Risk Assessment Document

7 ADDITIONAL STUDIES

7.1 PUBLIC CONSULTATION

Petroleum, Chemical and Petro-chemical Investment Region (PCPIR) at Dahej, Vagra, District-Bharuch, by M/s. Gujarat Industrial Development Corporation. (F. No. 21-49/2010-IA-III) received Environmental/CRZ clearance dated 14th September, 2017, so public hearing will not be required for M/s. Radhamadhav Processers Private Limited as it is located in at Plot No. D-2/CH/576, GIDC, Dahej II, Taluka- Vagra, District- Bharuch.

7.2 Risk Assessment

7.2.1 Background

Key issues in Risk Assessment (RA) of the proposed manufacturing activities are discussed in this chapter. The risk assessment process is intended to identify probable hazards in the work environment and all operations, to quantify the hazards and to assess the risk levels of those hazards in order to prioritize those that need an immediate attention.

In the unlikely event that an abnormal consequence has occurred, the disaster management kicks in. This includes prescribing the procedures pertaining to a number of issues such as communication, encounter, rescue, rehabilitation and further steps to prevent recurrence of such consequence in future. These issues are addressed in the disaster management plan.

Both, the RA and DMP are living documents and need to be updated whenever there are changes in operations, equipment or procedures.

7.2.2 Key Definitions

The terminologies used in this Risk Assessment (RA) study are defined below.

Consequence: Magnitude or size of the damage or loss. In terms of health and safety, it is the degree of harm that could be caused to the people exposed to hazard, the potential severity of injuries or ill health, and/or the number of people who could be potentially affected. Consequence of hazard need not only be in terms of human safety criteria, but could also be in terms of a financial loss due to production and incurred costs due to repairs/replacement, environmental impacts as well as public outrage.

Disaster: A catastrophic consequence of a major emergency/accident that leads to not only extensive damage to life and property, but also disrupts all normal human activity for a significant period of time and requires a major national and/or international effort for rescue and rehabilitation of those affected.

Emergency: A situation of process deviation that, if uncontrolled, may lead to a major accident/disaster with potential short term and/or long term risk damage consequence to life and property in and/or around the workplace.

Emergency Response Planning Guidelines1 (EPRG1): The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour (without a

respirator) without experiencing other than mild transient adverse health effects or without perceiving a clearly defined objectionable odour.

Emergency Response Planning Guidelines2 (ERPG2): 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 that could impair their abilities to take protective action.

Emergency Response Planning Guidelines3 (ERPG3): The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

Hazard: Source of potential harm, injury or loss to man and machines.

Immediately Dangerous to life and health (IDLH): It represents the maximum concentration of a chemical from which, in the event of respiratory failure, one could escape within 30 minutes without a respirator and without experiencing any escape/impairing (e.g. severe irritation) or irreversible health effects.

Lethal Concentration Low (LCLo): It is the lowest concentration of a material in air, other than LC50, which has been reported to cause death in human or animals.

Risk: Combination of the likelihood of a specific unwanted event and theseverity of potential consequences, if it occurs.

Risk Assessment: A process that involves estimation and measurement of risk to determine priorities and to enable identification of appropriate level of risk treatment (used also to describe the overall process of risk management).

Risk Control: Implementation of strategies to prevent, control and minimize hazards.

Risk Management: Overall description of the steps taken to manage risk, by identifying hazards and implementing controls in the workplace.

Risk Rating: The category, level, or risk assigned following risk assessment (e.g. High, Medium, or Low).

Threshold Limit Value (TLV): it is the permitted level of exposure for a given period on a weighted average basis (usually 8 hrs for 5 days in a week)

Short Time Exposure Limit (STEL): it is the permitted short-term exposure limit usually for a 15 minutes exposure.

Toxic Concentration Low (TCLo): It is the lowest concentration of a material in air, to which humans or animals have been exposed for any given period of time that has produced a toxic effects in humans or produced carcinogenic, neoplastigenic or tetratogenic effect in humans or animals.

7.2.3 Methodology for Risk Assessment

The methodology includes,

- Hazard identification,
- Selection of potential loss scenarios,
- Simulation of release source model on DNV's PHAST 7.0,
- Plotting the damage contour on site map

These steps undertaken to carry out risk assessment for this project are described in following sections.

7.2.4 Hazard Identification

The project description, and other project related data provided by the client have been comprehensively reviewed to identify the hazardous operations. Also the information on the hazardous properties (MSDS) of all the chemicals handled at the site has been reviewed to identify the hazards associated with the same.

At present Radha Madhav is going to set up a Greenfield Project of Chlorinated and Hydrogenated Derivatives for Agro Intermediates plant manufacturing unit of 11,000 MTM. This involves storage of some of the raw material at the site which can lead to uncontrolled release of hazardous material causing hazard. On the basis of this, the important hazards that can lead to accident in the proposed project are described in ***Table 7-1.***

Table 7-1: Important Hazardous Events

Type of Event	Explanation
BLEVE	Boiling Liquid Evaporating Vapor Explosion; may happen due to catastrophic failure of refrigerated or pressurized gases or liquids stored above their boiling points, followed by early ignition of the same, typically leading to a fire ball
Deflagration	Is the same as detonation but with reaction occurring at less than sonic velocity and initiation of the reaction at lower energy levels
Detonation	A propagating chemical reaction of a substance in which the reaction front advances in the unreacted substance at or greater than sonic velocity in the unreacted material
Explosion	A release of large amount of energy that form a blast wave
Fire	Fire
Fireball	The burning of a flammable gas cloud on being immediately ignited at the edge before forming a flammable/explosive mixture.
Flash Fire	A flammable gas release gets ignited at the farthest edge resulting in flash-back fire
Jet Fire	A jet fire occurs when flammable gas releases from the pipeline (or hole) and the released gas ignites immediately. Damage distance depends on the operating pressure and the diameter of the hole or opening flow rate.
Pool Fire	Pool fire is a turbulent diffusion fire burning above a horizontal pool of vaporizing hydrocarbon fuel, where the fuel has zero or low initial momentum
Spill Release	'Loss of containment'. Release of fluid or gas to the surroundings from unit's own equipment / tanks causing (potential) pollution and / or risk of explosion and / or fire
Structural Damage	Breakage or fatigue failures (mostly failures caused by weather but not necessarily) of structural support and direct structural failures
Vapor Cloud Explosion	Explosion resulting from vapor clouds formed from flashing liquids or non-flashing liquids and gases

Hazard and Damage Assessment

Toxic, flammable and explosive substances released from sources of storage as a result of failures or catastrophes, can cause losses in the surrounding area in the form of:

- Toxic gas dispersion, resulting in toxic levels in ambient air,
- Fires, fireballs, and flash back fires, resulting in a heat wave (radiation), or
- Explosions (Vapours Cloud Explosions) resulting in blast waves (overpressure).

Consequences of Fire/Heat Wave

The effect of thermal radiation on people is mainly a function of intensity of radiation and exposure time. The effect is expressed in term of the probability of death and different degree of burn. The consequence effects studied to assess the impact of the events on the receptors are provided in ***Table 7-2.***

Table 7-2 : Damage due to Radiation Intensity

Radiation (kW/m^2)	Damage to Equipment	Damage to People
4.0	-	Causes pain if duration is longer than 20 sec. But blistering is unlikely.
12.5	Minimum energy to ignite wood with a flame; melts plastic tubing.	1% lethality in one minute. First degree burns in 10 sec.
37.5	Severe damage to plant	100% lethality in 1 min. 50% lethality in 20 sec. 1% lethality in 10 sec.

Consequences of Overpressure

The effects of the shock wave vary depending on the characteristics of the material, the quantity involved and the degree of confinement of the vapor cloud. The peak pressures in an explosion therefore vary between a slight over-pressure and a few hundred kilopascals (kPa). Whereas dwelling are demolished and windows and doors broken at overpressures as low as 0.03- 0.1 bar. Direct injury to people occurs at greater pressures. The pressure of the shock wave decreases rapidly with the increase in distance from the source of the explosion. The overpressure damage is shown in ***Table 7-3.***

Table 7-3: Overpressure Damage

Overpressure (bar)	Damage
0.02068	Limited minor structural damage
0.068 to 0.136	Corrugated asbestos shattered; corrugated steel or aluminum panels, fastenings fail, followed by buckling, wood panels (standard housing) fastenings fail, panels blown in
0.204 to 0.272	Frameless, self -framing steel panel building demolished; rupture of oil storage tanks

Source: CCPS Consequence Analysis of Chemical Release

Consequences of Toxic Release

The effect of exposure to toxic substance depends upon the duration of exposure and the concentration of the toxic substance.

Short-term exposures to high concentration give Acute Effects while long term exposures to low concentrations result in Chronic Effects.

Only acute effects are considered under hazard analysis, since they are likely credible scenarios. These effects are:

- Irritation (respiratory system, skin, eyes)
- Narcosis (nervous system)
- Asphyxiation (oxygen deficiency)

- System damage (blood organs)

7.2.5 Selection of Maximum Credible Loss Scenarios (MCLs')

Following important points should be considered for the selection of release scenarios.

