CHAPTER – 7 ADDITIONAL STUDIES

7.1 Public Consultation/Hearing

Public consultation is exempted for the proposed expansion project as per Para 7(i) (III) (i) (b) of EIA Notification, 14th September, 2006 as the project is located inside the Notified industrial area of Gujarat Industrial Development Corporation (GIDC), District Bharuch (Gujarat).

7.2 Philosophy and Methodology of Risk Assessment

Industries have a wide variety of process involving consumption, production and storage of chemicals. The condition that contributes to the danger, by these chemicals, are when these chemicals are not kept/stable at normal pressure and temperature. Very often these chemicals are kept at/or high pressure and temperatures; these gases in liquefied state by refrigeration, to facilitate storage in bulk quantities. Under these circumstances, it is essential to achieve and maintain high standards of plant integrity through good design, management and operational controls.

However, accidents do occur and these can cause serious injuries to employees or the public, and damage to property. The public concern at such events invariably leads to call for additional control at national and international levels. It is against this background that the various Section and Rules under the Environment Protection Act, 1986, the Factories Act, 1948 and other Acts specify the requirements for a safe and reliable working of an industry. They require carrying out various studies and analysis to assess and mitigate hazards prevalent in the factory in line with the above goal of safe and reliable working. These are more commonly known as “Risk Assessment Studies”. This chapter explains the basis of Risk Assessment and its objectives.

Major hazard installations have to be operated to a very high degree of safety; this is the core responsibility of the management. In addition, management holds a key role in the organization in the implementation of a major hazard control systems. In particular, the management has the responsibility to

- Provide the information required to identify major hazard installations.
- Carry out hazard/risk assessment.
- Report to the authorities on the results of the hazard / risk assessment.
- Conceive Disaster Management plans and carryout “MOCK DRILLS” on the scenarios envisaged.
- Adequately inform the Vulnerability status of the company to district management.
- Undertake measures to in-plant safety assurance systems.
- In order to fulfill the above responsibility, the Management must be aware of the nature of the hazard, of the events that cause accidents and of the potential consequences of such accidents.
- In order to control a major hazard successfully, the Management must have answers to the following questions:
- Do toxic, explosive or flammable substances in our facility constitute a major hazard?

- Which failures or errors can cause abnormal conditions leading to a major accident?
- If a major accident occurs, what are the consequences of a fire, an explosion or a toxic release for the employees, people living outside the factory, the plant or the Environment?
- What can Management do to prevent these accidents from happening?
- What can be done to mitigate the consequences of an accident?

The most appropriate way of answering these questions is to carry out a hazard or risk assessment study, the purpose of which is to understand, why accidents occur and how they can be avoided or at least mitigated. A properly conducted RISK assessment will therefore to

- Analyze the existing safety concept or develop a new one;
- Develop optimum measures for technical and organization protection in event of an abnormal plant operation.

7.3 Objective of the Study

The main objectives of the Risk Assessment Studies are as given below:

- To define and assess emergencies, including risk hazard assessment.
- To control and contain incidents.
- To safeguard employees and people residing in vicinity of the company.
- To minimize damage to property and environment through appropriate installed mitigating procedures.

To be ready for mutual aid if need arise to help neighboring units. Normal jurisdiction of an OEP (ON-SITE EMERGENCY PLAN) is to control events in own premises only. When it comes to the mutual aid it requires catering to Mutual Aid Partners also.

7.4 Elements of the RH Study

7.4.1 Storage and Handling of Hazardous Chemicals

identification, analysis and assessment of hazard and risk are very useful in providing information to risk management. It provides basis for what should be the type and capacity of its, on-site and off-site emergency plans. Risk analysis is carried out considering storage and handling of various hazardous raw materials, manufacturing process and storage of hazardous finished goods. Toxic Effects of Chemical Substances limits are given in table 7.1

Table- 7.1 Toxic Effects of Chemical Substances. What are the limits?

Sr. No	Toxicity	Oral Toxicity LD50(mg/kg)	Dermal Toxicity LD50(Mg/Kg)	Inhalation Toxicity LC50(mg/l)
1.	Extremely toxic	> 5	<40	< 0.5

2.	Highly toxic	>5-50	>40-200	< 0.5 - 2.0
3.	Toxic	>50-200	> 200-1000	>2-10

7.4.2.1 Toxic Hazards of Substances

Toxic substances affect in three ways by ingestion, absorption & inhalation. Adequate provision of safety along with personal protective equipment will be made; emergency kit shall be provided at various locations of the installation.

Intoxication – Analytical Analysis.

The consequences from inhalation of a toxic vapour/gas are determined by the toxic dose.

This dose D is basically determined by:

- Concentration of the vapour in air;
- Exposure duration.

Furthermore, of course, the breathing rates of the victim, as well as the specific toxic mechanism unto the metabolism play an important role.

The dose is defined as $D = C^n.t$, with:

C = concentration of the toxic vapour, in [ppm] or [mg/m^3];
t = exposure duration, in [sec] or [min];
n = exponent, mostly > 1.0; this exponent takes into account the fact that a high concentration over a short period results in more serious injury than a low concentration over a relatively longer period of exposure. The value of n should be greater than zero but less than 5.

The given definition for D only holds if the concentration is more or less constant over the exposure time; this may be the case for a (semi) continuous source. In case of an instantaneous source, the concentration varies with time; the dose D must be calculated with an integral equation:

$$D = \int C^n.dt$$

For a number of toxic materials, so-called Vulnerability Models (V.M.) have been developed. The general equation for a V.M. (probit function) is:

$Pr = a + b.\ln (C^n.t)$, with

Pr = probit number, being a representation of the percentage of people suffering a certain kind of damage, for instance lethality

Pr = 2.67 means 1% of the population;
Pr = 5.00 means 50% of the population;
a and b material dependent numbers;

$C^n.t =$ dose D, as explained above.

The values for a and b are mostly derived from experiments with animals; occasionally, however, also human toxicity factors have been derived from accidents in past. In case only animal experiments are available, the inhalation experiments with rats seem to be best applicable for predicting the damage to people from acute intoxication. Although much research in this field have been done over the past decades, only for a limited number of toxic materials consequence models have been developed. Often only quite scarce information is available to predict the damage from an acute toxic exposition. Data transformation from oral intoxication data to inhalation toxicity criteria is sometimes necessary. Generally, in safety evaluations pessimistic assumptions are applied in these transformation calculations. The calculated damage (distance) may be regarded as a maximum. For the purposes of a response to a major incident, the IDLH value level has been chosen for the 'wounded' criteria. This type of injury will require medical attention.

7.4.3 Assessment of Flammability & Explosive Properties.

Flammable Chemicals: what law interprets and gives limits.

(1) **Flammable gases**: Gases which at 20^oC and at standard pressure of 101.3KPa are: -

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

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

(2) **Extremely flammable liquids**: Chemicals which have flash point lower than or equal to 23^oC and boiling point less than 35^oC.

- **(a) Very highly flammable liquids**: Chemicals which have a flash point lower than or equal to 23^oC and initial boiling point higher than 35^oC.
- **(b) Highly flammable liquids**: Chemicals which have a flash point lower than or equal to 60^oC but higher than 23^oC.
- **(c) flammable liquids**: Chemicals which have a flash point higher than 60^oC but lower than 90^oC.

(3) **Explosives**: Explosives mean a solid or liquid or pyrotechnic 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 the 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.

7.4.3.1 Flammability Hazards of Substances

Since the Stone Age term 'fire' is associated with fear. Fire destroys everything when not controlled. It is very dangerous if occurs in uncontrolled manner. It should be clearly understood that when a liquid is used having flash point (Beginning of transformation phase from liquid to vapor) below the normal ambient temperature, it could, in suitable circumstances, liberate a sufficient quantity of vapor to give rise to flammable mixtures with air. Any source of ignition will transform the vapor to fire.

Heat Radiation – Analytical Analysis Parameters.

The consequence caused by exposure to heat radiation is a function of:

- The radiation energy onto the human body [kW/m^2];
- The exposure duration [sec];
- The protection of the skin tissue (clothed or naked body).
- The limits for 1% of the exposed people to be killed due to heat radiation, and for second-degree burns are given in the table herein:

Table- 7.2 Damages to Human Life Due to Heat Radiation

Exposure Duration	Radiation for 1% lethality (kW/m^2)	Radiation for 2nd degree burns(kW/m^2)	Radiation for first degree burns, (kW/m^2)
10 Sec	21.2	16	12.5
30 Sec	9.3	7.0	4.0

Since in practical situations, only the own employees will be exposed to heat radiation in case of a fire, it is reasonable to assume the protection by clothing. Damages to Human Life Due to Heat Radiation is given in table 7.2. It can be assumed that people would be able to find a cover or a shield against thermal radiation in 10 sec. time. Furthermore, 100% lethality may be assumed for all people suffering from direct contact with flames, such as the pool fire, a flash fire or a jet flame. The effects due to relatively lesser incident radiation intensity are given below in table 7.3.

Table- 7.3 Effects Due to Incident Radiation Intensity

Incident Radiation – kW/m^2	Type of Damage
0.7	Equivalent to Solar Radiation
1.6	No discomfort for long exposure
4.0	Sufficient to cause pain within 20 sec. Blistering of skin (first degree burns are likely)
9.5	Pain threshold reached after 8 sec. second degree burns after 20

	sec.
12.5	Minimum energy required for piloted ignition of wood, melting plastic tubing etc.

7.4.3.2 Explosion Hazards

Release of energy in a rapid and uncontrolled manner gives rise to explosion. Explosion is very dangerous because it has the potential to spread the flammable material and fire on low flammable substances also. This effect of spreading fire instantaneously at different installations due to explosion is called "DOMINO EFFECT".

Explosion –Analytical Analysis Parameters

In case of vapour cloud explosion, two physical effects may occur:

* A flash fire over the whole length of the explosive gas cloud;
* A blast wave, with typical peak overpressures circular around ignition source.

As explained above, 100% lethality is assumed for all people who are present within the cloud proper.

For the blast wave, the lethality criterion is based on:

* A peak overpressure of 0.1 bar will cause serious damage to 10% of the housing/structures.
* Falling fragments will kill one of each eight persons in the destroyed buildings.

The following damage criteria given in table 7.4 may be distinguished with respect to the peak overpressures resulting from a blast wave:

Table- 7.4 Damage Due to Overpressures:

Peak Overpressure	Damage Type
0.83 bar	Total Destruction
0.30 bar	Heavy Damage
0.10 bar, 0.03 bar	Moderate Damage, Significant Damage
0.01 bar	Minor Damage

From this it may be concluded that p = 0.17 E+5 pa corresponds approximately with 1% lethality. Furthermore, it is assumed that everyone inside an area in which the peak overpressure is greater than 0.17 E+ 5 pas will be wounded by mechanical damage. For the gas cloud explosion this will be inside a circle with the ignition source as its centre.

