisation and send it statutory authorities for approval and integration in District Disaster Management Plan. A sample EMP is enclosed for reference.

President (Operations) of the BCSLLP is the Chief Emergency Coordinator and he shall be the main guiding person directing the emergency operations. He shall be assisted by:

Chief Site Coordinator	GM (Production) Coordinate and direct all the activities from Emergency site. In absence of GM (Prod.), DGM (Prod. I/II) will act as Chief Site Coordinator.
Chief Maintenance Coordinator	Manager-Maintenance Coordinate all the maintenance activities from the Emergency Control Center. In absence of Manager (Maint.), Asst. Manager will act as Chief maintenance Coordinator.
Chief Service Coordinator	Manager (HR) Coordinate with local administration take care of transport, medical, canteen arrangements, and evacuation of people if required. In absence of Manager (HR), Asst. Manager (P&A) will act as Chief Service Coordinator.
Chief Material Coordinator	Manager (Material) In absence of Manager (Material), Asst. Manager (Material) will act as Material Coordinator.
Operation Coordinator	Manager (Prod.) is the Incident Controller for Vehicle Control & Security PersonnelSecurity Officer In absence of Security Officer, Security Supervisor will act for Vehicle Control & Security Personnel deployment.
Fire & Safety Controller	Incharge (F&S) In absence of Incharge (F&S), Supervisor. (F & S) will act as Fire & Safety Controller and also for first aid.

Two “Assembly Points” will be identified (based on wind direction and away from hazardous areas) and duly marked.

Chief Service Coordinator shall contact the following senior officers stationed at Gajraula.

Format for Telephone Numbers of the Authorities:

DISASTER MANAGEMENT			
KEY PERSONNEL - OFFSITE EMERGENCY RESPONSE			
OFFICERS	**PLACE**	**OFFICE**	**RES.**
DIVISIONAL COMMISSIONER			
COLLECTOR & DISTRICT MAGISTRATE			
CITY MAGISTRATE			
DY.I.G. OF POLICE			
SUPDT.OF POLICE			
POLICE CONTROL ROOM (CITY)			
POLICE STATION (Gajraula or nearby)			
DY CHIEF INSPECTOR OF FACTORIES			
STATE POLLUTION CONTROL BOARD			
FIRE BRIGADE, Gajraula			
HOME GUARD			
NEAREST CIVIL HOSPITAL (CHIEF MEDICAL SUPTD)			

6.25. Responsibilities & Role of Key Personnel

6.25.1 Over all In-charge –President (Operation)

On getting the information about emergency from GM (Prod.) rush to incident site/ECC. Assess the overall situation and provide guidance in critical decision-making.

6.25.2 Chief Site Coordinator- Manager (Prod.)

- On getting the information about emergency from Supervisor Plant, inform over all In-charge Plant (Operation).
- Rush to the emergency site to assess the situation and decide to:
  - Declare emergency based on amount/extent of hazards and water/air analysis (toxic / flammable material release) and advise Incharge (F&S) for sounding emergency siren.
  - Review if plant shutting down is required to contain / control the hazard.
  - Review, evacuation from affected areas and sending the affected person to a safe place.

- Advise Incident Controller and other key personnel to take necessary action.
- He will interact with Chief Service Coordinator and advise him on possible effects on areas inside and outside the factory to initiate Off- Site Emergency Response Plan.
- Remain in touch with Overall in-charge (P -O) and inform about the situation & actions being taken and seek his advice for the critical decisions.

6.25.3 Chief Maintenance Coordinator- GM (Maintenance)

- After getting information about emergency from manager concerned Plant. Inform all concerned personnel to be on alert.
- Rush to the ECC, assess the situation and facilitate Chief Site Coordinator-GM (Prod.), Maintenance support needed to tackle the emergency.
- Facilitate elect. isolation of the affected area, if required through Supervisor (E&I)
- Facilitate lighting arrangements at (a) affected locations and (b) Assembly points if required through Supervisor (E&I)
- Facilitate work-shop facilities with adequate manpower if required through Manager (Maintenance). Remain in touch with Chief Site Controller.