- Flammability and the flash point of the material
- Phase of material i.e. liquid or gas
- Threshold quantity of the chemicals as prescribed in MSHIC Rule
- Operating temperature and pressure of the material
- Total inventory of the material

On the basis of study of chemical properties (MSDS) of the chemicals those are selected for simulation are presented ***Table 7-4.***

Table 7-4: Storage Details of Hazardous Material

S. No.	Containment (Vessel)	Flash Point (°C)	IDLH (PPM)	Max. Storage Capacity	No. of Storage Vessels	Total Storage Capacity (MT)	Pressure	Temperature
1	Aniline	70	100	30 KL Tank	2	50 KL	Atmospheric	Ambient
2	Benzene	-11	500	55 KL Tank	4	210 MT	Atmospheric	Ambient
3	Benzyl Chloride	67.2	10	55 KL Tank	4	210 KL	Atmospheric	Ambient
4	Methanol	9	-	30 KL Tank	3	77 MT	Atmospheric	Ambient
5	Ortho Di-Chloro Benzene (ODCB)	66	200	30 KL Tank	3	80 MT	Atmospheric	Ambient
6	Pera Chloro Toluene	53	-	55 KL Tank	4	210 KL	Atmospheric	Ambient
7	Phenol	79	250	0.2 KL drum	760	152 MT	Atmospheric	Ambient
8	Propargyl Chloride	18	-	55 KL Tank	3	150 KL	Atmospheric	Ambient
9	Pyridine	20	1000	5 KL/0.2KL drum	1 tank/2 drum	0.4 KL	Atmospheric	Ambient
10	Toluene	4	500	30 KL Tank	3	90 KL	Atmospheric	Ambient
11	Chlorine	-	10	Pipeline	-	120 MT	Atmospheric	Ambient
12	Hydrogen	-253	-	Pipeline	-	50 KL	Atmospheric	Ambient

On the basis of the information provided in ***Table 7-4,*** and as discussed over failures sceneries given in publications like World Bank Technical Paper 55 and TNO Purple Book and the experience of the consultant, MCLs' which may take place are presented in ***Table 7-5.***

Table 7-5: Scenario Selected for Simulation

S. No.	Containment (Vessel)	Types of Failure Possible	Consequences Studied
1	Aniline	10 mm dia hole leak in tank, 25 mm dia hole leak in tank and Catastrophic Rupture	Jet Fire, Pool Fire & Explosion
2	Benzene	10 mm dia hole leak in tank, 25 mm dia hole leak in tank and Catastrophic Rupture	Jet Fire, Pool Fire & Explosion
3	Benzyl Chloride	10 mm dia hole leak in tank, 25 mm dia hole leak in tank and Catastrophic Rupture	Jet Fire, Pool Fire & Explosion
4	Methanol	10 mm dia hole leak in tank, 25 mm dia hole leak in tank and Catastrophic Rupture	Jet Fire, Pool Fire & Explosion
5	Ortho Di-Chloro Benzene (ODCB)	10 mm dia hole leak in tank, 25 mm dia hole leak in tank and Catastrophic Rupture	Jet Fire, Pool Fire & Explosion
6	Pera Chloro Toluene	10 mm dia hole leak in tank, 25 mm dia hole leak in tank and Catastrophic Rupture	Jet Fire, Pool Fire & Explosion
7	Phenol	10 mm dia hole leak in tank, 25 mm dia hole leak in tank and Catastrophic Rupture	Jet Fire, Pool Fire & Explosion
8	Propargyl Chloride	10 mm dia hole leak in tank, 25 mm dia hole leak in tank and Catastrophic Rupture	Jet Fire, Pool Fire & Explosion
9	Pyridine	10 mm dia hole leak in tank, 25 mm dia hole leak in tank and Catastrophic Rupture	Jet Fire, Pool Fire & Explosion
10	Toluene	10 mm dia hole leak in tank, 25 mm dia hole leak in tank and Catastrophic Rupture	Jet Fire, Pool Fire & Explosion
11	Chlorine	2 mm dia hole leak in tank, 5 mm dia hole leak in tank	Toxic release
12	Hydrogen	10 mm dia hole leak in tank, 25 mm dia hole leak in tank	Jet fire, Late Ignition

Failure Rates

A leak or rupture of a tank, release some or all of its content, can be caused by brittle failure of the tank wall, welds or connected pipework due to use of inadequate materials, combined with loading such as wind, earthquake or impact. Failure rates for selected MCLS' are provided in ***Table 7-6.***

Table 7-6: Failure Frequency for Storage Tanks

Categories	Catastrophic Rupture Frequency (per tank per year)	Leak Frequency (per year)
Refrigerated Storage Tank (Single Wall)	2.3×10^{-5}	1.0×10^{-5}
Refrigerated Storage Tank (Double Walled)	2.5×10^{-8}	1.0×10^{-5} (for primary containment)
Atmospheric Storage Tank	3.0×10^{-6}	2.8×10^{-3}
Pressure Vessels	4.7×10^{-7}	1.2×10^{-5} (for Hole Size 3 to 10 mm)
		7.1×10^{-6} (for Hole Size 10 to 50 mm)

Reference: International Association of Oil & Gas Producers (OGP); Report No. 434-3, March 2010

Also, the risk assessment is considered using certain internationally recognized yardsticks for measuring risk. These first need to be explained, and this is done as ***Table 7-7.***

Table 7-7: Broadly Accepted Frequency

Annual Fatality risk level per year	Conclusion
10^{-3}	Unacceptable to everyone. Immediate action shall be taken to reduce the hazards
10^{-4}	Willing to spend public money to control hazards, such as traffic signs, fire departments etc
10^{-5}	People still recognize. Safety slogans have precautionary rings. Such as never swim alone, never point a gun
10^{-6}	Not of great concern to everyone. People are aware of these hazards but feel that they cannot happen to them. Such as Lightning Never Strikes twice an Act of God.

7.2.6 Simulation of Release and Development of Contours

As the MCLS' were developed for the selected set of chemicals, the next step is to carry out the consequence analysis. The consequence analysis results along with their contours are presented in the following sections.

Aniline

Radiation level and effect distance due to the release of Aniline are presented in ***Table 7-8***and flash fire effect distance are presented in ***Table 7-9*** whereas overpressure effect distance are presented in ***Table 7-10***and distance Equivalent to Toxic Dose due to release of Aniline are given in***Table 7-11.***

The contours for effect distance generated for the release of Aniline are presented in***Figure 7-1***to

Figure 7-4.

Table 7-8: Radiation Level and Effect Distance due to Release of Aniline

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
				4 kW/m²	12.5 kW/m²	37.5 kW/m²
Aniline	10 mm leak	Jet fire	2.5/F	NR	NR	NR
			3.3/D	NR	NR	NR
			5/D	NR	NR	NR
		Late pool fire	2.5/F	82	54	32
			3.3/D	83	55	34
			5/D	82	55	36
	25 mm leak	Jet fire	2.5/F	2	NR	NR
			3.3/D	2	NR	NR
			5/D	2	NR	NR
		Late pool fire	2.5/F	184	119	74
			3.3/D	186	121	78
			5/D	182	120	82
	Catastrophic Rupture	Late pool fire	2.5/F	240	153	95
			3.3/D	243	156	100
			5/D	238	156	105

Table 7-9: Flash Fire Effect Distance due to Release of Aniline

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter	
				0.5 LFL	LFL
Aniline	10 mm leak	Flash Fire	2.5/F	4	4
			3.3/D	4	4
			5/D	4	4
	25 mm leak	Flash Fire	2.5/F	5	5
			3.3/D	5	5
			5/D	5	5
	Catastrophic Rupture	Flash Fire	2.5/F	13	13
			3.3/D	13	13
			5/D	14	14

Table 7-10: Overpressure Effect Distance due to Release of Aniline

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Overpressure Distances in Meters		
				0.02	0.21	1.00
Aniline	Catastrophic rupture	Late Ignition	2.5/F	34	15	12
			3.3/D	34	15	12
			5/D	34	15	12

Table 7-11: Distance Equivalent to Toxic Dose due to Release of Aniline

Chemical (Storage Tank)	Failure Scenario	Met Data	Effective Distance in meter to Toxic Level			
			EPRG 1 (50 ppm)	EPRG 2 (150 ppm)	EPRG 3 (200 ppm)	IDLH (100 ppm)
Aniline	10 mm leak	2.5/F	58	40	36	48
		3.3/D	52	39	34	45
		5/D	32	23	20	27
	25 mm leak	2.5/F	150	104	93	123
		3.3/D	128	101	93	112
		5/D	105	82	78	92
	Catastrophic Rupture	2.5/F	144	30	27	81
		3.3/D	121	100	95	105
		5/D	162	140	130	153

Figure 7-1: Late Pool Fire Risk Consequence Contour due to 10 mm leak in Aniline Storage Tank at Weather Condition 3.3/D

Figure 7-2: Toxic Effect Contour due to 10 mm leak in Aniline Storage Tank at Weather Condition 2.5/F

Figure 7-3: Late Pool Fire Risk Consequence Contour due to 25 mm leak in Aniline Storage Tank at Weather Condition 3.3/D

Figure 7-4: Late explosion effect contour due to 25 mm leak in Anililne storage tank at weather condition 3.3/D

Benzene

Radiation level and effect distance due to the release of Benzene are presented in ***Table 7-12***and flash fire effect distance are presented in ***Table 7-13*** whereas overpressure effect distance are presented in ***Table 7-14.***

The contours for effect distance generated for the release of Benzene are presented in ***Figure 7-5to Figure 7-17.***

Table 7-12: Radiation Level and Effect Distance due to Release of Benzene

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
				4 kW/m²	12.5 kW/m²	37.5 kW/m²
Benzene	10 mm leak	Jet fire	2.5/F	13	10	9
			3.3/D	13	10	8
			5/D	12	9	7
		Late pool fire	2.5/F	45	22	NR
			3.3/D	45	24	13

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
				4 kW/m²	12.5 kW/m²	37.5 kW/m²
			5/D	45	25	13
	25 mm leak	Jet fire	2.5/F	28	22	18
			3.3/D	27	21	18
			5/D	26	20	16
		Late pool fire	2.5/F	71	29	NR
			3.3/D	71	29	NR
			5/D	74	28	NR
	Catastrophic Rupture	Late pool fire	2.5/F	140	61	NR
			3.3/D	147	61	NR
			5/D	154	62	NR

Table 7-13: Flash Fire Effect Distance due to Release of Benzene

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter	
				0.5 LFL	LFL
Benzene	10 mm leak	Flash Fire	2.5/F	30	22
			3.3/D	30	20
			5/D	26	14
	25 mm leak	Flash Fire	2.5/F	58	41
			3.3/D	54	35
			5/D	48	29
	Catastrophic Rupture	Flash Fire	2.5/F	125	87
			3.3/D	150	99
			5/D	142	96

Table 7-14: Overpressure Effect Distance due to Release of Benzene

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Overpressure Distances in Meters		
				0.02	0.21	1.00
Benzene	10 mm leak	Late Ignition	2.5/F	79	40	34
			3.3/D	65	37	33
			5/D	40	24	22
	25 mm leak	Late Ignition	2.5/F	142	68	57
			3.3/D	121	64	56
			5/D	95	51	44
	Catastrophic rupture	Late Ignition	2.5/F	350	152	127
			3.3/D	339	156	145
			5/D	323	148	135

Figure 7-5: Jet Fire Risk Consequence Contour due to 10 mm leak in Benzene Storage Tank at Weather Condition 3.3/D