7.4.4.1 Corrosion Hazards

Corrosion is a chemical reaction-taking place at the surface of metal. It is also the effects of tissue damage caused to human beings when contacted accidentally. All substances pH 0-5 & 8.0-12.0 are corrosive. Most corrosive substances will produce chemical burns, while certain chemical substances produce deep ulceration. The effect will be for internal organs also when the fumes are inhaled/ ingested. Other damages are, has a detailing effect on skin and may cause dermatitis.

On contact with metals, corrosive substances will oxidize the load bearing columns, beams and truss structure and bring down the stability factor of the buildings.

7.4.5.1 Reactivity Hazards

Reactivity is a property of causing a violent chemical reaction when TWO OR MORE compatible materials coming in contact. The resulting impetus shall release energy in the form of heat, detonation, vapors/gases.

The criteria of avoiding reactivity type hazards are to follow the REACTIVITY MATRIX for storing materials given in table 7.5. (Enlarge to view and read).

Table- 7.5 Incompatible Storage Recommendations.

Chemical Segregation by chemical Group		Class	1	2	3			4		5	6
Explosives	1	1.0 Explosive		Segregate From	Segregate From	Segregate From	Segregate From	Segregate From	Segregate from	Segregate from	Segregate From
Flammable Liquids	2		Segregate FROM		Keep Apart					Keep Apart	Keep Apart
flammable Solids	**3**	Readily Combustible	Segregate From	Keep Apart						**Keep Apart**	
		Spontaneously Combustible	Segregate From	Segregate From	KEEP APART					Keep Apart	Keep Apart
		Dangerous When Wet	Segregate From	Segregate From							
Oxidizing Substances	**4**	OXIDIZING SUBSTANCE	Segregate From	Segregate From						**Keep Apart**	keep Apart
		ORGANIC PEROXIDE	Segregate From	Segregate From	Keep Apart					Keep Apart	Keep Apart
Toxic Substances	5		Segregate From	Keep Apart	Keep Apart	Keep Apart		Keep Apart	Keep Apart		
			Segregate From	Keep Apart	Keep Apart	Keep Apart		Keep Apart	Keep Apart		
Corrosive Substances	6		segregate from	Keep Apart	Keep Apart	Keep Apart		Keep Apart	Keep Apart		

7.5 Raw Materials Storage

Raw materials are stored in the manufacturing units in many ways. There are different system of storage practices for storing

a. Liquid Raw Materials

a.1 In Storage Tanks - Stored in multiple units of tanks same chemical when the quantity is very large in a tank-farm.

a.2 In Storage Tanks - Stored in a single tank, with other material tanks in a tank –farm. (Mixed materials tank-farm.

a.3 In Storage Tanks - Specific material stored in A TANK / TANKS in a tank-farm **demarcated and isolated storage**, Licensed and separated with minimum safe distances.

a.4 In Storage Sheds - Separate storage sheds made for storing specifically raw materials in drums and carboys.

b. Solid Raw Materials

b.1 In Silos - Large quantities of powder / Granules are stored in silos. The handling of materials are done pneumatically. The quantity dispatch in terms of weight are measured with the provision of load cells.

b.2 In Bags & Solid raw materials are received in bags and boxes are stored in closed sheds as per the **Boxes** compatibility norms.

C. Gaseous Raw Materials

C.1 In Tonners & Gas Cylinders- Flammable and toxic raw materials are stored in **demarcated and isolated storage** in Licensed premises.

C.2 In Pipelines - Received in pipelines up to the unit and parameters processed in the skid for end use.

7.5.1 The raw materials are planned for storage in drums and carboys in Raw Materials Stores as shown in table 7.6.

Hazardous Chemicals Used in HIKAL.

Hazard Parameters Chart - Raw Materials in Tank Farms, Drums & Carboys.

Highly Flammable **Highly Toxic**

Table 7.6 Raw Material Storage

S. No	Name	Monthly Consu mption	Liquid/ Vapor TPQ	Tank Farm Yes / No	NFPA Label F-H-R-O	VD	LEL UEL%	F.P °C	B.P °C	TLV ppm/mg/m³	IDLH ppm/mg/ m³	CAS. NO	UN NO
1	Toluene	2000	L 200	YES	3-2-0-X	3.14	1.27 7.1	4.4	110.5	67	500	108-88-3	1294
2	Methanol	1250	L 150	YES	3-1-0-x/ Soluble	1.1	5.5 36.5	11.1	64.5	270	6000	67-56-1	1230
3	DMF	520	L 50	YES	2-2-0-X/ Soluble	2.51	2.2 15.2	67	156	2 ppm	500 ppm	68-12-2	2265
4	Solvent-1 / IPA	900	L 100	YES	3-1-0-X Soluble	2.07	2.0 12.0	11.6	82.5	400	2000	67-63-0	1219
5	Solvent A/ Acetone	1000	L 100	YES	3-1-0-x Soluble	2	2.6 12.8	(-)18	56.0	200	NA	67-64-1	1090
6	Solvent E /Ethylene Dichloride	3000	L 300	YES	3-2-0-X	3.4	6.2 15.9	13.3	83.5	50	50	107-06-2	1184
7	N Hexane	70	L 10	NO	3-X-X-0 Soluble	2.97	1.2 7.5	(-)23	68.8	260	1100	110-54-3	1208
8	Solvent / Xylene	25	L 10	NO	3-2-0-X	3.67	0.9 8.1	8F	282F	130	NA	1330-20-7	1307
10	Cyclo Hexane	5	L	NO	3-1-0-X	2.9	1.3 8.4	-20	81	300	1300	110-82-7	1145
11	Methylene Chloride	2	Solutio n	NO	4-2-0-x	NA	NA	NA	NA	300	NA	75-09-2	1912
12	Ethyl Acetate	90	L 10	NO	3-1-0-X	3.04	2.0 11.5	(-) 4.4	77.2	1200	2000	141-78-6	1173
	2 Chloro Ethanol	2	L	NO	Corrosive	NA	NA	78.3	146	NA	NA	598-38-9	2810

S. No	Name	Monthly Consumption	Liquid/ Vapor TPQ	Tank Farm Yes / No	NFPA Label F-H-R-O	VD	LEL UEL%	F.P °C	B.P °C	TLV ppm/mg/m³	IDLH ppm/mg/m³	CAS. NO	UN NO
	Potassium Hydroxide	2	L	NO	Corrosive	NA	NA	NA	130	NA	NA	1310-58-3	1814
	Caustic Soda Flakes	**2**	**S**	**NO**	**Corrosive**	**NA**	**NA**	**NA**	**NA**	**0.5mg/m3**	**10 mg /m3**	**1310-73-2**	**1823**
	Sodium Mono chloro Acetate	1	S	NO	Corrosive	NA	NA	NA	NA	7.2mg/m3	NA	3926-62-3	2659
13	HCL	300	L	YES 20	0-3-1-x	1.267	NA	NA	110	5	NA	7647-01-0	1789
14	Sulphuric Acid	70	L	YES 10	0-3-2-W	3.4	NA	NA	554	1MG/M3	15MG/ M3	7664-93-9	1830
15	Nitric Acid	25	L	YES 10	0-4-1-OX	NA	NA	NA	82.7	0.16	25	7697-37-2	2032
16	Formaldehyde	200	L 20	YES	4-3-0-X	7 73	1.067	60	(-) 19.5	0.9	20	50-00-0	1198
17	Bromine	600	L 40	NO	0-3-0-X	NA	5.51	NA	59.4	0.1	3	7726-95-6	1744
18	Liquid Ammonia	130	L 10	Yes	1-3-0-X	NA	NA	NA	NA	30	300	7664-41-7	2672
19	Chlorine	200	GAS 10	Tonner	0-4-0-X	NA	2.49	NA	(-) 34.5	0.5	10	7782-50-5	1017
	Tartaric Acid	**1.0**	**S**	**NO**	**Corrosive**	**NA**	**NA**	**NA**	**NA**	**0.8MG/M3**	**NA**	**3164-29-2**	**3077**
	Farmin	**1.0**	**L**	**NO**	**Corrosive**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**112-18-5**	**2735**
	Hydro Bromic Acid	**1.0**	**L**	**NO**	**0-3-0-X**	**NA**	**NA**	**NA**	**NA**	**1PPM**	**30 PPM**	**10035-10-6**	**1788**
	Di Methyl Sulfate	**1**	**S**	**NO**	**2-4-1-X**	**NA**	**4.35**	**83**	**204**	**0.024 PPM**	**7 PPM**	**77-78-1**	**1595**
	Chloroform	**5**	**L**	**NO**	**0-2-0-X**	**NA**	**4.12**	**NA**	**78**	**2 PPM**	**50 PPM**	**67-66-3**	**1888**

S. No	Name	Monthly Consu mption	Liquid/ Vapor TPQ	Tank Farm Yes / No	NFPA Label F-H-R-O	VD	LEL UEL%	F.P °C	B.P °C	TLV ppm/mg/m³	IDLH ppm/mg/ m³	CAS. NO	UN NO
	Dimethyl Sulfoxide	5	L	NO	2-2-0-X	2.6 63.0	2.71	95	188	150 PPM	NA	67-68-5	2811
	Benzene Sulphonic Acid	1	L	NO	Corrosive	NA	NA	NA	NA	NA	NA	98-11-3	2583
	Epichlorohyd rin	1	L	NO	3-4-2-X	3.8 29.0	3.29	34	117	1.7 PPM	75 PPM	106-89-8	2023
	Polyethylene Glycol	0.5	L	NO	1-1-0-X	NA	NA	182	NA	30 MG /M3	NA	25322-68-3	NA

TPQ - Threshold Planned Quantity, FP – Flash Point, BP – Boiling Point, VD – Vapor Density, SG- Specific Gravity, LEL/UEL – Explosive Limits, TLV – Threshold Limit Value, IDLH – IMME. Danger to Life & Health, NFPA –Hazard Parameters Label, UN-UN Transport Code Number CAS: Case Abstract System Number

7.5.2 Risk Scenarios: Quantitative Analysis

Table-7.7 These hazardous chemicals are assessed with the scenarios, for deriving and identifying the vulnerable zones