6.25.4 Chief Service Coordinator - Manager (HR)

- On getting information from the Medical Coordinator rush to the Emergency Control Centre.
- Assess the situation in consultation with Chief Site Coordinator and Incident Controller and ensure that casualties get adequate transport / medical help.
- Make arrangement to shift all the persons to the safest place if called for.
- Assess 'Law and Order' situation.
- Inform press, TV / Radio, local authorities about the severity of situation in close co-ordination with Chief site Coordinator and in consultation with Over all In-charge -P (O).
- Inform the District Authority / local police station in case their help is required for evacuation of personnel / preserving law and order.
- Evacuation of adjoining areas and villages, if required.
- Remain in touch with over all In-charge - P (O) and seek his advice for the critical decisions.

6.25.5 Chief Material Coordinator- Manager (Materials)

- Rush to the emergency control center on receipt of the message from Chief Service Coordinator / on hearing the emergency siren and inform Supervisor. (Store) about the emergency.
- Get the stores opened for requirement of the Fire fighting/safety and other materials, which may be required during emergency.
- Assess the situation in consultation with Chief site coordinator & incident controller for any material requirement /help at the affected site.
- He will be responsible for the arrangements of trucks for movement of bulk material if required.

- Remain in touch with Chief site coordinator, Incident controller, and Chief maintenance coordinator.

6.25.6 Incident Controller Concerned Plant -Manager Concerned Plant

- Rush to the site of emergency after getting information from Shift In-charge assesses the situation and immediately inform
  - GM – Prod.
- Take over charge from shift in charge.
- Ensure that persons working in the area are safe and isolate source of toxic release if possible.
- Advise and assist in charge (F&S) for providing water curtains to contain toxic release with in the plant battery.
- Remain in touch with Chief Site Controller and other concerned officers.
- Coordinate with Chief Maintenance / Chief Material coordinators for assistance required at site.
- Depending upon the severity of incident, ensure that adequate emergency services like Medical/ Laboratory/ Mechanical/ Electrical etc. are summoned.
- Preservation of evidence as far as possible without affecting the operation of emergency procedures to facilitate any subsequent inquiries into the causes and circumstances, which led to the emergency.

6.25.7 Shift In charge (Concerned Plant):

- Immediately proceed to the site of emergency and assess the situation:
- Emergency Control Room at 101/123 (with name and location of emergency)
- During odd hours/till arrival of Fire shift I/C should act as chief fire coordinator.
- Initiate the shutting down operations for controlling the hazard if unavoidable.
- Cordon off the area and do not allow any body to enter the affected area without respiratory protection (In case of toxic gas leakage).
- Direct rescue operations with the help of fire and safety staff.
- Open safety Almirah for the use of plant personnel.
- Have regard to the need for preserving evidence that could facilitate subsequent inquiry.
- Advise Supervisor of the plant to take roll call and account for missing personnel.
- Hand over charge of the operation to the Manager when he arrives at site.
- Ensure service agencies like Electrical, mechanical, instrumentation are mobilized to handle the emergencies.

6.25.8 Security Officer Vehicle Control and Security Personnel Deployment at the Locations

- Rush to the spot of emergency on getting information from Security Officer on duty and inform Manager (HR) about emergency.
- Arrange one emergency vehicle immediately for ECC.

- Keep in touch with Chief Service Coordinator, Chief Site Coordinator and Incharge (F&S).
- He will act as a special rescue Coordinator at the time of evacuation of employees and others if required.
- Alerts complete staff under his control and make it available at a known point, as per the guidance of Chief Site Coordinator / Chief Service Coordinator.
- Anticipate and arrange vehicles required at emergency site in consultation with Incharge (F&S) and Chief Site Coordinator and Chief Service Coordinator.
- On request send vehicles for getting plant personnel / fire personnel required for emergency.
- Arrange vehicle in consultation with Medical Coordinator / Chief Service Coordinator for shifting injured to city hospital.
- During emergency arrange for opening of relevant gates/ barriers for easy movement of vehicles. Security Guards should be posted on these gates / barriers to prevent unauthorized entry.
- Arrange transport and temporary shelters for evacuated personnel and inform the relatives of the affected personnel if required.