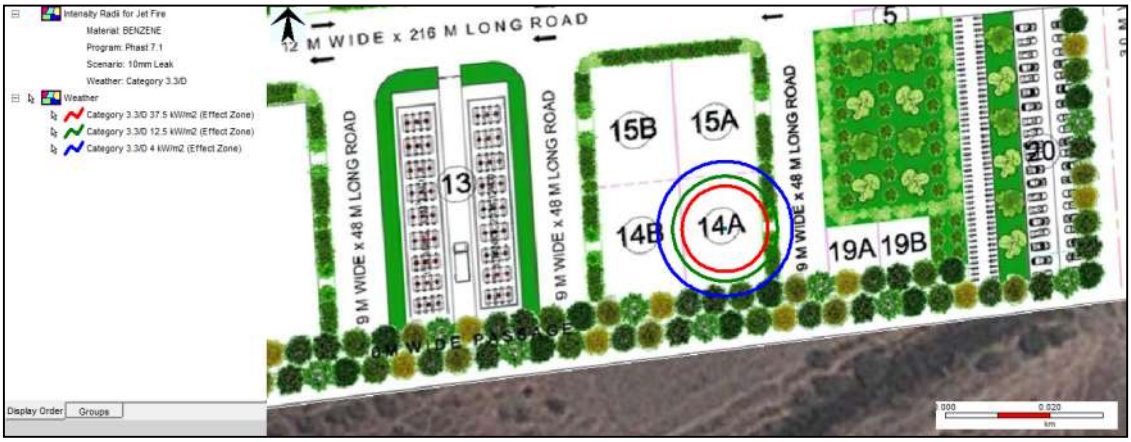

Figure 7-6: Late Pool Fire Risk Consequence Contour due to 10 mm leak in Benzene Storage Tank at Weather Condition 5.0/D

Figure 7-7: Late Explosion Risk Consequence Contour due to 10 mm leak in Benzene Storage Tank at Weather Condition 2.5/F

Figure 7-8: Jet Fire Risk Consequence Contour due to 25 mm leak in Benzene Storage Tank at Weather Condition 2.5/F

Figure 7-9: Late Explosion Risk Consequence Contour due to Catastrophic Rupture of Benzene Storage Tank at Weather Condition 5.0/D

Benzyl Chloride

Radiation level and effect distance due to the release of Benzyl Chloride are presented in ***Table 7-15***and flash fire effect distance are presented in ***Table 7-16***whereas overpressure effect distance are presented in ***Table 7-17***and distance Equivalent to Toxic Dose due to release of Benzyl Chloride are given in***Table 7-18.***

The contours for effect distance generated for the release of Benzyl Chloride are presented in***Figure 7-10 to Figure 7-13.***

Table 7-15: Radiation Level and Effect Distance due to Release of Benzyl Chloride

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
				4 kW/m²	12.5 kW/m²	37.5 kW/m²
Benzyl Chloride	10 mm leak	Jet fire	2.5/F	NR	NR	NR
			3.3/D	NR	NR	NR
			5/D	NR	NR	NR
		Late pool fire	2.5/F	46	22	NR
			3.3/D	48	23	NR
			5/D	49	23	NR
	25 mm leak	Jet fire	2.5/F	4	2	NR
			3.3/D	4	2	NR
			5/D	3	2	NR
		Late pool fire	2.5/F	84	38	NR
			3.3/D	87	39	NR
			5/D	90	39	NR
	Catastrophic Rupture	Late pool fire	2.5/F	134	64	NR
			3.3/D	139	64	NR
			5/D	145	66	NR

Table 7-16: Flash Fire Effect Distance due to Release of Benzyl Chloride

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter	
				0.5 LFL	LFL
Benzyl Chloride	10 mm leak	Flash Fire	2.5/F	4	4
			3.3/D	4	4
			5/D	4	4
	25 mm leak	Flash Fire	2.5/F	7	5
			3.3/D	7	6
			5/D	6	5
	Catastrophic Rupture	Flash Fire	2.5/F	18	18
			3.3/D	18	18
			5/D	19	19

Table 7-17: Overpressure Effect Distance due to Release of Benzyl Chloride

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Overpressure Distances in Meters		
				0.02	0.21	1.00
Benzyl Chloride	Catastrophic rupture	Late Ignition	2.5/F	39	16	12
			3.3/D	40	16	12
			5/D	39	16	12

Table 7-18: Distance Equivalent to Toxic Dose due to Release of Benzyl Chloride

Chemical (Storage Tank)	Failure Scenario	Met Data	Effective Distance in meter to Toxic Level			
			EPRG 1 (1 ppm)	EPRG 2 (10 ppm)	EPRG 3 (50 ppm)	IDLH (10 ppm)
Benzyl Chloride	10 mm leak	2.5/F	967	236	62	384
		3.3/D	337	110	55	156
		5/D	273	86	39	123
	25 mm leak	2.5/F	2701	679	198	1072
		3.3/D	809	246	108	360
		5/D	674	208	93	304
	Catastrophic Rupture	2.5/F	7744	995	35	2064
		3.3/D	2171	294	18	588
		5/D	1645	206	18	415

Figure 7-10: Jet Fire Risk Consequence Contour of Benzyl Chloride due to 25mm leak at Weather Condition 2.5/F

Figure 7-11: Late Pool Fire Risk Consequence Contour of Benzyl Chloride due to 10 mm leak at Weather Condition 5.0/D

Figure 7-12: Late Explosion Risk Consequence Contour of Benzyl Chloride due to Catastrophic Rupture at Weather Condition 5.0/D

Figure 7-13: Toxic Effect Contour of Benzyl Chloride due to 10 mm leak at Weather Condition 2.5/f

Methanol

Radiation level and effect distance due to the release of Methanol are presented in ***Table 7-19***and flash fire effect distance are presented in ***Table 7-20***whereas overpressure effect distance are presented in ***Table 7-21.***

The contours for effect distance generated for the release of Methanol are presented in ***Figure 7-14 to Figure 7-16.***

Table 7-19: Radiation Level and Effect Distance due to Release of Methanol

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
				4 kW/m²	12.5 kW/m²	37.5 kW/m²
Methanol	10 mm leak	Jet fire	2.5/F	14	NR	NR
			3.3/D	13	NR	NR
			5/D	12	10	NR
		Late pool fire	2.5/F	35	24	NR
			3.3/D	34	24	NR
			5/D	34	25	NR

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
				4 kW/m²	12.5 kW/m²	37.5 kW/m²
	25 mm leak	Jet fire	2.5/F	29	23	NR
			3.3/D	28	23	NR
			5/D	26	22	NR
		Late pool fire	2.5/F	80	55	34
			3.3/D	78	54	33
			5/D	76	55	33
	Catastrophic Rupture	Late pool fire	2.5/F	113	77	47
			3.3/D	114	78	46
			5/D	114	81	48

Table 7-20: Flash Fire Effect Distance due to Release of Methanol

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter	
				0.5 LFL	LFL
Methanol	10 mm leak	Flash Fire	2.5/F	19	7
			3.3/D	15	5
			5/D	9	5
	25 mm leak	Flash Fire	2.5/F	30	14
			3.3/D	27	12
			5/D	22	10
	Catastrophic Rupture	Flash Fire	2.5/F	126	38
			3.3/D	61	28
			5/D	69	29

Table 7-21: Overpressure Effect Distance due to Release of Methanol

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Overpressure Distances in Meters		
				0.02	0.21	1.00
Methanol	10 mm leak	Late Ignition	2.5/F	18	12	11
			3.3/D	18	12	11
			5/D	-	-	-
	25 mm leak	Late Ignition	2.5/F	63	37	33
			3.3/D	37	23	21
			5/D	35	23	21
	Catastrophic rupture	Late Ignition	2.5/F	154	62	55
			3.3/D	152	55	46
			5/D	160	54	46

Figure 7-14: Jet Fire Risk Consequence Contour of Methanol due to 10 mm leak at Weather Condition 2.5/F

Figure 7-15: Late Pool Fire Risk Consequence Contour of Methanol due to 25 mm leak at Weather Condition 2.5/F

Figure 7-16: Late Explosion Risk Consequence Contour of Methanol due to Catastrophic Rupture at Weather Condition 5.0/D

O-Dichloro Benzene (ODCB)

Radiation level and effect distance due to the release of ODCB are presented in ***Table 7-22***and flash fire effect distance are presented in ***Table 7-23***whereas overpressure effect distance are presented in ***Table 7-24***and distance Equivalent to Toxic Dose due to release of ODCB are given in***Table 7-25.***

The contours for effect distance generated for the release of ODCB are presented in***Figure 7-17 to Figure 7-20.***

Table 7-22: Radiation Level and Effect Distance due to Release of ODCB

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
				4 kW/m²	12.5 kW/m²	37.5 kW/m²
ODCB	10 mm leak	Jet fire	2.5/F	NR	NR	NR
			3.3/D	NR	NR	NR
			5/D	NR	NR	NR
		Late pool fire	2.5/F	67	43	20
			3.3/D	69	45	20
			5/D	39	47	20
	25 mm leak	Jet fire	2.5/F	3	NR	NR
			3.3/D	3	NR	NR
			5/D	3	NR	NR
		Late pool fire	2.5/F	150	96	49
			3.3/D	152	99	51
			5/D	151	101	53
	Catastrophic Rupture	Late pool fire	2.5/F	204	130	68
			3.3/D	207	134	71
			5/D	207	137	75

Table 7-23: Flash Fire Effect Distance due to Release of ODCB

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter	
				0.5 LFL	LFL
ODCB	10 mm leak	Flash Fire	2.5/F	4	4
			3.3/D	4	4
			5/D	4	4
	25 mm leak	Flash Fire	2.5/F	5	5
			3.3/D	5	5
			5/D	5	5
	Catastrophic Rupture	Flash Fire	2.5/F	15	15
			3.3/D	15	15
			5/D	16	16

Table 7-24: Overpressure Effect Distance due to Release of ODCB

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Overpressure Distances in Meters		
				0.02	0.21	1.00
ODCB	Catastrophic rupture	Late Ignition	2.5/F	39	16	12
			3.3/D	40	16	12
			5/D	38	16	12

Table 7-25: Distance Equivalent to Toxic Dose due to Release of ODCB

Chemical (Storage Tank)	Failure Scenario	Met Data	Effective Distance in meter to Toxic Level			
			EPRG 1 (50 ppm)	EPRG 2 (150 ppm)	EPRG 3 (1000 ppm)	IDLH (200 ppm)
ODCB	10 mm leak	2.5/F	67	41	15	37
		3.3/D	55	42	14	39
		5/D	39	28	4	26
	25 mm leak	2.5/F	217	75	37	66
		3.3/D	111	70	40	67
		5/D	93	58	33	56
	Catastrophic Rupture	2.5/F	338	106	15	105
		3.3/D	221	174	102	169
		5/D	284	249	138	239

Figure 7-17: Late Pool Fire Risk Consequence Contour of ODCB due to 10 mm leak at Weather Condition 3.3/D

Figure 7-18: Jet Fire Risk Consequence Contour of ODCB due to 25mm leak at Weather Condition 2.5/F