S. No	Source Scenarios	Failure Mechanism	RISK Consequences	Probability[1]	Severity [2]	Risk Rating[3]
1	**Acetone: Failure of a tank in Tank farm (Worst Case Scenario)**	**Tank Weld joint failure and leaks through the weld joint.**	**Low flash point, flammable vapors quickly spreads and catches fire by way of flashback from a distance area.**	**3**	**5**	**15**
2	**Ethylene DICHLORIDE: Failure of a tank in Tank farm (Worst Case Scenario)**	**Tank Weld joint failure and leaks through the weld joint.**	**Low flash point, flammable vapors quickly spreads and catches fire by way of flashback from a distance area.**	**3**	**5**	**15**
3	**Toluene: Failure of a tank in Tank farm (Worst Case Scenario)**	**Tank Weld joint failure and leaks through the weld joint.**	**Low flash point, flammable vapors quickly spreads and catches fire by way of flashback from a distance area.**	**3**	**5**	**15**
4	**Methanol: Failure of a tank in Tank Farm (Worst Case Scenario)**	**Tank Weld joint failure and leaks through the weld joint.**	**Low flash point, flammable vapors quickly spreads and catches fire by way of flashback from a distance area.**	**3**	**5**	**15**
5	**Isopropanol: Failure of a tank in Tank Farm (Worst Case Scenario)**	**Tank Weld joint failure and leaks through the weld joint.**	**Low flash point, flammable vapors quickly spreads and catches fire by way of flashback from a distance area.**	**3**	**5**	**15**
6	**Cyclohexane : Failure of a tank in Tank Farm (Worst Case Scenario)**	**Tank Weld joint failure and leaks through the weld joint.**	**Low flash point, flammable vapors quickly spreads and catches fire by way of flashback from a distance area.**	**2**	**4**	**8**
7	**DMF: Failure of a tank in tank farm (Worst Case Scenario)**	**Tank Weld joint failure and leaks through the weld joint.**	**Low flash point, flammable vapors quickly spreads and catches fire by way of flashback from a distance area.**	**2**	**4**	**8**
8	**Hexane: Failure of a tank in Tank Farm (Worst Case Scenario)**	**Tank Weld joint failure and leaks through the weld joint.**	**Low flash point, flammable vapors quickly spreads and catches fire by way of flashback from a distance area.**	**2**	**4**	**8**
9	**Formaldehyde: Failure of**	**Tank Weld joint**	**Low vaporizing point**	**2**	**4**	**8**

S. No	Source Scenarios	Failure Mechanism	RISK Consequences	Probability[1]	Severity [2]	Risk Rating[3]
	a tank in Tank Farm (Worst Case Scenario)	**failure and leaks through the weld joint.**	**releases toxic, corrosive vapors quickly spreads and to a distance area**			
10	**HCL: Failure of a tank in Tank farm (Worst Case Scenario)**	**Tank Weld joint failure and leaks through the weld joint.**	**Low vaporizing point releases toxic, corrosive vapors quickly spreads and to a distance area.**	**2**	**4**	**8**
11	**Bromine: Failure of a tank in Tank farm (Worst Case Scenario)**	**Crates of Bromine fall while in transport due to dashing on a column on the road side.**	**Low boiling point toxic, corrosive, oxidizing vapors quickly spreads downwind to a distance area.**	**3**	**5**	**15**
12	**Chlorine: Failure of a tank in Tank farm (Worst Case Scenario)**	**TONNERS VALVE failure gives a big leakage of CHLORINE GAS**	**Due to release from failure of valves, toxic, corrosive vapors quickly spreads downwind to distance areas.**	**3**	**5**	**15**
END						

LEGEND

[1]probability:	[2]severity:	[3]risk Rating:
1 – Highly Unlikely	1 – Extremely Mild	Probability x Severity
2 – UNLIKELY	2 – MILD	
3 – SOMEWHAT LIKELY	3 – MODERATE	
4 – LIKELY	4 – SEVERE	
5 – VERY LIKELY	5 – MOST SEVERE	

- There are equal numbers of FLAMMABLE RISKS from the following chemicals. (Methanol, Toluene, Ethyl acetate, IPA, Acetone. Equally high amount of TOXIC RISKS with Tri Amine, DMF, Tartaric Acid, Hydro Bromic Acid, Dimethyl sulphate, Epichlorohydrin.).
- The WORST CASE SCENARIO is also well within the reach of fire protection/mitigation measures, planned for the installation.
- Fire protection/ control / mitigation measures are to be suitable planned and incorporate prior to commissioning of the plant.

7.5.3 Software Used for Calculations

ALOHA (Areal Locations of Hazardous Atmospheres):

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

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

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

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 adverse health effects or perceiving a clearly defined, objectionable odor.

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 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.

IDLH: The Immediately Dangerous to Life or Health (IDLH) level. A chemical's IDLH is an estimate of the maximum concentration in the air to which a healthy worker could be exposed without suffering permanent or escape-impairing health effects.

7.5.3.1 Vulnerability Analysis

A vulnerability analysis is carried out on the maximum credible accident scenario and the worst case scenario. The analysis is carried out using the help of sophisticated computer software which provides the zone of influence as well as the geographical risk contours.
The calculations are complex in nature, and various parameters are defined to assist the software in simulating the risk contours. The parameters include details such as the size of the leakages / holes, quantity of materials released, duration of the release, weather and geographical conditions.
The simulations are generated under standard operating conditions. Data given in the reports and manuals are taken as correct information. Weather Condition are given table 7.8

Table – 7.8 Weather Conditions

Parameters	Condition D	Condition F

Parameters	Condition D	Condition F
Wind Speed	10.0 m/s	3.0 m/s
Wind Direction	225° true at 3 m	45° true at 3 m
Pasquill Stability	D	F
Ground Roughness	Open country	Open country
Air Temperature (°C)	32	25
Surface temperature	32	25
Relative Humidity	75%	50%
Cloud Cover	70%	50%

7.5.3.2 Maximum Credible Accident Scenario

The MAXIMUM CREDIBLE ACCIDENT SCENARIO was analyzed based on flammable vapor and toxic vapor risks. The ALOHA simulation software was used to obtain the risk contours and the zone of influence, as well as levels of risk associated with each zone.

The calculations performed are based on Unified Dispersion Modeling and provide the foot prints of hazardous chemical dispersion and the distances of critical concentrations for flammability and toxicity. The model considers a three stage method as given in the following illustration.

POOL SPREADING AND VAPORIZATION
The release containing liquid droplets forms a pool. Any evaporation from this pool will contribute to the dispersing pool.

Evaporation
↓

DISPERSION
The vapor cloud disperses in the atmosphere until it has reached harmless concentration.

Calculation of the concentration profile of the cloud
↓

FLAMMABILITY AND TOXICITY

7.5.4 the project site details for study of Dispersion Patterns for hazardous chemicals:

Longitude : 72° 49’ 23” 12 E
Latitude : 21° 46’ 14” 12 N

Location: ANKALESHWAR, INDIA
Building Air Exchanges Per Hour: 12 (user specified)
Time: August 10, 2018 1936 hours ST (using computer's clock)
Wind: 10 meters/second from 45° true at 3 meters
Ground Roughness: open country
Cloud Cover: 7 tenths
Air Temperature: 32° C
Relative Humidity: 75%

7.5.5 Dispersion Patterns of Chemicals:

Dispersion Scenarios: Hazardous Chemical: Acetone
Worst Case Scenario Stability Class ’D’

Threat Zone:
Threat Modeled: Thermal radiation from fireball
Red: 344 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)
Orange: 491 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)
Yellow: 770 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

Threat at Point:
Thermal Radiation Estimates at the point:
Downwind: 50 meters
Off Centerline: 20 meters
The point selected is within the fireball radius.

Threat Zone:

Hazardous Chemical : Acetone
Worst Case Scenario Stability Class 'D'

Threat at a Point:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

Dispersion Scenarios: Hazardous Chemical: Acetone
Worst Case Scenario Stability Class 'F'

Threat Zone:
Threat Modeled: Thermal radiation from fireball
Red : 359 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 512 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 803 meters --- (2.0 kW/(sq m) = pain within 60 sec)

Threat at Point:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

Dispersion Scenarios: Hazardous Chemical: Acetone
Worst Case Scenario Stability Class 'F'

Threat at a point:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

Dispersion Scenarios: Hazardous Chemical: Methanol
Worst Case Scenario Stability Class 'D'

Threat Zone: Threat Modeled: Thermal radiation from fireball
Red : 283 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 409 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 646 meters --- (2.0 kW/(sq m) = pain within 60 sec)

Threat at Point:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

Threat Zone : Hazardous Chemical: Methanol
Worst Case Scenario Stability Class 'D'

Threat at a point:
Thermal Radiation Estimates at the point:

Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

Dispersion Scenarios: Hazardous Chemical: Methanol
Worst Case Scenario Stability Class 'F'

Threat Zone:
Threat Modeled: Thermal radiation from fireball
Red : 295 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 427 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 674 meters --- (2.0 kW/(sq m) = pain within 60 sec)

Threat at Point:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

Threat Zone: Hazardous Chemical: Methanol
Worst Case Scenario Stability Class 'F'

Threat at Point:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

Dispersion Scenarios: Hazardous Chemical: Toluene
Worst case Scenario Stability Class 'D'

Threat Zone: Threat Modeled: Thermal radiation from fireball
Red : 426 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 602 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 939 meters --- (2.0 kW/(sq m) = pain within 60 sec)

Threat at Point:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

Threat Zone : Hazardous Chemical: Toluene
Worst Case Scenario Stability Class 'D'

Threat at Point:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius

Dispersion Scenarios: Hazardous Chemical: Toluene
Worst Case Scenario Stability Class 'F'

Threat Zone: Threat Modeled: Thermal radiation from fireball
Red : 444 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 628 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 980 meters --- (2.0 kW/(sq m) = pain within 60 sec)

Threat at Point:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

Threat Zone: Hazardous Chemical: Toluene
Worst Case Scenario Stability Class 'F'

Threat at Point:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius

Dispersion Scenarios: Hazardous Chemical: DMF
Maximum Credible Accident Scenario Stability Class 'D'

Threat Zone: Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Gaussian
Red : 13 meters --- (13800 ppm = 60% LEL = Flame Pockets)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
Yellow: 13 meters --- (2300 ppm = 10% LEL)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

Threat at Point: Concentration Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
Max Concentration: Outdoor: 0.113 ppm Indoor: 0.111 ppm

Threat Zone : Hazardous Chemical: DMF
Maximum Credible Accident Scenario :Stability Class 'D'

Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Gaussian
Red : 13 meters --- (13800 ppm = 60% LEL = Flame Pockets)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
Yellow: 13 meters --- (2300 ppm = 10% LEL) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

Threat at Point:

Dispersion Scenarios: Hazardous Chemical: DMF

Maximum Credible Accident Scenario Stability Class 'F'

Threat Zone:
Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Gaussian
Red : 13 meters --- (13800 ppm = 60% LEL = Flame Pockets) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
Yellow: 22 meters --- (2300 ppm = 10% LEL) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

Threat at Point: Concentration Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
Note: Concentration not drawn because there is no significant concentration at the point selected.