6.25.9 Fire & Safety Controller- Incharge (F&S)

- Rush to the spot of emergency after getting information from ECC and inform to Supervisor. (F&S).
- Direct rescue operations under the guidance of Chief Site Coordinator/ Incident controller if required
- Ask additional help from C.S.O. for cordoning off the area and advise fire personnel for rescue / fire fighting if required
- Arrange to provide water curtains, water monitors, at affected locations if required.
- Organize and supervise fire-fighting operations if called or.
- Provide necessary respiratory equipment to plant personnel for emergency use.
- Advise Chief Site Coordinator to arrange additional help Mutual aid group / neighbouring industries if required.
- Give safety precautions to the personnel at rescue work.

6.25.10 Fire Control Room In-Charge

On receiving emergency message from the Incharge (F&S)/ on hearing siren. Rush to ECC and take charge of Fire Control Centre from the fire operator / fire supervisor.

- Assess the situation and Call fire staff from fire barrack.
- Immediately rush fire crew to emergency spot.
- Inform Medical Centre for sending ambulance to emergency site.

6.26. Fire Supervisor should also ensure the following:

a. Supervisor to look for the wind direction and cordon off the area.

b. Use water monitors/hydrants/water curtains in consultation with incident/Chief site controller.

c. Provide respiratory equipment's to the plant personnel.

d. In case of toxic spillage at site, put foam (HAZMAT)/ sand on the spillage area.

e. Remain in touch with Incharge (F&S).

f. Chief Site Co-coordinator will instruct Fire Control Room In-charge for operation of "All Clear Siren" when the disaster is contained / controlled.

g. However, regular testing of siren & emergency buzzer plant control rooms for 2 minutes on every Monday at 13.00 hrs is being done .All clear siren will sound for 2 minutes with a continuous sound.

6.27. Post Emergency Recovery

The post-emergency procedures discussed briefly below are designed to successfully manage the damage / losses of an emergency event. The focus of these procedures is to move the plant back into normal operating mode as quickly and efficiently as possible.

Immediately after the "ALL CLEAR" an emergency meeting will be held in emergency control centre to assess the loss both for men & materials, where in following will be present with attendance records, details of injured, outside situation and preparation of press release (if felt necessary)

- Overall In charge
- Chief Site Coordinator
- Chief Maintenance Coordinator
- Chief Service Coordinator
- Incident Controller
- Material Coordinator
- Security
- Fire & Safety Controller

6.28. Accident Investigation

a.	As soon as possible after the emergency is over and plant operation has become normal, the investigation and analysis is to be carried out to determine the cause of the event.
b.	Representatives from various disciplines will be members of the investigation and analysis team.
c.	The areas of the events are to be sealed off so that tempering or alterations of the physical evidence are not likely to occur.
d.	Key components are to be photographed and logged with time, place, direction etc.
e.	Statements are to be taken from those who were involved with the operation or who witnessed the event.

6.29. Damage Assessment

This phase of recovery establishes the quantum of replacement machinery considered necessary for bringing back plant to normal operation; property and personnel losses accounted and culminates in a list of necessary repair, replacement and construction work.

Insurance companies will be informed of the damage and requested to pay the compensation as per claim.

6.30. Clean-up and Restoration

This phase will only begin once the investigation is complete. Reporting documentations are to be prepared and forwarded to appropriate authorities. Repair, clean up and restoration work to begin.

6.31. 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. There are possibilities of domino effect and the secondary scenario not predictable can be worse than the primary one. Two scenarios (specifically toxic hazards scenarios) are crossing the BCSLLP 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 Chlorine and all liquid products. Regular 'Hazard Survey' ensures the detection of leakage in the plant.

Chlorine leakage can have adverse impact in large area and also in areas outside the BCSLLP battery limit. BCSLLP should have provision for sucking and scrubbing Chlorine in alkali solution. In house 'capability building' to attend hazardous scenarios is to be taken up through mock drills. Real time exercise with controlled release of Chlorine

- To attend the leakage in cylinder
- To transfer leaky cylinder near scrubber and absorb chlorine in alkali solution
- To attend leaky cylinder with 'Chlorine safety Kit'.
- Train staff in attending such scenarios.

Human Factors: BCSLLP should have well equipped fire station 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:

If no accident has happened so far probability of incident / accident occurring increases.

'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.

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.