Figure 7-19: Late Explosion Risk Consequence Contour of ODCB due to Catastrophic Rupture at Weather Condition 3.3/D

Figure 7-20: Toxic Effect Contour of ODCB due to 10 mm leak at Weather Condition 2.5/F

p-Chloro Toluene

Radiation level and effect distance due to the release of p-Chloro Toluene are presented in ***Table 7-26***and flash fire effect distance are presented in ***Table 7-27***whereas overpressure effect distance are presented in ***Table 7-28.***

The contours for effect distance generated for the release of p-Chloro Toluene are presented in***Figure 7-21 to Figure 7-23.***

Table 7-26: Radiation Level and Effect Distance due to Release of p-Chloro Toluene

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
				4 kW/m²	12.5 kW/m²	37.5 kW/m²
p-Chloro Toluene	10 mm leak	Jet fire	2.5/F	2	NR	NR
			3.3/D	2	NR	NR
			5/D	2	NR	NR
		Late pool fire	2.5/F	84	54	29

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
				4 kW/m²	12.5 kW/m²	37.5 kW/m²
			3.3/D	84	55	31
			5/D	84	56	32
	25 mm leak	Jet fire	2.5/F	6	4	NR
			3.3/D	6	4	NR
			5/D	5	4	NR
		Late pool fire	2.5/F	187	120	71
			3.3/D	188	122	75
			5/D	185	122	79
	Catastrophic Rupture	Late pool fire	2.5/F	328	208	126
			3.3/D	332	213	133
			5/D	327	213	140

Table 7-27: Flash Fire Effect Distance due to Release of p-Chloro Toluene

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter	
				0.5 LFL	LFL
p-Chloro Toluene	10 mm leak	Flash Fire	2.5/F	4	4
			3.3/D	4	4
			5/D	4	4
	25 mm leak	Flash Fire	2.5/F	12	6
			3.3/D	13	6
			5/D	11	6
	Catastrophic Rupture	Flash Fire	2.5/F	16	16
			3.3/D	16	16
			5/D	17	17

Table 7-28: Overpressure Effect Distance due to Release of p-Chloro Toluene

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Overpressure Distances in Meters		
				0.02	0.21	1.00
p-Chloro Toluene	25 mm leak	Late Ignition	2.5/F	17	11	11
			3.3/D	16	11	10
			5/D	17	11	11
	Catastrophic rupture	Late Ignition	2.5/F	45	17	13
			3.3/D	47	17	13
			5/D	45	17	13

Figure 7-21: Jet Fire Risk Consequence Contour of p-Chloro Toluene due to 10 mm leak at Weather Condition 2.5/F

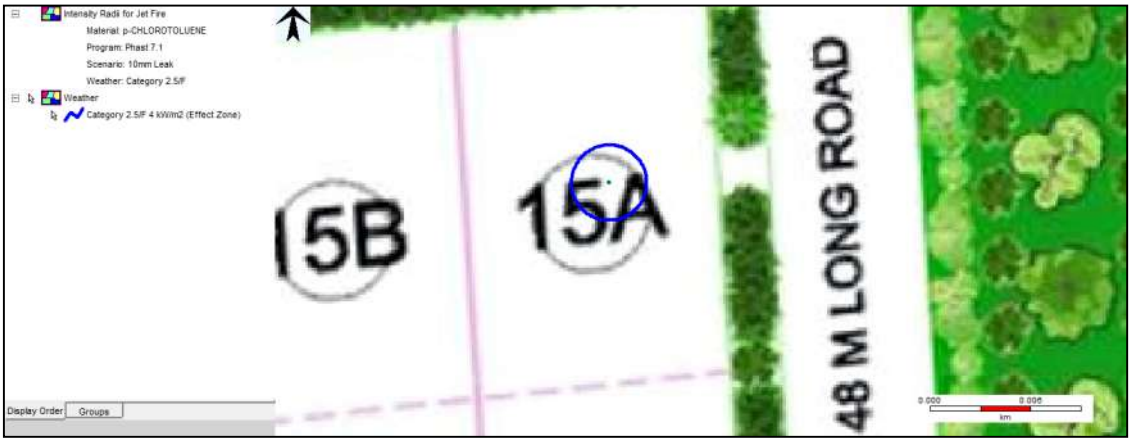

Figure 7-22: Late Pool Fire Risk Consequence Contour of p-Chloro Toluene due to 25mm leak at Weather Condition 3.3/D

Figure 7-23: Late Explosion Risk Consequence Contour of p-Chloro Toluene due to Catastrophic Rupture at Weather Condition 3.3/D

Phenol

Radiation level and effect distance due to the release of Phenol are presented in ***Table 7-29***and flash fire effect distance are presented in ***Table 7-30***whereas distance Equivalent to Toxic Dose due to release of Phenol are given in***Table 7-31.***

The contours for effect distance generated for the release of Phenol are presented in***Figure 7-24 to Figure 7-26.***

Table 7-29: Radiation Level and Effect Distance due to Release of Phenol

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
				4 kW/m²	12.5 kW/m²	37.5 kW/m²
Phenol	10 mm leak	Jet fire	2.5/F	NR	NR	NR
			3.3/D	NR	NR	NR
			5/D	NR	NR	NR
		Late pool fire	2.5/F	25	17	9
			3.3/D	25	18	9
			5/D	25	18	10
	25 mm leak	Jet fire	2.5/F	2	NR	NR
			3.3/D	2	NR	NR
			5/D	2	NR	NR
		Late pool fire	2.5/F	26	19	10
			3.3/D	27	19	11
			5/D	27	19	11
	Catastrophic Rupture	Late pool fire	2.5/F	21	14	5
			3.3/D	22	14	6
			5/D	22	15	6

Table 7-30: Flash Fire Effect Distance due to Release of Phenol

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter	
				0.5 LFL	LFL
Phenol	10 mm leak	Flash Fire	2.5/F	4	4
			3.3/D	4	4
			5/D	4	4
	25 mm leak	Flash Fire	2.5/F	5	5
			3.3/D	5	5
			5/D	5	5
	Catastrophic Rupture	Flash Fire	2.5/F	2	2
			3.3/D	2	2
			5/D	2	2

Table 7-31: Distance Equivalent to Toxic Dose due to Release of Phenol

Chemical (Storage Tank)	Failure Scenario	Met Data	Effective Distance in meter to Toxic Level			
			EPRG 1 (10 ppm)	EPRG 2 (50 ppm)	EPRG 3 (200 ppm)	IDLH (250 ppm)
Phenol	10 mm leak	2.5/F	4	4	NH	NH
		3.3/D	7	4	4	4
		5/D	8	4	4	4
	25 mm leak	2.5/F	5	5	5	5

Chemical (Storage Tank)	Failure Scenario	Met Data	Effective Distance in meter to Toxic Level			
			EPRG 1 (10 ppm)	EPRG 2 (50 ppm)	EPRG 3 (200 ppm)	IDLH (250 ppm)
		3.3/D	8	5	5	5
		5/D	9	5	5	5
	Catastrophic Rupture	2.5/F	2	1	NH	NH
		3.3/D	2	1	NH	NH
		5/D	2	1	NH	NH

Figure 7-24: Late Pool Fire Risk Consequence Contour of Phenol due to 10 mm leak at Weather Condition 5.0/D

Figure 7-25: Jet Fire Risk Consequence Contour of Phenol due to 25mm leak at Weather Condition 2.5/F

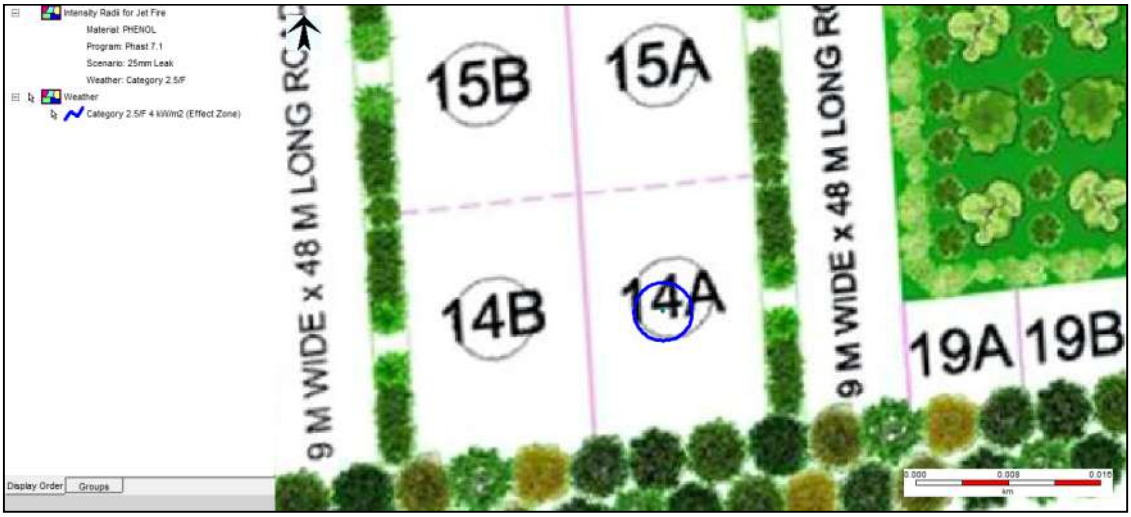

Figure 7-26: Toxic Effect Contour of Phenol due to Catastrophic Rupture at Weather Condition 5.0/D

Propargyl Chloride

Radiation level and effect distance due to the release of Propargyl Chloride are presented in ***Table 7-32***and flash fire effect distance are presented in ***Table 7-33***whereas overpressure effect distance are presented in ***Table 7-34.***

The contours for effect distance generated for the release of Propargyl Chloride are presented in***Figure 7-27 to Figure 7-29.***

Table 7-32: Radiation Level and Effect Distance due to Release of Propargyl Chloride

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
				4 kW/m²	12.5 kW/m²	37.5 kW/m²
Propargyl Chloride	10 mm leak	Jet fire	2.5/F	15	12	NR
			3.3/D	14	11	10
			5/D	13	11	9
		Late pool fire	2.5/F	47	31	14
			3.3/D	44	29	13
			5/D	43	30	13
	25 mm leak	Jet fire	2.5/F	32	26	21
			3.3/D	31	25	20
			5/D	29	23	19
		Late pool fire	2.5/F	113	72	38
			3.3/D	107	70	36
			5/D	103	69	36
	Catastrophic Rupture	Late pool fire	2.5/F	296	188	108
			3.3/D	298	191	114
			5/D	294	193	121