Threat Zone: Hazardous Chemical: DMF
Maximum Credible Accident Scenario Stability Class 'F'

Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Gaussian
Red: 13 meters --- (13800 ppm = 60% LEL = Flame Pockets) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
Yellow: 22 meters --- (2300 ppm = 10% LEL) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances

Threat at Point:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius

Dispersion Scenarios: Hazardous Chemical: Hexane
Maximum Credible Accident Scenario Stability Class 'D'

Threat Zone: Threat Modeled: Overpressure (blast force) from vapor cloud explosion Type of Ignition: ignited by spark or flame Level of Congestion: congested Model Run: Gaussian No explosion: no part of the cloud is above the LEL at any time THREAT AT POINT: Overpressure Estimate at the point: Downwind: 20 meters Off Centerline: 10 meters
There is no significant overpressure at the point selected.

Threat Zone : Hazardous Chemical: Hexane
Maximum Credible Accident Scenario Stability Class 'D'

Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame Level of Congestion: congested
Model Run: Gaussian
No explosion: no part of the cloud is above the LEL at any time

Threat at Point:
Overpressure Estimate at the point:
Downwind: 20 meters Off Centerline: 10 meters
There is no significant overpressure at the point selected

Dispersion Scenarios: Hazardous Chemical: Hexane
Worst Case Scenario Stability Class 'F'
The puddle spread to a diameter of 17.6 meters.
THREAT ZONE: Threat Modeled: Flammable Area of Vapor Cloud Model Run: Heavy Gas Red : 17 meters --- (7200 ppm = 60% LEL = Flame Pockets) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. Yellow: 57 meters --- (1200 ppm = 10% LEL)
THREAT AT POINT: Concentration Estimates at the point: Downwind: 20 meters Off Centerline: 10 meters Max Concentration: Outdoor: 2,950 ppm Indoor: 2,900 ppm

THREAT ZONE : HAZARDOUS CHEMICAL: HEXANE
WORST CASE SCENARIO STABILITY CLASS 'F'

THREAT AT POINT:

DISPERSION SCENARIOS : HAZARDOUS CHEMICAL: ISOPROPONOL
WORST CASE SCENARIO STABILITY CLASS 'D'

THREAT ZONE:
Threat Modeled: Thermal radiation from fireball
Red : 356 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 508 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 795 meters --- (2.0 kW/(sq m) = pain within 60 sec)

THREAT AT POINT:

Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

THREAT ZONE : HAZARDOUS CHEMICAL: ISOPROPANOL
WORST CASE SCENARIO STABILITY CLASS 'D'

THREAT AT A POINT
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

DISPERSION SCENARIOS : HAZARDOUS CHEMICAL: ISOPROPONOL
WORST CASE SCENARIO STABILITY CLASS 'F'

THREAT ZONE: Threat Modeled: Thermal radiation from fireball
Red : 372meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 530 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 829 meters --- (2.0 kW/(sq m) = pain within 60 sec)
THREAT AT POINT:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

THREAT ZONE : HAZARDOUS CHEMICAL: ISOPROPANOL
WORST CASE SCENARIO STABILITY CLASS 'F'

THREAT AT A POINT
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

DISPERSION SCENARIOS : HAZARDOUS CHEMICAL: CYCLOHEXANE
MAXIMUM CREDIBLE ACCIDENT SCENARIO STABILITY CLASS 'D'
THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : 15 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec) Orange: 18 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec) Yellow: 24 meters --- (2.0 kW/(sq m) = pain within 60 sec)
THREAT AT POINT:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
Max Thermal Radiation: 0.232 kW/(sq m)

THREAT ZONE : HAZARDOUS CHEMICAL: CYCLOHEXANE
WORST CASE SCENARIO STABILITY CLASS 'D'

THREAT AT A POINT

DISPERSION SCENARIOS : HAZARDOUS CHEMICAL: CYCLOHEXANE MAXIMUM CREDIBLE ACCIDENT SCENARIO
STABILITY CLASS 'F'

THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : 15 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 20 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 28 meters --- (2.0 kW/(sq m) = pain within 60 sec)

THREAT AT POINT:
Thermal Radiation Estimates at the point:

Downwind: 50 meters Off Centerline: 20 meters
Max Thermal Radiation: 0.418 kW/(sq m)

THREAT ZONE : WORST CASE SCENARIO **HAZARDOUS CHEMICAL: CYCLOHEXANE STABILITY CLASS 'F'**

THREAT AT A POINT

DISPERSION SCENARIOS : HAZARDOUS CHEMICAL: ETHYLENE DICHLORIDE WORSTCASE SCENARIO STABILITY CLASS 'D'

THREAT ZONE: Threat Modeled: Thermal radiation from fireball
Red : 231 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 349 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 564 meters --- (2.0 kW/(sq m) = pain within 60 sec)
THREAT AT POINT:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

THREAT ZONE : HAZARDOUS CHEMICAL: ETHYLENE DICHLORIDE WORST CASE SCENARIO STABILITY CLASS 'D'

THREAT AT POINT:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

DISPERSION SCENARIOS : HAZARDOUS CHEMICAL: ETHYLENE DICHLORIDE WORSTCASE SCENARIO STABILITY CLASS 'F'
THREAT ZONE: Threat Modeled: Thermal radiation from fireball
Red : 242 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 365 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 588 meters --- (2.0 kW/(sq m) = pain within 60 sec)
THREAT AT POINT:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

THREAT ZONE : HAZARDOUS CHEMICAL: ETHYLENE DICHLORIDE WORST CASE SCENARIO STABILITY CLASS 'F'

THREAT AT POINT:
Thermal Radiation Estimates at the point:
Downwind: 50 meters Off Centerline: 20 meters
The point selected is within the fireball radius.

DISPERSION SCENARIOS : HAZARDOUS CHEMICAL: FORMALDEHYDE MAXIMUM CREDIBLE ACCIDENT SCENARIO STABILITY CLASS 'D'

THREAT ZONE:
Model Run: Gaussian
Red : 63 meters --- (35 ppm = AEGL-3 (60 min))
Orange: 113 meters --- (14 ppm = AEGL-2 (60 min))
Yellow: 528 meters --- (0.9 ppm = AEGL-1 (60 min))
THREAT AT POINT: Concentration Estimates at the point:
Downwind: 20 meters Off Centerline: 10 meters
Note: Concentration not drawn because there is no significant concentration at the point selected.

THREAT ZONE : HAZARDOUS CHEMICAL: FORMALDEHYDE WORST CASE SCENARIO STABILITY CLASS 'D'

THREAT AT A POINT
Concentration Estimates at the point:
Downwind: 20 meters Off Centerline: 10 meters
Note: Concentration not drawn because there is no significant concentration at the point selected.

DISPERSION SCENARIOS : HAZARDOUS CHEMICAL: HYDROCHLORIC ACID MAXIMUM CREDIBLE ACCIDENT SCENARIO STABILITY CLASS 'D'

THREAT ZONE: Model Run: Gaussian
Red : 20 meters --- (100 ppm = AEGL-3 (60 min))
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
Orange: 52 meters --- (22 ppm = AEGL-2 (60 min))
Yellow: 196 meters --- (1.8 ppm = AEGL-1 (60 min))
THREAT AT POINT: Concentration Estimates at the point:
Downwind: 20 meters Off Centerline: 10 meters

Note: Concentration not drawn because there is no significant concentration at the point selected.

THREAT ZONE : HAZARDOUS CHEMICAL: HYDROCHLORIC ACID
MAXIMUM CREDIBLE ACCIDENT SCENARIO
STABILITY CLASS 'D'

THREAT AT A POINT
Concentration Estimates at the point:
Downwind: 20 meters Off Centerline: 10 meters
Note: Concentration not drawn because there is no significant concentration at the point selected

DISPERSION SCENARIOS : HAZARDOUS CHEMICAL: BROMINE
WORST CASE SCENARIO STABILITY CLASS 'D'

THREAT ZONE: Model Run: Gaussian
Red : 248 meters --- (8.5 ppm = AEGL-3 (60 min))
Orange: 1.9 kilometers --- (0.24 ppm = AEGL-2 (60 min))
Yellow: 5.7 kilometers --- (0.033 ppm = AEGL-1 (60 min))
THREAT AT POINT:
Concentration Estimates at the point:
Downwind: 20 meters Off Centerline: 10 meters
Note: Concentration not drawn because there is no significant concentration at the point selected.

THREAT ZONE : HAZARDOUS CHEMICAL: BROMINE
WORST CASE SCENARIO STABILITY CLASS 'D'

THREAT AT POINT:
Concentration Estimates at the point:
Downwind: 20 meters Off Centerline: 10 meters
Note: Concentration not drawn because there is no significant concentration at the point selected

Dispersion Scenarios: Hazardous Chemical: Nitric Acid
Maximum Credible Accident Scenario Stability Class 'D'

Threat Zone: Model Run: Gaussian
Red : 24 meters --- (92 ppm = AEGL-3 (60 min))
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
Orange: 52 meters --- (24 ppm = AEGL-2 (60 min))
Yellow: 782 meters --- (0.16 ppm = AEGL-1 (60 min))

Threat at Point: Concentration Estimates at the point:
Downwind: 20 meters Off Centerline: 10 meters
Note: Concentration not drawn because there is no significant concentration at the point selected.

Threat Zone: **Hazardous Chemical: NITRIC ACID**
Maximum Credible Accident Scenario **Stability Class 'D'**

Threat at a Point
Concentration Estimates at the point:
Downwind: 20 meters Off Centerline: 10 meters
Note: Concentration not drawn because there is no significant concentration at the point selected

Dispersion Scenarios: **Hazardous Chemical: Aqueous Ammonia**
Maximum Credible Accident Scenario **Stability Class 'D'**
THREAT ZONE: Model Run: Gaussian
Red : 52 meters --- (1100 ppm = AEGL-3 (60 min))
Orange: 144 meters --- (160 ppm = AEGL-2 (60 min))
Yellow: 354 meters --- (30 ppm = AEGL-1 (60 min)

Threat at Point:
Concentration Estimates at the point:
Downwind: 20 meters Off Centerline: 10 meters
Note: Concentration not drawn because there is no significant concentration at the point selected.

Threat Zone : **Hazardous Chemical: Aqueous Ammonia**
Maximum Credible Accident Scenario **Stability Class 'D'**

Threat at a Point
Concentration Estimates at the point:
Downwind: 20 meters Off Centerline: 10 meters
Note: Concentration not drawn because there is no significant concentration at the point selected.
Dispersion Scenarios: **Hazardous Chemical: Chlorine**
Worst Case Scenario **Stability Class 'D'**
Threat Zone:
Model Run: Gaussian
Red : 273 meters --- (20 ppm = AEGL-3 (60 min))
Orange : 1.0 kilometers --- (2 ppm = AEGL-2 (60 min))
Yellow : 2.1 kilometers --- (0.5 ppm = AEGL-1 (60 min))

Threat at Point:
Concentration Estimates at the point:
Downwind: 20 meters Off Centerline: 10 meters
Note: Concentration not drawn because there is no significant concentration at the point selected.