Table 7-33: Flash Fire Effect Distance due to Release of Propargyl Chloride

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter	
				0.5 LFL	LFL

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter	
				0.5 LFL	LFL
Propargyl Chloride	10 mm leak	Flash Fire	2.5/F	26	19
			3.3/D	24	14
			5/D	18	9
	25 mm leak	Flash Fire	2.5/F	51	36
			3.3/D	45	29
			5/D	37	22
	Catastrophic Rupture	Flash Fire	2.5/F	157	119
			3.3/D	171	117
			5/D	171	113

Table 7-34: Overpressure Effect Distance due to Release of Propargyl Chloride

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Overpressure Distances in Meters		
				0.02	0.21	1.00
Propargyl Chloride	25 mm leak	Late Ignition	2.5/F	47	25	22
			3.3/D	39	24	22
			5/D	24	13	11
	Catastrophic rupture	Late Ignition	2.5/F	153	70	58
			3.3/D	95	51	44
			5/D	65	37	33

Figure 7-27: Jet Fire Risk Consequence Contour of Propargyl Chloride due to 10 mm leak at Weather Condition 2.5/F

Figure 7-28: Jet Fire Risk Consequence Contour of Propargyl Chloride due to 25mm leak at Weather Condition 2.5/F

Figure 7-29: Late Explosion Risk Consequence Contour of Propargyl Chloride due to 10 mm leak at Weather Condition 2.5/F

Pyridine

Radiation level and effect distance due to the release of Pyridine are presented in ***Table 7-35***and flash fire effect distance are presented in ***Table 7-36***whereas overpressure effect distance are presented in ***Table 7-37.***

The contours for effect distance generated for the release of Pyridine are presented in***Figure 7-30 to Figure 7-32.***

Table 7-35: Radiation Level and Effect Distance due to Release of Pyridine

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
				4 kW/m²	12.5 kW/m²	37.5 kW/m²
Pyridine	10 mm leak	Jet fire	2.5/F	6	4	NR
			3.3/D	6	4	NR
			5/D	5	4	NR
		Late pool fire	2.5/F	74	48	28
			3.3/D	72	48	29

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
				4 kW/m²	12.5 kW/m²	37.5 kW/m²
			5/D	70	47	30
	25 mm leak	Jet fire	2.5/F	13	11	9
			3.3/D	13	10	9
			5/D	12	9	8
		Late pool fire	2.5/F	106	69	42
			3.3/D	105	69	44
			5/D	104	69	46
	Catastrophic Rupture	Late pool fire	2.5/F	104	66	39
			3.3/D	105	68	41
			5/D	104	68	44

Table 7-36: Flash Fire Effect Distance due to Release of Pyridine

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter	
				0.5 LFL	LFL
Pyridine	10 mm leak	Flash Fire	2.5/F	18	9
			3.3/D	17	7
			5/D	12	5
	25 mm leak	Flash Fire	2.5/F	25	10
			3.3/D	23	10
			5/D	20	8
	Catastrophic Rupture	Flash Fire	2.5/F	24	12
			3.3/D	25	11
			5/D	26	10

Table 7-37: Overpressure Effect Distance due to Release of Pyridine

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Overpressure Distances in Meters		
				0.02	0.21	1.00
Pyridine	10 mm leak	Late Ignition	2.5/F	16	11	10
			3.3/D	17	11	11
			5/D	10	11	11
	25 mm leak	Late Ignition	2.5/F	31	22	21
			3.3/D	30	22	21
			5/D	16	11	10
	Catastrophic rupture	Late Ignition	2.5/F	61	23	21
			3.3/D	59	20	14
			5/D	58	20	14

Figure 7-30: Jet Fire Risk Consequence Contour of Pyridine due to 10 mm leak at Weather Condition 2.5/F

Figure 7-31: Jet Fire Risk Consequence Contour of Pyridine due to 25 mm leak at Weather Condition 3.3/D

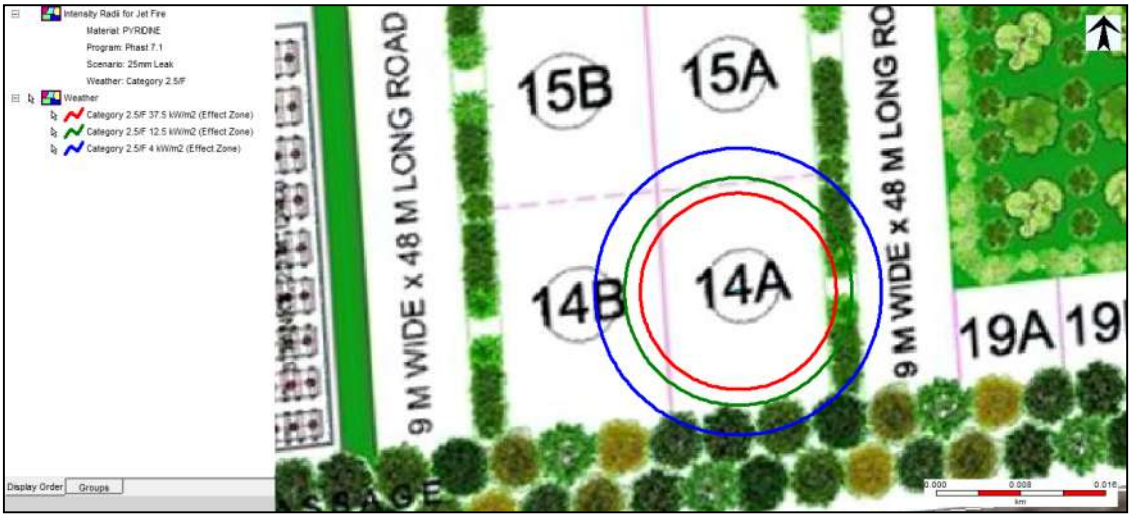

Figure 7-32: Late Explosion Risk Consequence Contour of Pyridine due to Catastrophic Rupture at Weather Condition 2.5/F

Toluene

Radiation level and effect distance due to the release of Toluene are presented in ***Table 7-38*** and flash fire effect distance are presented in ***Table 7-39*** whereas overpressure effect distance are presented in ***Table 7-40*** and distance Equivalent to Toxic Dose due to release of Toluene are given in ***Table 7-41.***

The contours for effect distance generated for the release of Toluene are presented in ***Figure 7-33 to Figure 7-35.***

Table 7-38: Radiation Level and Effect Distance due to Release of Toluene

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
				4 kW/m²	12.5 kW/m²	37.5 kW/m²
Toluene	10 mm leak	Jet fire	2.5/F	9	7	6
			3.3/D	9	7	6
			5/D	8	6	5
		Late pool fire	2.5/F	48	22	NR
			3.3/D	49	23	NR
			5/D	51	24	NR
	25 mm leak	Jet fire	2.5/F	20	15	13
			3.3/D	19	15	12
			5/D	18	14	11
		Late pool fire	2.5/F	82	35	NR
			3.3/D	83	34	NR
			5/D	86	34	NR
	Catastrophic Rupture	Late pool fire	2.5/F	111	46	NR
			3.3/D	117	46	NR
			5/D	123	48	NR

Table 7-39: Flash Fire Effect Distance due to Release of Toluene

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter	
				0.5 LFL	LFL
Toluene	10 mm leak	Flash Fire	2.5/F	23	16
			3.3/D	23	13

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter	
				0.5 LFL	LFL
			5/D	18	8
	25 mm leak	Flash Fire	2.5/F	44	29
			3.3/D	39	23
			5/D	34	20
	Catastrophic Rupture	Flash Fire	2.5/F	58	38
			3.3/D	68	39
			5/D	70	38

Table 7-40: Overpressure Effect Distance due to Release of Toluene

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Overpressure Distances in Meters		
				0.02	0.21	1.00
Toluene	10 mm leak	Late Ignition	2.5/F	39	24	22
			3.3/D	38	24	21
			5/D	19	12	11
	25 mm leak	Late Ignition	2.5/F	104	53	45
			3.3/D	69	38	33
			5/D	64	37	33
	Catastrophic rupture	Late Ignition	2.5/F	173	71	58
			3.3/D	167	68	62
			5/D	167	65	61

Table 7-41: Distance Equivalent to Toxic Dose due to Release of Toluene

Chemical (Storage Tank)	Failure Scenario	Met Data	Effective Distance in meter to Toxic Level			
			EPRG 1 (50 ppm)	EPRG 2 (300 ppm)	EPRG 3 (1000 ppm)	IDLH (500 ppm)
Toluene	10 mm leak	2.5/F	503	119	42	441
		3.3/D	180	68	40	162
		5/D	153	58	31	138
	25 mm leak	2.5/F	1168	264	81	1008
		3.3/D	414	132	70	365
		5/D	361	120	63	321
	Catastrophic Rupture	2.5/F	1867	298	60	1571
		3.3/D	455	102	50	383
		5/D	335	92	41	279

Figure 7-33: Jet Fire Risk Consequence Contour of Toluene due to 10 mm leak at Weather Condition 2.5/F

Figure 7-34: Late Pool Fire Risk Consequence Contour of Toluene due to 25 mm leak at Weather Condition 5.0/D

Figure 7-35: Late Explosion Risk Consequence Contour of Toluene due to Catastrophic Rupture at Weather Condition 2.5/F

Chlorine

Toxic effect distance due to the release of Chlorine are presented in following table;

Table 7-42: Toxic Effect Distance due to Release of Chlorine from Pipeline

Chemical (Pipeline)	Failure Scenario	Met Data	Effective Distance in meter to Toxic Level
			IDLH (10 ppm)
Chlorine	2 mm leak	2.5/F	176.4
		3.3/D	54.2
		5.0/D	44.01
	5 mm leak	2.5/F	578.1
		3.3/D	167.5
		5.0/D	123.6

Hydrogen

Radiation level and effect distance due to the release of Hydrogen are presented in ***Table7-43,*** the overpressure effect distance are presented in ***Table 7-44.***

Table7-43: Radiation Level and Effect Distance due to Release of Hydrogen

Chemical	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
				4 kW/m²	12.5 kW/m²	37.5 kW/m²
Hydrogen	5 mm leak	Jet Fire	2.5/F	NR	NR	NR
			3.3/D	NR	NR	NR
			5.0/D	NR	NR	NR
	25 mm leak	Jet Fire	2.5/F	14.89	11.3	NR
			3.3/D	15.19	11.8	NR
			5.0/D	15.6	12.7	NR

Table 7-44: Overpressure Effect Distance due to Release of Hydrogen

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Overpressure Distances in Meters		
				0.02 bar	0.21 bar	1.0 bar
Hydrogen	5 mm leak	Late Ignition	2.5/F	NR	NR	NR
			3.3/D	NR	NR	NR
			5.0/D	NR	NR	NR
	25 mm leak	Late Ignition	2.5/F	53.8	26.7	22.7
			3.3/D	50.6	26.07	22.4
			5.0/D	48.6	25.7	22.3

7.2.7 Conclusion

From the above study concluded results are present in ***Table 7-45 and Table 7-47.***

Table 7-45: Effect Distances for 25mm Leak in Storage Tank

S. No.	Chemical	Effect Distance in Meters at Weather condition 5.0/D	
		At Radiation Level 37.5 kW/m2	At Overpressure 0.02 bar
1	Aniline	82 (Late pool fire)	-

2	Benzene	NR	95 (Late Ignition)
3	Benzyl Chloride	NR (Late pool fire)	-
4	Methanol	33 (Late pool fire)	35 (Late Ignition)
5	o-Dichloro Benzene (ODCB)	53 (Late pool fire)	-
6	p-chloro Toluene	79 (Late pool fire)	17 (Late Ignition)
7	Phenol	11 (Late pool fire)	-
8	Propargyl Chloride	36 (Late pool fire)	65 (Late Ignition)
9	Pyridine	46 (Late pool fire)	16 (Late Ignition)
10	Toluene	NR	64 (Late Ignition)

NR: Not Reached

Table 7-46: Effect Distances Leak in pipeline

S. No.	Chemical	Effect Distance in Meters at Weather condition 5.0/D		
		IDLH (10 ppm)	At Radiation Level 37.5 kW/m2	At Overpressure 0.02 bar
1	Chlorine at 5mm leak	123.6	-	-
2	Hydrogen at 25 mm leak	-	NR	48.6 (Jet fire)

Table 7-47: Effect Distance for Catastrophic Rupture of Storage tank

S. No.	Chemical	Effect Distance in Meters at Weather condition 5.0/D	
		At Radiation Level 37.5 kW/m^2	At Overpressure 0.02 bar
1	Aniline	105 (Late pool fire)	34 (Late Ignition)
2	Benzene	NR	323 (Late Ignition)
3	Benzyl Chloride	NR	39 (Late Ignition)
4	Methanol	48 (Late pool fire)	160 (Late Ignition)
5	o-Dichloro Benzene (ODCB)	75 (Late pool fire)	38 (Late Ignition)
6	p-chloro Toluene	140 (Late pool fire)	45 (Late Ignition)
7	Phenol	6 (Late pool fire)	-
8	Propargyl Chloride	121 (Late pool fire)	550 (Late Ignition)
9	Pyridine	44 (Late pool fire)	58 (Late Ignition)
10	Toluene	NR	167 (Late Ignition)

NR: Not Reached

7.2.8 Treatment and Control

After examining the high priority risks, a prime consideration is given to the potential to reduce or eliminate the risk by using the hierarchy of controls. This assists in establishing methods to reduce risk. The desirability of control plans (with reducing effectiveness) is as follows;

- Elimination: Take step to eliminate the hazard completely,
- Substitution: Replace with less hazardous material, substance or process,
- Separation: Isolate hazard from person by guarding, space,
- Administrative: Adjusting the time or conditions of risk exposures,

- Training: Increasing awareness, improving skills and making tasks less hazardous to persons involved,
- Personal protective equipment: Use appropriately designed and properly fitted PPE.

The control measures and action to be considered to minimize the risk present in the facility for the hazardous events are summarized in ***Table 7-48***.

Table 7-48: Event Consequences, Treatment and Control

Hazardous Event	Possible Consequences	Treatment and Control
Loss of containment Rupture / leak in storage tanks	Fire, explosion and toxic hazards	Gas detectors, Dyke wall provision, Level indicator, Earthing, flame arrestor & visual observation, Ready availability of fire extinguishers and fire hydrant system

7.2.9 Precautions to be taken during Storage and transportation

Aniline

Handling & Storage

Keep locked up. Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, metals, acids, alkalis.

Storage:

Air and light sensitive. Store in light-resistance container. Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame).

Personnel Protective Equipments

Personal Protection:

Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:

Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self-contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist before handling this product.

Benzene

Handling & Storage

Keep locked up. Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, acids.

Storage:

Store in a segregated and approved area. Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame).

Personnel Protective Equipments

Personal Protection:

Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:

Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self-contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist before handling this product.

Benzyl Chloride

Handling & Storage

Keep locked up. Keep container dry. Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Never add water to this product. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents.

Storage:

Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame).

Personnel Protective Equipments

Personal Protection:

Face shield. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves. Boots.

Personal Protection in Case of a Large Spill:

Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self-contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist before handling this product.

Methanol

Handling & Storage

Store in a segregated and approved area. Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame).

Personnel Protective Equipments

Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:

Splash goggles, Full suit, Vapor respirator, Boots, Gloves. A self-contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist before handling this product.

O-Dichloro Benzene (ODCB)

Handling & Storage

Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. In case of insufficient ventilation, wear suitable respiratory equipment if ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes

Flammable materials should be stored in a separate safety storage cabinet or room. Keep away from heat. Keep away from sources of ignition. Keep container tightly closed. Keep in a cool, well-ventilated place. Ground all equipment containing material. Keep container dry. Keep in a cool place.

Personnel Protective Equipments

Personal Protection:

Face shield. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves. Boots.

Personal Protection in Case of a Large Spill:

Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self-contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist before handling this product.

P- Chloro Toluene

Handling & Storage

Empty containers retain product residue, (liquid and/or vapor), and can be dangerous. Keep away from heat, sparks and flame. Keep away from heat, sparks, and flame. Flammables-area.

Personnel Protective Equipments

Eyes: Wear chemical splash goggles. Wear safety glasses and chemical goggles if splashing is possible.

Skin: Wear safety glasses and chemical goggles if splashing is possible. Wear appropriate protective gloves to prevent skin exposure.

Clothing: Wear appropriate protective clothing to minimize contact with skin.

Respirators: A respiratory protection program that meets OSHA's 29 CFR 1910.134 and ANSI Z88.2 requirements or European Standard EN 149 must be followed whenever workplace conditions warrant respirator use. Wear a NIOSH/MSHA or European Standard EN 149 approved full-face piece airline respirator in the positive pressure mode with emergency escape provisions.

Phenol

Handling & Storage

Keep locked up. Keep container dry. Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not ingest. Do not breathe dust. Never add water to this product. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, acids.

Air Sensitive. Sensitive to light. Store in light-resistant containers. Moisture sensitive. Keep container tightly closed. Keep container in a cool, well-ventilated area.

Personnel Protective Equipment

Personal Protection:

Splash goggles. Synthetic apron. Vapor and dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:

Splash goggles. Full suit. Vapor and dust respirator. Boots. Gloves. A self-contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist before handling this product.

Propargyl Chloride

Handling & Storage

Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not breathe gas/ fumes/ vapor/spray. In case of insufficient ventilation, wear suitable respiratory equipment if you feel unwell, seek medical attention and show the label when possible. Avoid contact with skin and eyes

Flammable materials should be stored in a separate safety storage cabinet or room. Keep away from heat. Keep away from sources of ignition. Keep container tightly closed. Keep in a cool, well-ventilated place. Ground all equipment containing material. A refrigerated room would be preferable for materials with a flash point lower than 37.8°C (100°F).

Personnel Protective Equipment

Personal Protection:

Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:

Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self-contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist before handling this product.

Pyridine

Handling & Storage

Keep locked up. Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, acids.

Store in a segregated and approved area. Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame).

Personnel Protective Equipment

Personal Protection:

Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:

Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self-contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist before handling this product.

Toluene

Handling & Storage

Keep locked up. Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, acids.

Store in a segregated and approved area. Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame).

Personnel Protective Equipment

Personal Protection:

Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:

Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self-contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist before handling this product.

Chlorine

Personnel Protective Equipments

- Cartridge type gas masks provided individually to employees working in chlorine handling area.
- Canister type gas masks provided to key personnel and are also available in control room.
- Online breathing apparatus with long hoses are installed at strategic locations within the plan

7.3 Disaster Management Plan

The Disaster Management Plan (DMP) is a guide which provides general considerations, directions and procedures for handling emergencies likely to arise from planned and unplanned operations. Site specific documentation contingent to – and demonstrating suitable implementation of the DMP is described in the annexure to the DMP. The Annexure, being site specific, will require to be updated once the actual site operations are underway (please refer***Annexure 24***)

The DMP must also be revaluated by the Plant Manager prior to start of operations. The DMP has been prepared for Radha Madhav Processors Pvt. Ltd. on the basis of the Risk Assessment and related findings covered in the earlier chapters of this report.

7.3.1 Structure

The DMP is supposed to be a dynamic, changing, document focusing on continual improvement of emergency response planning and arrangement. A structure working on a Plan, Do, Check and Review (PDCR) cycle has been therefore suggested. Another advantage of doing this is to have a system that

is in synchronicity with commonly used EHS system such as ISO 14001. The DMP is covered in further details in the remaining sections of this Chapter.

7.3.2 Policy

The Environment, Health and Safety (EHS) policies are to be made accessible to all at site and to other stakeholders. The policies must be framed considering Legislative Compliance, Stakeholder Involvement, Continual Improvement, and Management Objectives.

7.3.3 Planning

Identification of Emergencies

Possible emergency situation can broadly be classified into toxic release, fire or explosion, while doing so, it is stressed that these results are only for the modeled scenarios and, that the distances as well as damages can change depending upon the actual development of a scenario. Additional emergency situations can be developed on the basis of audit / HAZOP or other procedures prior to commencement of operations.

Emergency Prevention

Some of the ways of preventing emergencies are as follows:

- Preparation of a Preventive Maintenance Schedule Programme, covering maintenance schedules for all critical equipment and instruments as per recommendations of the manufacturers user manuals.
- Establishment of a computerized Failure Modes Effects and Criticality Analysis (FMECA) or similar procedure to generate data on failures of critical equipment and instruments based on mode wise failures and their criticality. This requires codification of equipment, instruments and their modes of failure and their criticality. Consideration may be given to the use of appropriate software for processing FMECA data for review of the Preventive Maintenance Schedule and for improvement of the same to ensure critical failures,
- Importantly, it is of great importance to collect and analyze information pertaining to minor incidents and accidents at the site, as well as for recording near-misses or emergencies that were averted. This information gives an indication of how likely or unlikely it is for the site to face actual emergencies and what should be further done to prevent them from occurring.
- Establishment of an ongoing training and evaluation programme, incorporating the development of capabilities amongst employees about potential emergencies and ways and means of identifying and averting the same. Most emergencies do not occur without some incident or an abnormal situation. So there is always sometime of few seconds to few minutes to arrest an incident of abnormal situation from turning in to an emergency. This is the role of the shift in-charge who is the Incident Controller (IC) along with his shift team.