Threat zone : **Hazardous Chemical: Chlorine**
Worst Case Scenario **Stability Class 'D'**

Threat at Point:
Concentration Estimates at the point:
Downwind: 20 meters Off Centerline: 10 meters
Note: Concentration not drawn because there is no significant concentration at the point selected.
Maximum Credible Accident Scenarios and worst Case Scenarios are given in table 7.9 and table 7.10

7.5.6 Vulnerable Analysis:

Table- 7.9 Maximum Credible Accident Scenarios.

Parameters – release of Gas	RISK	Threat Zones 'D' in 'm'	Threat Zones 'F 'in 'm '	PPM/ PSI Limits	Actions to reduce Severity	Threat at point:
DMF : Storage Tank Failure (Flammable area vapor cloud)	Flam mable vapor Cloud	13	13	13800	LEL not reached. Cover up the spilled liquid with dry sand and FFF FOAM. Soluble in water. High Auto ignition temp not easily flammable. Use PPEs for protection	DW:50 CW:20 No significant effect.
		13	22	2300		
		NA	NA			
Cyclohexane Tank Failure (Burning Pool)	Flam mable Vapor Cloud	15	15	10.0kw/m2	1150 kgs of materials spilled. Burn duration 13 minutes. Cover up the spilled liquid with dry sand and FFF FOAM. Use PPEs for protection	DW:50 CW:20 Target Audience: People working near the plant requires evacuation
		18	20	5.0kw/m2		
		24	28	2.0 kw/m2		
N- Hexane Tank Failure (Flammable area vapor cloud)	Flam Mable Vapor Cloud	NA	R - 17	10.0kw/m2	ISOLATE the area with a cordoning tape. Cover up the spilled liquid with dry sand and FFF FOAM. Use PPEs for protection. Always work in the upwind side.	DW:50 CW:20 No significant effect.
		NA	O - 57	5.0kw/m2		
		NA	NA	2.0 kw/m2		
Formaldehyde Storage tank failure (Toxic vapor cloud)	Toxic Vapor Cloud	R - 63	NA	35 ppm	ISOLATE the area with a cordoning tape. Cover up the spilled liquid with dry sand and FFF FOAM. Use PPEs for protection. Always work in the upwind side.	The people working inside the plant and adjacent plants also require alertness.
		O - 113	NA	14 ppm		
		Y - 528	NA	0.9 ppm		
Hydro Chloric Acid : Storage Tank Failure (Toxic Vapor Cloud)	Toxic Vapor Cloud	R - 20	NA	100 ppm	Neutralize the spillage by dry sand and soda ash. Keep away from the toxic fumes. Stay in upwind locations. Wear PPEs to avoid gas exposure. Measure the gas existence with VOC meter and allow people to restore operations.	The people working inside the plant and adjacent plants also require alertness.
		0 - 52	NA	22 ppm		
		Y - 196	NA	1.8 ppm		
		O- 1000	NA	2 ppm		
		Y- 2100	NA	0.5 ppm		

7.5.7 Vulnerable Analysis:

Table-7.10 Worst Case Scenarios.

Parameters – Release of Gas	Risk	Threat Zones 'D' in 'm'	Threat Zones 'F 'in 'm '	PPM/ PSI	Actions to Reduce Severity	Threat at Point:
Acetone: Storage tank Failure. Bleve (4 storage tanks cluster)	Flammable Vapor Cloud Bleve	R-344	359	10.0kw/m2	Cooling with foam and flooding water is recommended. Mitigating team shall maintain safe distances. Nearby areas shall be also extinguished. Domino effect possible. Fire wall is advised	Area clearance is required and district Govt. Authorities to be informed for off-site requirements.
		O-491	512	5.0kw/m2		
		Y-770	803	2.0 kw/m2		
Methanol: Storage tank failure Bleve (5 storage tanks cluster)	Flammable Vapor Cloud Bleve	R-283	295	10.0kw/m2	Cooling with foam and flooding water is recommended. Mitigating team shall maintain safe distances. Nearby areas shall be also extinguished. Domino effect possible. Fire wall is advised	Area clearance is required and district Govt. Authorities to be informed for off-site requirements.
		O-409	427	5.0kw/m2		
		Y-646	674	2.0 kw/m2		
Toluene: Storage tank failure BLEVE (6 storage tanks cluster)	Flammable Vapor Cloud Bleve	R - 426	444	10.0kw/m2	Cooling with foam and flooding water is recommended. Mitigating team shall maintain safe distances. Nearby areas shall be also extinguished. Domino effect possible. Fire wall is advised	Area clearance is required and district Govt. Authorities to be informed for off-site requirements
		O - 602	628	5.0kw/m2		
		Y - 939	980	2.0 kw/m2		
Isopropanol: Storage tank failure BLEVE (4 storage tanks cluster)	Flammable Vapor Cloud BLEVE	R - 356	372	10.0kw/m2	Cooling with foam and flooding water is recommended. Mitigating team shall maintain safe distances. Nearby areas shall be also extinguished. Domino effect possible. Fire wall is advised	Area clearance is required and district Govt. Authorities to be informed for off-site requirements
		O -508	530	5.0kw/m2		
		Y - 795	829	2.0 kw/m2		
Ethylene Dichloride (Storage tank failure BLEVE (6 storage tanks cluster)	FLAMMABLE Vapor Cloud	R - 231	242	10.0kw/m2	Cooling with foam and flooding water is recommended. Mitigating team shall maintain safe distances. Nearby areas shall be also extinguished. Domino effect possible. Fire wall is advised	Area clearance is required and district Govt. Authorities to be informed for off-site requirements
		O - 349	365	5.0kw/m2		
		Y - 564	588	2.0 kw/m2		
Bromine : Falling of Crates and Breaking of bottles During Transport.	Toxic Vapor Cloud	R - 248	NA	8.5 ppm	Neutralize the spillage by dry sand and sodium thio-sulphate solution. Keep away from the toxic fumes. Stay in	The people working inside the plant and adjacent plants also require
		O- 1900	NA	0.24 ppm		

Parameters – Release of Gas	Risk	Threat Zones 'D' in 'm'	Threat Zones 'F 'in 'm '	PPM/ PSI	Actions to Reduce Severity	Threat at Point:
		Y- 5700	NA	0.033 ppm	upwind locations. Wear PPEs to avoid gas exposure. Measure the gas existence with VOC meter and allow people to restore operations.	alertness
Chlorine: (Tonner Valve Leakage)	Toxic Vapor Cloud	R - 273	NA	20 ppm	Arrest the Chlorine gas leakage from the leaking valve by the leakage kit. Position the chlorine hood and transfer the gas through a vent. Always be in the protection gear for the purpose. Use SCBA set and full body suits.	The people working inside the plant and adjacent plants also require alertness
		O - 1000	NA	2.0 ppm		
		Y - 2100	NA	0.5 ppm		

7.6 Management of Risk and Health Scenarios

7.6.1 Risk Assessment & Management-

This plant is expanded to increase production. the plant has high hazard potential and all the safety precautions shall be adopted regularly.

1. Toxic, corrosive & reactive materials are high in numbers. Their storage quantity is very high. They are all stored in tank farms in clusters. The daily filling quantities are very high. The number of filling tankers / trucks will be very high. There must be a separate department to maintain this hazardous area During manipulations and transportation spillages and damages are possible. Whenever there is spillage on the ground happens, the liquid pool of material has to be immediately covered with sand and neutralizers like SODA ASH/LIME shall be spread on the spillage. 90% of the potential harm will be reduced.

2. The tank farm will be a very large one. The design of the tank farm shall be as per the standard COP. Fire walls at appropriate places, Fire-fighting, cooling devices to drench fire have to be appropriately planned. Remote control operations with suitable automation, will perform controls appropriately.

3. Highly flammable liquids mostly solvents are stored in high quantities. the threshold planned quantities shall be kept as low as possible with number of replenishments more. solvents methanol, ethylene dichloride, toluene, acetone, dmf shall have cluster of tanks to accommodate the quantity. they are planned in vertical tanks to be kept in tank farm. the fire hydrant system shall have both water spray and foam extinguishing media. these chemicals are a potential source of major fires. the storage area shall be well protected from any ignitable substances. all the electrical fittings shall be flameproof. only qualified /trained persons shall be used to operate in the tank farm. the tank farm shall be monitored all the 365 days including nights. major accident scenarios have to be planned and mock drills conducted.

4. The Process reactors are assumed to work at a pressure of 10 kg/cm2 and temperatures below 250° C. The temperature monitoring shall be with two RTDs and the cooling system of reactors during the reaction period shall have a standby system. The temperature indicators RTDs shall have big& bright display system.

5. in the dispersion pattern of risks threat zone is the area to be avoided and people have to be outside the zone “confidence lines” to the extent possible. people at yellow zone in any case shall be removed within an hour time. people who are engaged in rescue operations have to use scba sets, fire suits, proximity suits appropriately.

6. “THREAT AT A POINT” in the analysis is given for the rescue team members to operate at a place for mitigating the emergency.

7. The tank-farm areas are designed with good safety practices. All the storage tanks facilities shall have dumping arrangements planned for reducing the severity during emergencies. Dumping arrangement is a spare tank facility kept empty and ready to receive the chemical from the tank with an emergency. The empty tank will be in the same tank farm and will be maintained empty.

8. Work place monitoring is very important and shall be performed frequently. It is a prevention process to avoid major accidents and an assessment of toxic conditions.

9. In case of pressure reactors where the pressures of operations are greater than atmospheric pressure, the overrun of exothermic reactions control is very important. In addition to the safety devices, there must be arrangement to dislodge the reaction mass through the bottom discharge valve. There shall be a provision of remote controlled discharge valves for this purpose.

7.6.2 Health Management (Large Hazard Unit)

1. Personal Hygiene practices shall be strictly implemented to avoid, inhalation and ingestion of gases. Air bubble hoods, canister masks, SCBA sets have to be readily available in the operational areas. Regular practice for wearing the equipment shall be given.
2. Competency of persons working shall be fully established. Work related trainings shall be imparted periodically.
3. Roles and responsibilities shall be assigned clearly and reviewed periodically.
4. PPEs shall be kept at designated places and indicated on the layout plan.
5. Periodic Mock Drills shall be conducted. Records shall be maintained.
6. Fire fighting using first aid fire extinguishers and hydrant system shall be practiced at monthly intervals.
7. Periodic health checkup programs have to be organized and records maintained. Critical Health parameters of the employees have to be monitored.

8. The first –aid center shall be equipped with anti-dotes and their appropriate usage.

7.7 Disaster Management Plan (Suggested Model Plan)

7.7.1 Introduction

The term 'Disaster' owes its origin to the French word desastre, which is a combination of two words 'des' meaning bad and 'aster' meaning star. Thus, the term 'disaster' refers to 'Bad or Evil Star'. In earlier days' disasters were considered to be an outcome or outburst of some unfavorable star.