7.3.4 Identification of, and Communication with, Relevant Stakeholders

This includes identifying, communicating and developing working relations with relevant offsite agencies that have an interest (either due to regulatory requirements or otherwise) in the continued safe operations of the site.

On the basis of the Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996, (referred to as The Chemical Accidents Rules), the following persons may be considered as

relevant stakeholders with regards to the maintenance of the Company's emergency response at the district level:

- District Collector
- Gujarat Pollution Control Board
- Inspector of Factories
- District Energy Officer
- Chief Fire Officer
- District Information Officer
- Controller of Explosives
- Chief, Civil Defense
- Deputy Superintendent of Police
- District Health Officer/Chief Medical Officer
- Commissioner, Municipal Corporations
- Representative of the Department of Public Health Engineering
- Experts (Industrial Safety, Health and Environment)
- Commissioner (Transport)

The following persons may be considered as relevant stakeholders at the local level:

- Sub-divisional Magistrate
- Inspector of Factories
- Regional Officer of SPCB
- Representative of Industries in the District
- Transporters of Hazardous Chemicals
- Fire Officer
- Station House Officer (Police)
- Block Development Officer
- One Representative of Civil Defense
- Primary Health Officer
- Editor of local News paper
- Community leader / Sarpanch / Village
- Non-Government Organization representatives
- Eminent Doctors in the Local area

The above groups of persons, between themselves, respectively form the District Level Crisis Group and Local Level Crisis Group for mitigation of chemical accidents as per the Chemical Accidents Rules. Consequently, it is suggested that company consider opening a dialogue with them and soliciting their assistance in management of onsite and offsite emergencies associated with its activities. These may be considered as inputs to other planning activities.

7.3.5 Formation of Emergency Plan Objectives

Specific objectives of the Emergency Response Plan are to be clearly listed with regards to the responses desired for successful management of the possible emergency situations. Suggested Objectives could, initially include:

- Formulation of suitable onsite / offsite fire release response
- Improved awareness of safety issues amongst site personnel
- Training of key persons in cardio-pulmonary resuscitation and other first aid

The objectives suggested currently are generic in nature. However, they will evolve and become more specific as the project develops further. Responsibilities, resources and timeframes require to be allocated for implementing the objectives.

7.3.6 Implementation

Allocation of Resources

Radha Madhav Processors Pvt. Ltd. will require allocation of suitable resources for effective implementation of the EP. Resources include both human and financial resources.

7.3.7 Responsibilities of Key Personnel

Emergency Controller

Factory Manager or equivalent responsible person is overall responsible for handling the emergency situation. He will judge the situation & accordingly communicate to local fire-fighting crew & police station.

Roll call leader

Appointed by emergency Controller is responsible for identifying all the employees inside the premises. He will start counting of headcount at assembly point & report to emergency controller.

Emergency Control Team

Emergency Control team is the team of people appointed by Emergency Controller for attending emergency.

7.3.8 Setting up of Emergency Infrastructure

To enable the key persons to implement the EP, the following infrastructure will require to be set up:

- Site Map with Escape Routes and Safe Assembly Points marked on it
- Site layouts have to be put up at key areas where assembly is to be done. These points could vary depending upon the atmospheric stability and location and intensity of the emergency.
- With the onset of emergency, all non-essential workers (those workers not assigned emergency duty) shall evacuate the area and report to the specified emergency assembly point.

Wind Sock

It is required to install wind sock at the top of any tall structure in the vicinity of the site. In case there is a risk of the structure getting damaged during the emergency, it is desirable to have alternate wind sock(s) as required. At least one wind sock should be visible from any part of the site. Site personnel have to be trained in reading the atmospheric conditions on the basis of the status of the wind sock.

Evacuation, Escape and Rescue (EER) Plan

In a major emergency, it will be necessary to evacuate personnel from affected areas and as a precautionary measure to further evacuate non-essential workers from areas likely to be affected should the emergency be escalate. Whether evacuation is required or not can be decided by the Incident Controller, and arrangements made to communicate with employees in this regards.

Arrangements could include announcements over the public address system, or through other suitable means.

On evacuation, employees should be directed to pre-determined assembly points already explained earlier. If they are required to be evacuated outside the site and at a remote place, their transportation will be necessary for which vehicles will be required.

The safe authorize passages/routes for escape shall be decided and marked by arrows in the plans as explained in the details of Emergency Control Center in this chapter.

Safe Assembly points

In affected sites, all non-essential workers (who are not assigned any emergency duty) shall evacuate the area and report to a specified assembly point. The need to evacuate non-essential workers from non-affected areas will be determined by the foreseeable rate at which the incident may escalate. Plan layout showing evacuation path is required.

Each assembly point must be situated in a safe place, well away from areas of risk and least affected by down wind direction. It may be in the open or in a building depending on hazard involved.

Before reaching an assemble point, or subsequently, if it is required to pass through an effected area, suitable personal protective equipment (PPEs) including respirator, helmets etc., should be available to the workers.

Emergency Control Centre

An Emergency Control Centre (ECC) is the primary area from where emergencies are handled. An ECC should contain various items as listed. The Main Control center or any structure on the site that is designed to withstand overpressure and radiation stress should be designated at the ECC.

1. For Communication

- Siren, or other suitable alarm system
- Intercom sets
- External phone sets
- Telephone directory
- Company Directory
- List of Important phone numbers
- Walkie-talkies
- Wireless set
- Mobile phone

2. Document for Ready Reference

- Site Plan
- Layout plan with hazard zones, assembly points marked and location of siren, safety/fire system shown (Display)
- Stock list of Fire extinguishers
- Fire-water system and additional sources of water
- Emergency Response Plan
- List of First Aid
- Mutual Aid Members list.
- List of employees and their addresses and phones numbers.

3. Wall Display

- Site plan
- Layout plan
- Emergency Organization
- Besides these, it should also contain stationery, recording system, utility items (such as torches and umbrellas) and a first aid box.

7.3.9 Awareness, Training, and Competence

Awareness

General awareness is to be invoked in all site personnel (including contractor's employees) with regards to the importance of safety in general and emergency procedures in particular. Awareness can be generated in a number of ways, some of which are:

- Awareness of Environment, Health and Safety Policies, and the role of each employee
- Awareness of the importance of carrying out tasks as mentioned in the Standard Operating Procedures and the potential impacts of not doing so.
- The importance of wearing personal protective equipment
- Awareness about relevant portions of the safety instructions covered in equipment manuals used at site.

Training

Specific training requires to be given to key employees. Examples of such training include:

- Testing of critical equipment and controls
- Use of firefighting equipment
- Emergency Evacuation and Rescue (EER) procedure.
- Training in use of communication procedure to be followed in case of emergencies.
- Training needs identification exercises should be undertaken prior to commencement of operations and the same must cover environment, health and safety issues.

Competence

Competence is a function of training, experience and education. Key persons involved in administering the EP, should be competent. The level of competence can be decided for each key task and a clearly defined competence chart should be prepared.

7.3.10 Drills and Exercise

Emergency drills and integrated exercises have the following objectives:

These constitute another important component of emergency preparedness. They refer to the re-enactment, under the assumption of a mock scenario, of the implementation of response actions to be taken during an emergency.

- To test the adequacy of the effectiveness, timing, and content of the DMP and implementing procedures.
- To ensure that the emergency organization personnel are familiar with their duties and responsibilities by demonstration.

- Provide hands-on experience with the procedures to be implemented during emergency.
- Maintain emergency preparedness.

The frequency of the drills would vary depending on the severity of the hazard. However, drills should be conducted twice in a year. Scenarios may be developed in such a manner as to accomplish more than one even objective. It may be ensured that the external agencies are also made to participate in the mock drill at least once a year in order to familiarize them of the emergency procedures/actions.

Drill and exercises shall be conducted as realistically as is reasonably practicable. Planning for drills and exercises shall include:

- The basic objectives
- The dates, times and places
- The participating organizations
- The events to be simulated
- An approximate schedule of events
- Arrangements for qualified observers
- An appropriate critique of drills/exercises with participants.

Evaluation of drills and exercises should be carried out which should include comments from the participants and observers (internal as well as external). Discrepancies noted by the drill observers during the drill shall be pointed out. The individual responsible for conducting the drill or exercise should prepare a written evaluation of the drill or exercise. The evaluation team should include assessments and recommendations on:

- Areas that require immediate correction.
- Areas where additional training is needed.
- Suggested modifications to the DMP or procedure.
- Deficiencies in equipment, training, and facilities.

Records of drills, exercises, evaluations, and corrective actions should be scrupulously maintained. The committee shall supervise the following activities:

- Functioning of Emergency Control Centre very specifically availability of all facilities etc. as mentioned in the plan and its functional healthiness.
- To evaluate communication of the DMP among all segments of employees for familiarizing them on their likely responsibilities in case of any disaster including evaluation of behavior of employees and others.
- To ensure that all facilities as required under the plan from within or from nearby industries/aid centers under mutual assistance scheme or otherwise are available.
- To ensure that the necessities under material assistance scheme is properly documented and the concerned employees are fully aware in this regard.
- To ensure that employees are fully aware to fight any emergency like firefighting, manual actuation of flooding system or other such causes.
- The mock drill operation should be timed and each timing should be reviewed with respect to the previous one and long lead-time should be identified.

7.3.11 Communication

Communication is vital during emergencies. Under the Factories Act, as well as the MSIHC Rules, communication is important and it is required to divulge the potential emergencies that could arise out of the operations related to hazardous units.

After undertaking an assessment of risks and their possible environmental impacts, and setting up an organization for the preparedness to control the emergency, including related infrastructure, the next step is operationalizing the communications system. Depending upon the severity of the event, communications may have to be made with:

- Persons inside the site premises
- Key personnel outside the site premises during their non-working hours
- Outside emergency services and authorities, and
- Neighboring businesses, industries and general public.
- Requirements pertaining to communication during emergencies are covered in this section.

Level of Emergency

Three levels of emergencies are to be recognized:

- First level: Confined to a particular unit of the entire site,
- Second level: A spreading emergency, that requires outside help, and
- Third level: A major emergency requiring neighboring population to be alerted.

Suitable alarms require to be made for each of these potential emergencies. The alarm should be audible in every part of the site. In areas of high noise levels, an alternative to an audible alarm, such as flashing lights may be installed.