Ideally, a disaster may be defined as "an event concentrated in time and space which threatens a society or a relative self-sufficient subdivision of a society with major unwanted consequences as a result of the collapse of precautions which had hitherto been culturally accepted as adequate".

Disaster according to the Disaster Management Act 2005 means "a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area";

Disasters are extreme events which cause great loss to life and property. They pose a serious threat to the normal life as well as the process of development and strike with sudden violence, tearing bodies, destroying lives and structures and throwing apart families. Natural disasters, which are both sudden and powerful, damage national economy and cause hardships to a large section of the population. They are the single largest concern for most of the nations as they take a heavy toll of human life, destroy belongings and infrastructure and have far reaching economic and social consequences for communities. Thus, the impact of disasters on human life is multi – dimensional, affecting it in all aspects- domestic, social, economic etc.,

Disaster Management Act:

The DM Act, 2005 provides for the requisite institutional mechanism for drawing up and monitoring the implementation of the DM Plans ensuring measures by various wings of government for prevention and mitigation effects of disasters and for undertaking a holistic coordinated and prompt response to any disaster situation. The Act seeks to institutionalize the mechanisms at the national, state and district levels to plan, prepare and ensure a swift response to both natural calamities and man-made disasters/accidents IN THREE LEVELS.

1. **National Level**
2. **State Level**
3. **District Level (In a state) - Local level in a district.**

Types of Disasters:

Generally, disasters are of two types – Natural and Manmade. Based on the devastation, these are further classified into major/minor natural disaster and major/minor man-made disasters. Some of the disasters are listed below:

Major natural disasters	**Minor natural disasters**	**Major man-made disaster:**	**Minor man-made disaster:**
Flood Cyclone Drought, Earth quake Major Forest Fires Major Epidemic Breakup	Cold wave Thunderstorms Heat waves Mud slides Storm	Deforestation Wars Industrial Disaster/ crisis Chemical Disaster/ pollution.	Road / train accidents, riots Food poisoning Environmental pollution

Industrial hazards are threats to people, and life-support systems that arise from the mass production of goods and services. When these threats exceed human coping capabilities, or the absorptive capacities of environmental systems, they give rise to industrial disasters.

Industrial hazards can occur at any stage in the production process, including extraction, processing, manufacture, transportation, storage, use, and disposal. Losses generally involve the release of damaging substances (e.g. chemicals, radioactivity, and genetic materials) or damaging levels of energy from industrial facilities or equipment into surrounding environments.

The growth of chemical industries has led to an increase in the risk of occurrence of incidents associated with hazardous chemicals (HAZCHEM). A chemical industry that incorporates the best principles of safety can largely prevent such incidents. Common causes for chemical accidents are deficiencies in safety management systems and human errors, or they may occur as a consequence of natural calamities or sabotage activities. Chemical accidents result in fire, explosion and/or toxic release.

The nature of chemical agents and their concentration during exposure ultimately decides the toxicity and damaging effects on living organisms in the form of symptoms and signs like irreversible pain, suffering, and death. Meteorological conditions such as wind speed, wind direction, height of inversion layer, stability class, etc., also play an important role by affecting the dispersion pattern of toxic gas clouds.

The Bhopal Gas tragedy of 1984—the worst chemical disaster in history, where over 2000 people died due to the accidental release of the toxic gas Methyl Iso-cyanate, is still fresh in our memories. Such accidents are significant in terms of injuries, pain, suffering, loss of lives, damage to property and environment. A small accident occurring at the local level may be a prior warning signal for an impending disaster. Chemical disasters, though low in frequency, have the potential to cause significant immediate or long-term damage.

Disaster Management is with the guidelines of

1. ON –SITE EMEGENCY PLAN - prepared by the plant
2. OFF-SITE EMERGENCY PLAN- Prepared by DDMA

ON-SITE EMERGENCY: Disaster within the premises of the PLANT / FACTORY describes the action scenarios, complying with a documented Plan, to manage and eliminate the Disaster by the Plant personnel.

OFF-SITE EMERGENCY: Disaster spilled outside the factory premises, describes the action scenarios, complying with a documented plan to manage and eliminate the disaster, by both the plant personnel and District Disaster Management Authorities. This plan will be prepared by DDMA seeking the details from plant authorities.

Glossary

Terms and Interpretations:

Disaster: "means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or man-made causes, or by accident or negligence which results in substantial loss of life & sufferings **or** damage & destruction of property, **or** damage & degradation of environmental systems, and is of such a magnitude as to be, beyond the coping capacity of the community of the affected area";

Management: "means a group of employees unifying to mitigate the undesirable effects of a disaster, controlling and eliminating its effects fully to bring back to erstwhile normal operating conditions."

Emergency: "an undesirable state of events of loss, beyond the coping capacity of the designated operating personnel of the plant".

Plan: "means set of activities laid in series, arrangements made in advance with internal trained personnel & external agencies, to perform them in a systematic way to mitigate, control and eliminate an emergency"

On-Site Emergency: "means an EMERGENCY SITUATION – Radiation, Toxicity, impact on environment, confined to the plant premises" to cause loss.

Off-Site Emergency: "means an adverse emergency situation- radiation, toxicity, impact on environment, spilling outside the plant premises to cause loss.

Loss: "means - ill health to people, destruction to property, stoppage of plant operations, forced layoff to employees, increased debt burden of loans on purchase of plant & machinery, good will loss, loss of employee's confidence level, impact on environmental systems which supports life in the area. (Loss of greenery, loss of cattle, and loss of aquatic life, land and water pollution and …….)

Emergency Control Room: "means designated room for the "incident controller" to perform his role on mitigating, controlling, eliminating the emergency and bring the plant back to normal working environment."

Incident Controller (IC): "means a designated person, vested with overall responsibility & authority to mitigate, control and eliminate emergency and put the plant in normal working condition. "it includes controlling the entire operations as a team leader and reporting to top management/ owners of the plant. normally this position is given to the plant coo or no.1 position holder of the plant.

Accident Site Controller (ASC): "means a designated person, vested with overall responsibility to mitigate, control and eliminate emergency from the designated site / sites inside the plant premises. He mitigates, controls, and eliminates the actual accident which has later become an emergency. (Engineering team, Rescue & Relief team, Fire fighting team, and other miscellaneous services will report to him.)". Normally this position is held by concerned plant head.

Rescue & Relief Head (RRH): "means a designated person, who will perform rescue operations, take relief measures to the injured, co-ordinates with liaison officer. rescue operations in the entire plant being a big operation he will have a fairly big team to perform this operation." this position is given to the head - civil department.

Engineering Head (EH): "means a designated person, who will advice operations to save damages to plant & machinery, operations to mitigate and control processes, performs safe shutdown operations, safely operating the utility services (electricity, instrument air, various water systems, waste water systems,). this position is given to the head - maintenance (mechanical, utility, electrical & instrumentation).

Laision Head (LH): "means a person authorized by incident controller for coordinating the external resources & services. he interacts with incident controller, and communicates to mainly district disaster management authorities. he receives the requirements from ic, analyses and coveys the same to his spokesperson, who in turn, contacts the concerned external agency, and gets the required external resources sought."

Spokes Person: "means a person authorized by laision head to contact and arrange for external resources / help (like district administration-collector, commissioner of police, commissioner of labor, factory inspectorate, health inspector, fire brigade head, local panchayat head, district transport officer……etc").

Key Emergency Personnel: "means employees, who take responsibilities and take positions to mitigate, control and eliminate emergency. they report to their respective team heads. during the entire course of emergency these personnel will be inside the plant to perform above operations. they will note down the real performance of operations carried out, analyze the gaps in the performance and discuss the same in the post emergency feedback meeting."

Non-Emergency Personnel: "means employees, visitors, contractors and other outsiders required to be evacuated from the factory premises on "declaration of emergency".

Safety Materials: "means additional materials, tools, PPEs and appliances required for use during EMERGENCY operations by the persons inside the factory." Also the additional safety materials required to be provided to district administration in the event of an OFF SITE EMERGENCY".

Emergency Plan: "means an authorized document (preconceived, discussed and agreed methodology of operations and responsibilities) having clear cut action scenarios without aberrations, to be performed by key emergency personnel, during MOCK DRILLS or REAL EMERGENCY situations."

Site Plan: "means a print copy of the layout of the plant / factory displaying the locations of different buildings, facilities, storage locations, roads, referred for easy communication and action during emergency.

Area Plan: "means plan showing the area e.g., jolwa industrial area to scale. useful for assessing the affected area in the event of an off-site emergency and preparations for evacuation of people till the emergency is over.

Toxicity: "means - Toxicity is, the degree to which a substance can damage an organism. Three types of toxicity are 1. CHEMICAL, 2. BIOLOGICAL, 3. PHYSICAL. The entry routes for damage of the organism are 1. INHALATION, 2. INGESTION, 3. SKIN ABSORPTION. Isolation from the source of origination is the effective way of safe guard. The degree of toxicity is given by the Threshold Limit Value (TLV), Immediate Danger to Life & Health (IDLH).

Flammability: "means- Flammability is, as how easily matter will burn or ignite, causing FIRE or COMBUSTION." The degree of flammability is determined by the explosion limits of the hazardous chemical, and its quantity & calorific value determines the "thermal radiation flux" liberated on combustion.

Spot Fire: "means fire liberated from a point or line opening of a container due to leakage of a flammable gas."

Flash Point/ Fire Point: - "the flash point of a volatile liquid is the lowest temperature at which it can vaporize to form an ignitable mixture in air". The fire point, a higher temperature, is defined as the temperature at which the vapor continues to burn after being ignited.

Threshold Limit Value: "means -The threshold limit value (TLV) of a chemical substance, is a level to which it is believed, a worker can be exposed day after day, for a working lifetime without adverse health effects.” It is expressed in ppm or mg/kg of body weight.

Threshold Quantity: “means the highest quantity of a hazchem (in m^3 or mt) of liquid or solid stored in a manufacturing unit storage area (in one or more vessels) at any point of time throughout the year, above which certain regulatory compliances are required.

Scenario: “means the mathematically arrived “virtual physical effects” of an accident, for the input conditions given.” It is presented in the form of a x-y graph.

Dispersion: “means the spread of any flammable combustible vapor or toxic cloud of vapor, in the atmosphere for a given set of wind speed and atmospheric stability conditions.”

Dispersion Foot Prints: “means graphical mapping of the dispersion clouds in the x-y-z coordinates with respect to distance traveled and over a said period of time.

Thermal Radiation Flux: “means the amount of thermal energy released by a flammable cloud of vapor in the atmosphere on a unit area, and its radiation effects, at a particular distance in the hazardous zone.

Safe Zone: “means a safe limit of toxic vapor cloud existing in an area where there is no damage to human beings or environment when they live in a free exposed condition for an hour or more. “means a safe limit of thermal radiation flux existing in an area, where there is no damage to human beings or environment when they live in a free exposed condition.”

Emergency Siren: “means a siren with a blowing range of 1 km radius, all around the source, and capable of giving long and short variances sound for a period of minimum 3 minutes.”

All Clear Siren: “means a siren with a blowing range of 1km radius, all around the source, and capable of giving a continuous non-variant sound for 5 minutes.”

Organization set Up Plan:

1. Approved ON-SITE, OFF-SITE EMERGENCY plans shall be available with OH&S Head.
2. All plant personnel have to be trained on the Emergency Plans.
3. Rescue members have to be additionally trained as per the TEAM responsibility.
4. Mock drills have to be performed once in every 6 Months. The drills shall be witnessed by DISH officials OR Senior management members of same group of Industries. The EXTERNAL OBSERVERS concept in MOCKDRILLS will improve the quality of drills.
5. All the improvements suggested in the Mock Drills have to be implemented through a MOM.

6. The reports of MOCKDRILLS have to be sent to DISH officials as a record.
7. A list of Risk Scenarios has to be identified and listed for performing the Mock Drills at periodic intervals.

Teams Fitment Plan

Sr. No.	Team	Team Leaders
1	Incident Controller	Senior Management Person
2	accident Site Controller	in Charge of Accident plant Sr. Supervisor /Chemist (II shift & III shift)
3	Liaison HEAD	HOD -HR
4	Engineering Team	Senior Management Personnel from projects, design , maintenance
5	Rescue & Relief Team	Senior Management Personnel from personnel, accounts
6	Fire Team	Safety Personnel
7	Medical Team	OHC Personnel
8	Security Team	Security Officers Security Guards

Responsibilities of Key Emergency Personnel - Teams

Incident Controller – Responsibilities

- The head of the PLANT will be normally the Incident Controller(IC). Ensures the emergency is properly dealt with, eliminated and normal operating conditions are restored as soon as possible.
- Ensures all the managers and officers of the plant are included as "key emergency personnel."
- Ensures the On-site Emergency Plan is prepared, and general training is given to all the employees of the plant. On-site Emergency Plan is submitted to Department of Industrial safety & Health for review.
- Ensures Mock drills (Virtual Emergency) are conducted quarterly in different shifts as per the provisions of On-Site Emergency plan.
- Ensures one or two District disaster management Authority (DDMA) personnel are invited to participate in the mock-drills.
- Ensures On-Site Emergency Plan is revised, based on the Mock-drill feed backs, till he is satisfied, that the plan is acceptable to all key emergency personnel.
- To officiate a person responsible to co-ordinate with District Disaster Management Authorities to prepare OFF-SITE EMERGENCY PLAN for the plant. The LIASION HEAD may be the appropriate person for the same.
- Ensure the firefighting system, safety materials required for use during real emergency, and first-aid medical facilities, are in order by review of documents, inspections and trials.

- Ensures to name the alternate key emergency personnel IC, ASC, LH, EH, RRH in case the emergency is reported after general shift hours. The key emergency personnel will take positions as soon as possible and replace the alternate team. (Mock drills conducted in II & III shifts will give necessary guidance to select the personnel)

On Declaration of Real Emergency

- Soon after hearing the emergency from the Main gate security or SMS – Emergency, incident controller rushes to ecc.
- He takes control on all operations to deal with the emergency from ecc.
- He ensures all the team leaders are in their respective positions of operation, soon after ordering to blow the emergency siren.
- On the advices of asc, lh, eh, rrh analyzes the actual situation at periodic intervals and declares off-site emergency if required.
- He ensures through liaison head, external emergency services are informed and called for help in time.
- Take periodic rounds to provide guidance and help to team leaders for effectively discharging their duties. notes down the short comings in the operations.
- Once the risk is eliminated completely as declared by accident site controller, he orders to blow "all clear siren".
- He calls a feedback meeting at ecc. all the key emergency personnel are to attend the meeting and participate in the deliberations.
- He co-ordinaries with department heads to normalize the plant for regular production activities and support services.

Accident Site Controller - Responsibilities

- Coordinates with ENGG TEAM, FIRE TEAM, RESCUE &RELIEF TEAM to mitigate emergency conditions'
- Ensures to finally eliminate the Emergency condition completely inside the plant.
- Ensures after eliminating emergency the area/s worked, are kept clean for normal operations.
- Ensures the required number of teams and personnel are kept ready for eliminating the emergency.
- Ensures all required materials, equipment and resources are available for eliminating the emergency. Is requested and brought in time.
- Ensures right information is given to IC at periodic intervals.

On Declaration of Real Emergency

- Soon after hearing the emergency siren or SMS Emergency, accident site controller rushes and takes control of the site inside the plant, which created an emergency situation.
- He assesses the risk, computes the requirements of teams, the requirement of key emergency personnel for each team, requirement of reserve teams in case the risk spreads, and orders them to take their positions.

- He assesses the complete scenario, and decides whether to declare off-site emergency and informs to IC accordingly.
- Ensures all the requirements for fighting the Emergency is available to eliminate the emergency at the shortest possible time.
- Ensures all requirements of external resources are informed in time to liaison team.
- He takes regular rounds and gives necessary guidance and help to teams to deal with emergency.
- He applies strategies, and tries all possible permutations & combinations to limit the emergency as on-site emergency.
- Ensures all the key emergency personnel, are operating strictly complying safety parameters.
- Gives constant feedback on the Emergency situation, and post his requirements to IC.
- He ensures emergency conditions are completely eliminated, areas are cleared, and informs to IC for blowing all clear siren.
- Notes down the short comings in the operations performed for eliminating the emergency, during his rounds.

LIAISON HEAD - RESPONSIBILITIES

- Head – HR department is nominated as Liaison Head.
- Ensures district disaster administration authorities are informed about the declaration of emergency and constantly keeps in touch with them. Informs the actions initiated by district administration officials to IC.
- Ensures local in habitations are well informed and measures taken for their safety.
- Ensures the external resource help is given in time to ASC.
- Ensures the medical assistance for the injured, in nearby Hospitals, and transport for non-emergency personnel movement.
- Ensures constant dialogue with nearby industries and arranges all possible help through district administration.
- Ensures proper gate security is maintained for preventing outside persons unauthorized entry inside the industry.

On Declaration of Real Emergency

- Soon after hearing the emergency siren or SMS Emergency, Liaison Head rushes to main gate.
- Briefly informs the district administration of the Emergency situation and the help required.
- Informs the Fire Brigade for fire tenders and transport department for buses to evacuate the non-emergency employees.
- Informs the nearby industries about the impact and precautions to be taken by them. On request distribute chemical masks for the employees inside factory.

- Takes periodic rounds of the affected areas and studies the situation. Notes down the points of concern of the Egg. Team, Fire mitigation Team, Rescue & Relief teams.
- Asks his spokesperson to meet the nearby village head and brief the actions taken for the safety of the people of that village.
- Keeps the district administration informed about the latest situation and the help required.

Engineering Team- Responsibilities

- Engineering team head is nominated from Maintenance Department.
- Mechanical, Electrical & Instrumentation & Utility Maintenance Head will be the team leaders.
- Ensures the Plant & Machinery inside the plant are protected from damages.
- Isolates EB power and takes essential operations on standby power.
- Ensures the plant with minimum required illumination to carryout emergency operations.
- Ensures the systematic stoppage of plant and machinery to cause minimum LOSS, and pave way for easy restart conditions.
- Ensures isolation of systems which can otherwise raise the risk level of emergency.
- Ensures the semi-finished products on the process line are protected from unwanted reactions and prevent it from becoming a waste.
- Ensures all the machines are in shut- off condition.
- Ensures the unaffected storage locations are well protected, using the built in safety protection systems.

On Declaration of Real Emergency

- Soon after hearing the emergency siren or SMS - emergency, Engineering Heads rushes and takes control of his key personnel to deal with the conditions of emergency.
- Associates with the site controller wherever he demands help in controlling the emergency.
- Isolates EB power and takes the unit on standby power.
- Provides minimum illumination required for the control of emergency operations throughout the plant.
- Puts off all running equipment and shuts off the continuous process plant following emergency shut-down procedures.
- Ensures unwanted chemicals are drained off the reactor vessels, heat exchangers and other systems as the plant demands.
- Keeps the waste water treatment plant running to clear off the excess load on the system?
- In the Tank storage farms take appropriate actions like – draining the Hazchem in the dyke, transferring from one vessel to another standby vessel, additional cooling arrangements of the equipment wherever required.

Rescue and Relief Team – Responsibilities

- On receiving information from SMS emergency rushes to accident site and coordinates activities with ASC.
- Group the team members and inform all non-emergency personnel to assemble at assembly points (Assembly points are located near main security gate).
- Subdivide the group and perform intensive search operation at all location to find out the injured.
- Make arrangements to transport to injured on stretcher to the medical team stationed at medical center.
- Search for the missing person given in the list by LH. Give periodic feedback to ASC.

On Declaration of Real Emergency

- Soon after hearing the emergency siren or SMS - emergency, Rescue and Relief Team Head rushes to accident site.
- Associates with the accident site controller wherever he demands help in controlling the emergency.
- Makes arrangements to search employees, contract persons and visitors missing in the HEAD COUNT.
- Search teams go all around the plant to search for the missing persons in the head count.

Fire Team – Responsibilities

- Fire Team head is nominated from Safety Department.
- Fire Team consists of Key emergency personnel from safety Department, First aid centre, process department and security departments.
- He ensures all electrical systems are isolated except emergency lighting systems.
- He ensures all the fuel /heating systems are isolated from both the ends of flow.
- He ensures required numbers of fire mitigation equipment are fully operational.
- He ensures all fire fighting persons are performing the operations safe.
- He ensures all external help required is informed to ASC in time.
- He ensures the water resources are fully operational.
- He ensures smooth co-ordination with external Fire Mitigation Agencies.

On Declaration of real Emergency

1. Soon after hearing the emergency siren or SMS Emergency FIRE Team Head rushes to Accident site and takes Instructions from ASC.
2. He plans with ASC and EH to isolate systems prior to start of fire extinguishing operations.
3. He takes note of wind direction and proper ventilation systems prior to start of fire-fighting.
4. He ensures the required number of fire-fighting teams is kept for fire-fighting and preventing fire spreading.

5. He ensures appropriate extinguishing systems are optimally used for controlling the situation.
6. He ensures wherever inert gases are used for controlling the fire, safe systems of operations are adopted.
7. He ensures personal safety is given utmost importance.
8. After ensuring complete extinguishment reports to ASC.
9. He ensures complete cleanup operations are performed prior to allowing persons for inspection.

Security Team – Responsibilities

Security Team head is nominated from Security Department.

- Security Team reports to Liaison Head. It is divided into three divisions
  a) Gate security Team
  b) Team to associate fire team
  c) Team to perform inside factory security and cordoning operations.
- He ensures overall assistance is given to all teams.
- He ensures non-emergency persons are guided to Assembly points.
- He ensures traffic regulation inside the plant is done to the requirement.
- He ensures gate security team protects all inside plant persons. Records the in time of key emergency personnel.
- Stops all persons/ vehicular movements as soon as Emergency Call is received.
- Allows DDMA vehicles, emergency service vehicles and guides them properly.
- He ensures all instructions given by Liaison Head are strictly followed.

On Declaration of Real Emergency

a. Soon after hearing the emergency call OR SMS-emergency, Security Team Head rushes and takes Instructions from LH.
b. He plans his persons for various operations and assigns a security supervisor for the same.
c. He takes note of wind direction and guides the persons to Assembly point/s.
d. He controls the gate operations and records the movement of vehicles and persons after the declaration of emergency.
e. He interacts with LH and performs his instructions.

Medical Team – Responsibilities

- Medical Team head is nominated from OHS Department.
- He ensures the ambulance and one male nurse is kept in the accident site.
- Ensures CPR is given to unconscious persons in the accident site.
- Depending on the requirement requests LH for additional ambulances.
- He ensures proper prearrangements are done at nearby hospitals for treatment of injured.
- Keeps records of injured persons and monitor the progress of injured regularly.

On Declaration of Real Emergency

a. Soon after hearing the emergency call OR SMS - emergency, Medical Team Head rushes and takes Instructions from LH.
b. He will be stationed in OHS center and monitor the medical needs of the injured.
c. He will ensure the required medicine, fire blankets, first aid boxes, and other essentials are kept ready for the injured persons.
d. One additional ambulance will always be kept at OHC depending on the emergency conditions.
e. He will have constant interactions with LH on the medical treatment to injured persons.

Communication System

Communication will be exchanged mainly from team to team or person to person using

- Mobile cell phones, Group SMS for Key emergency personnel.
- Land line phones wherever available.
- Designated intercom cell phones.
- Public Address system installed in offices & Plants.

First - Incident Information:

The first incident information about, informing an incident/accident will be given by an employee, who has seen the incident. He will give the information to the main Security Main Gate/ Fire Room, giving his identity in full.

The security officer on duty/ Safety Person on duty, who receives the information informs to their Heads. Both the fire team lead by safety supervisor/ security persons will rush to incident site immediately for mitigating the emergency. The Head of Safety/Security passes information by flashing SMS message (Template) to all the KEY EMERGENCY PERSONNEL by group SMS using Mobile Cell phone. For easy sending, each group is recommended to have 10 persons. The person informed is requested to REPLY positively.

By this system all the Key members of the emergency will be officially informed about the emergency. Their replies will confirm their receipt. The replies shall be as concise as 'YES'.

Emergency Siren

Emergency 'on' Siren:

Fire mode / Toxic Mode 0-0-0-0-0-0-0-0 Wailing Siren

(10 sec) (5 sec) (10 sec) (5 sec)…UP-Down-UP-Down - for Three Minutes All Clear Siren:

Continuous Siren for 5 Minutes

Emergency Control Centre (ECC)

ECC will be occupied by Incident Controller... It will have provisions to sit for five persons, a conference room to house 15 persons, and a store to accommodate safety materials storage required during Emergency. The following documents, (latest revisions) will be kept in the emergency Control Center, for immediate reference and use, in the event of an Emergency. A key will be kept with IC.

Reference Documents

1. On-site Emergency Plan – 5 copies
2. Off-site Emergency Plan – 5 copies
3. Plant - site plan - 5 copies
4. MSDS of all HAZCHEMS – Each chemical.
5. Short note books -25 no's
6. Ball pens, Pencils, erasers, sharpeners -25+10 + 10+ 2 no's
7. Digital Cameras – 2 no's
8. Laptops – 2 no's network connected.

List of Safety Materials

1.	Self-Contained Breathing Apparatus- 10kg	- 10 no's
2.	Full Face masks	- 25 no's
3.	Trolley mounted oxygen cylinders	- 05 no's
4.	Full body chemical protection suits	- 10 no's
5.	Chemical splash proof goggles	- 50 no's
6.	Aluminized fire fighting suits	- 10 no's
7.	25mm hose clips with screw clips	- 10 no's
8.	Gum boots full length	- 25 pairs
9.	Leather hand gloves	- 50 pairs
10.	Electrical hand gloves	- 05 pairs
11.	Non permeable hand gloves	- 25pairs
12.	Safety helmets	- 50 no's
13.	Safety shoes sizes	- 60 pairs
14.	Pick axles	- 02 no's
15.	Shovels	- 05 no's
16.	Rain coats full size	- 10 no's
17.	Stretchers	- 02 no's

First- aid Medical Services

First –Aid service center is available in the Main gate of plant. There is a doctor and qualified medical nurses. They will be assisted by trained first aiders where- ever there is an urgent need. Medical examinations are out sourced, and reports are maintained by the HR department. EHS manager has a formal agreement, with "Full-fledged hospitals" in the nearby area of the plant, for immediate admission and treatment to the injured.

Assembly Point/s

Assembly point is the place, where the non-emergency employees are assembled for a head count. Later they are kept at the same place OR shifted to a safer place on the advice of IC. Two assembly points are planned.

Assembly point is located inside the site of the plant. Normally assembly points are away from the bulk storage locations, near to the plant main security gate, and located in upward side of the predominant wind direction. The wind sock is installed, for instantly knowing the current wind direction, is located on the top of the plant building, and is clearly seen from the assembly points.
FIRST ASSEMBLY POINT: Near ADMIN building
SECOND ASSEMBLY POINT: Near the MAIN GATE.

Fire Fighting built in Facilities

- Fire hydrant system – Fire water storage, Fire Pump, Jockey pump, PP Power / DG Power, Fire Room, systems to control water supply and power.
- Hydrant Pipes, Risers, Spray Nozzles, control gate valves, Hydrant boxes, Hydrant control valves.
- DCP, CO_2, FOAM portable fire extinguishers of different capacity.
- Water and Foam Fire Tender stationed at CP.

Pollution Control

- The water used for firefighting will be diverted to ETP
- The wastes collected at the site of accident will be sent to waste yard in designated packages. EHS environment department will do the necessary formalities for its disposal.

Wind Socks

- Wind socks are installed on buildings to instantly catch up the wind direction. the sock flying indicates the downwind direction.
- Four wind shocks are installed. one at the top of the ceo building second solvent-2. third on the RM stores fourth on admin building.

Rescue Teams.

- The positions of rescue team members are created in all plants, departments and service centers. They are given a RED HELMET for east identification. They are being trained in different aspects of activities involving emergencies. They are from workers, operators, supervisors and chemists. They are well distributed in the shifts so that their availability is felt, round the clock.
- On hearing the emergency siren, the RESCUE team members (Respective shift) are requested to rush to the emergency site location and assemble at the Ground floor. Information will be given about their arrival to accident site controller.
- They will form the team members for performing necessary activities as per the directions of their respective team leaders.
- Both during accidents and big events like emergencies they will be fully utilized.

7.8 Occupational Health and Safety Program- mitigating measures.

Health hazards associated with the occupation are called occupational hazards. In chemical industry due to handling of toxic and hazardous chemicals there are possibilities of developing occupational diseases. The manufacturing process does not involve hazardous chemicals of high health effects.

These diseases are caused due to

Acute exposure of chemical fume Chronic effects of exposure of chemical fumes M/s. Hikal, has planned for the following checks to curb the problem:

- Pre - employment medical checkup at the time of employment.
- Annual medical check must be done for all employees.
    - <30 years - Once in five years
    - 31-40 years - Once in four years
    - 41-50 years - Once in two years
    - >50 years once every year.

i. Occupational Health center for rendering immediate first aid prior to sending to nearby hospitals. First aid training must be given to “a section” of employees.

ii. Monitoring of occupational hazards like noise, ventilation, chemical exposure shall be carried out at frequent intervals, the records of which shall be documented.

iii. Suitable PPEs have to be provided and application enforced. All the PPEs procured are of BIS approved products. Work place enforcement of wearing is done regularly. The same will be followed in the extension unit also.

iv. All the hazardous chemicals are to be identified by the hazchem visuals. All the workmen have to be properly trained.

v. Evaluation of health of workers viz. chest x ray, Audiometry, Spirometry Vision testing (Far and Near vision, color vision and any other ocular defect) ECG, during pre-employment and periodical examinations must be carried out.

vi. The injuries record and the gas effect record shall be maintained for assessing the controls at the workplace monitoring.

7.8.1 Occupational Health center. (OHC)

- The OHC shall be maintained and controlled by qualified medical team consisting of doctors, nurses and other Para medical staff.
- The OHC shall be maintained for 24x7 – 365 days operation.
- All the available antidotes as available, shall be maintained by the OHC personnel.
- A fully loaded ambulance shall be maintained for carrying persons to nearby Hospitals.
- The safety officer shall maintain the legal requirement records in the prescribed formats as called in different laws.
- Symptomatic treatment is given to the persons affected by chemicals by the authorized Medical Practitioner.
- HSE monthly reports have to be maintained.

7.8.2 HSE Organization.

The systems to be maintained by HSE department shall be taken from BIS 14489 1998. There shall be appropriate staff qualified as per the requirement of law, has to be maintained in the HSE department.

Periodic reports shall be sent to director of industrial safety &health (dish) authorities as specified in the law books.

The Inspection book remarks made by the Factory Inspector shall be fully complied and records maintained.

7.8.3 DOS &DON'TS to be Followed.

- All the machines are to undergo Preventive Maintenance latest by once in a year. Productive maintenance rounds (Daily visual rounds) have to be undertaken periodically to assess the healthiness of the machines. Records to be maintained.
- For critical machines: All fasteners, gaskets, oil rings, lubricating oils, plastic parts, hose pipes etc., have to be changed at the time of maintenance.
- All load bearing members of the machine parts have to be thoroughly cleaned and visually inspected for any cracks and other defects.
- All the PPEs procured shall conform to BIS or other equivalent standards.
- Use of PPEs in the form of visuals has to be displayed at appropriate places.
- All Hygiene practices are to be followed, restrictions for entry to specified places have to be displayed.
- Emergency escape routes and exit points have to be vividly displayed.
- Near- miss inspections have to be carried out, discussed with area owners and hazards to be mitigated.
- Ammonia used in the chilling plants have to be suitably disposed, when there is leakage.
- REUSE, RECYCLE, RECOVERY of chemicals and liquids shall be devised and practiced.
- All hazardous wastes in the form of solids and liquids shall be disposed off as per the stipulated regulations.
- EMERGENCY mitigation equipment locations and routing has to be displayed at prominent locations.
- Pressure and temperature parameters have to be monitored and records maintained wherever called for.
- All cooling arrangements for controlling temperatures shall have standby arrangements.
- All continuous processing facilities shall have power backup facility.
- Emergency lighting system shall be available during emergencies.