Communication of Emergency

There should be an effective system to communicate emergency:

- Inside the factory, i.e. to the workers including key personnel and essential workers on duty, and inside normal working hours,
- To the key personnel and essential workers not on duty and outside during normal working hours
- To outside emergency services and the government authorities, and
- To the neighboring businesses, and public in general

Communication inside with Personnel inside the Site during the Incident

Relevant statutory information pertaining to the site must be made available beforehand, preferably in the form of a booklet, to workers so that they can prepare themselves to prevent or control the emergency.

In all cases, once the communication of emergency is done, through an alarm, all personnel should be ready to undertake their roles in the same.

Communication with Personnel outside the Site during the Incident

Because of the suggested planning, key personnel will typically be available in all shifts or on short call. But due to some reason, if some are outside or not on duty and if their help is required, their updated details should be kept in the ECC for communication.

Communication inside with External Emergency Services and Relevant Authorities

Communication with external agencies is important and essential, both to control the emergency and as per regulatory compliance requirements. This is specially so for reportable (lost time) accidents. In such cases, it is essential that the outside emergency services as well as relevant outside agencies be informed in the shortest possible time. Liaison at the local level will help determine the best means for achieving this.

Relevant agencies that provide emergency services include the fire brigade, nearby hospitals and doctors, and the police, besides senior local and district administration personnel. Statutory information, given to such agencies in advance will help them in arranging emergency services.

Communication with Neighboring Firms and the General Public

In the study area, since there are other major industries, contact with these industries in the study area with a view of receiving mutual aid, may be practical.

The public in the area, in some circumstances, may require to be informed about the emergency, which as stated earlier, should be done after careful evaluation.

Communication with District Crisis Group and the Local Crisis Group

In addition to the general public communication will require being provided to the district administration and this may be done by liasioning with different agencies.

7.3.12 Steps in Case of Emergency

- After finding any emergency actuate emergency siren through manual call points.
- After actuating emergency siren report to assembly point
- All visitors visiting on locations are required to be guided to assembly point through designated routes by their respective escorts.
- All Personnel gathered at assembly point shall inform roll call leader and wait for the instructions from the Emergency Controller.
- As soon as emergency is declared by emergency controller, security shall ensure to stop all personnel and vehicles movement from security gates and close the gates. They will also ensure that gates have no restriction e.g. any parked vehicle, to ensure prompt entry of emergency vehicle, if required.

Fire Fighting

- All Operators should position themselves well upwind of a fire that is beyond the Incipient Level and prepare the area for immediate evacuation.
- For all major fires plant relies on external fire brigade as expert skills and trainings are required.

Spill Response

- Plant personnel should stay up wind of spills or releases, and avoid all contact with the material when performing spill response operations.
- Spill response operations or clean-ups should only be performed by trained personnel. PPE requirements should be reviewed, and the appropriate PPE should be wared before offensive operations are carried out.

- The atmosphere should be continually monitored for explosion potential if the spill or release involves a flammable or combustible material.
- All response operations should be terminated and responders should move to a safe location upwind if an explosion potential exists.

Site Evacuation

- On hearing emergency alarm all personnel shall stop their work / equipment and evacuate. However if stopping the equipment would not be done within reasonable time, leave area running and inform area in-charge / emergency controller.
- All personnel shall evacuate through emergency exit routes and assemble at assembly points.
- Do not run, walk fast.
- While evacuation take visitors and physically challenged personnel along. Do not run, walk fast. Do not create panic.
- Report roll call leader at assembly point. Inform emergency controller authentic information related to incident or any personnel trapped inside.
- If have role in emergency control teams, report emergency controller.
- After emergency controller declares all clear, re-enter in the Office.

7.3.13 Specific Emergency Scenario and Response

Fire on Persons Clothings

- Call for help from all available employees.
- Do not allow the person to run in panic.
- Small fire in clothing can often be beaten out with sacks or by rolling on the ground. The clothing can often be torn off before serious burns are caused.

Water and Food Poisioning

- Person observing the symptom should inform Factory Mgr.
- Factory Manager to call for ambulance and Doctor immediately.

Crush Injuries

- When a person is trapped or crushed by heavy weight, the trapped person should be quickly removed to Hospital.

Electrical Injuries

- Cut off Source of Current
- Treat the burn by quickly covering the area Exclude contact with air.

Burns and Scalds

- Exclude contact with air.
- Give shock victims salted drink in case of severe burn if removal of casualty is likely to be delayed.
- Do not rupture a blister.
- Arrange for medical aid.

Unconsciousness

- Arrange ambulance & admit casualty to the nearest hospital

Shock

- Find out whether the patient is conscious or not and try to ascertain the cause of the shock. If the patient is conscious assure and let the patient lie flat on his back. The head should be a little lower and legs raised above the body level. Loosen all tight clothing. Wipe off sweat. Cover with cotton sheet during summer and with blanket during winter. Nothing should be given by mouth except sips of water or ice to quench thirst. Hot water bottles are not to be used. Arrange removal to the hospital at the earliest

Blast of Material Tank, Drum, Compressor, D.G., Vehicle, Spillage ofHazardousMaterial on Body, Building Collapse due to hitting of the vehicle, fall of machinery/hoist, Leakage of Hazardous or flammable materials on the floor

- Call for help from all available employees.
- Check for injuries. Render first aid.
- Check for damage, spills & flow of material or fires.
- If the damage is severe vacate the area immediately.
- The first consideration should be for the safety and accountability of people.
- Communications with civil authorities and services (Fire brigade, Police, ambulance, Factory Inspector, Pollution Control Board Inspector) will probably be limited and Office personnel will have to handle conditions in the plant for several hours before outside help can be obtained.
- It is possible that power and water services will be cut off and fires may have to be contained using fire extinguishers only.
- Evacuate to the assembly area
- Keep non emergency personnel out of the office and buildings until the damage has been evaluated.
- After emergency collect all spilled material including spoil & dispose through waste management.

Fire to the building or to the material inside or outside the factory building

- Call for help from all available employees.
- Check for injuries. Render first aid.
- Check for damage or fires.
- In case of small fire, use the fire fighting equipments (Fire extinguishers, Fire hose, sand buckets etc) for extinguishing the fire.
- If the fire in not in control & damage is severe vacate the area immediately & call the Fire brigade immediately.
- The first consideration should be for the safety and accountability of people.
- Communications with civil authorities and services (Fire brigade, Police, ambulance, Factory Inspector, Pollution Control Board Inspector) will probably be limited and Office personnel will have to handle conditions in the plant for several hours before outside help can be obtained.
- It is possible that power and water services will be cut off and fires may have to be contained using fire extinguishers only.

7.3.14 Emergency Response during Earthquake

During Earthquake

The duration of an earthquake is likely to be short and action during the earthquake should be self protection. Avoid windows or areas where objects above you can fall.

- Stay indoors and take cover under a desk or in a doorway.
- If outdoors, get into an open area away from buildings or overhead structures.
- If driving, pull over and stop in an area clear of buildings or overhead structures. Stay in the vehicle.

When Earthquake Stops

Remain in the same position for several minutes in preparation for after shocks.

- Check for injuries. Render first aid.
- Check for damage or fires.

If Damage is Severe

The first consideration should be for the safety and accountability of people.

Communications with civil authorities and services will probably be limited and Office personnel will have to handle conditions in the plant for several hours before outside help can be obtained.

It is possible that power and water services will be cut off and fires may have to be contained using fire extinguishers only.

- Evacuate to the assembly area.
- Keep non emergency personnel out of the office and buildings until the damage has been evaluated.
- Await instructions from the Emergency controller

Employee Response

- Persons working in office area are exposed to hazard of false ceiling falling down. They can take shelter under heavy furniture e.g. tables from protecting them from falling false ceiling.
- Personnel are not supposed to stand or walk near walls and glass windows.
- Don not stand near pylons around building.
- Objects mounted on walls and lights are weak points may fall during earthquake. Do not stand or walk near them. Choose evacuation route in such a way that these can be avoided.

Emergency Controller

- Ensure head count after evacuation/ earth quake.
- Identify list of personnel trapped inside, if any and form and send teams inside for rescue.
- Ensure first aid is provided.
- Form various teams e.g. fire fighters, first aiders, assessment etc. and maintain the records of personnel sent inside.

7.3.15 Emergency Documentation and Document Control

Documentation

Emergency documentation consists of:

- The Emergency Plan
- The Contingency Plan
- Related Formats and Records showing compliance with these documents

The EP and CP need to be approved prior to use. All documents should be easily accessible at site.

Document Control

Documents should be legible

- All documents should be protected against damage, deterioration and loss
- Changes, if any, should also be approved
- Copies of the approved EP and CP are to be kept with the project in-charge at the project office, as well as at each site, in the Emergency Control Centre, with the site in-charge / Site Main Controller
- Obsolete documents should be marked as such, and copies of such documents are to be collected and prevented from being used

Emergency Control

In case of emergencies, actions can broadly be categorized into the following activities:

- Saving of human lives
- Controlling the spread of the emergency and ultimately stopping it from further developing

On the basis of the issues covered in this chapter, the following are to be incorporated into the CP for implementing this EP's requirements:

Onsite Emergency Control

- Shut down and Isolation: Raising the alarm, followed by immediate safe shut down of the power supply, and isolation of effected areas.
- Escape, Evacuation and Rescue: Safeguarding human lives at site by commencement of the Emergency Evacuation and Rescue Plan. Ensuring that all personnel are accounted for and carrying out a head count of persons evacuated. Notification and commencement of offsite emergency plan in case offsite impacts are possible.
- Stopping the development of the emergency: Control or response to the emergency depending upon its nature (fire or explosion).
- Treatment of injured: First aid and hospitalization of injured persons.
- Protection of environment and property: During mitigation, efforts should be made to prevent impacts on environment and property to the extent possible.
- Welfare of the personnel managing the emergency: Changeover, first aid and refreshments for the persons managing the emergency.
- Informing and collaborating with statutory, mutual aid and other authorities including those covered in the Local Crisis Group.
- Informing and assisting relatives of the victims.

- Informing the print and electronic media.
- Preserving all evidence and records: This should be done to enable a thorough investigation of the true causes of the emergency.
- Investigation and follow up: This requires to be carried out to establish preventive measures for the future and a review of the EP and CP to fill up the deficiencies in the emergency planning procedures.
- Ensuring safety of personnel prior to restarting of operations: Efforts require to be made to ensure that work environment is safe prior to restarting the work.

Off-site Emergency Response Plan

The following are the responsibilities towards generation of the Offsite Emergency Plan:

- To provide basic information on Risk and Environmental Impact Assessment to the Local/District Authority, Police, Fire Brigade, Doctors, surrounding industries and the public and to appraise them on the consequences and the protection/prevention measures and control plans and seek their help to manage the emergency.
- To assist District Authorities in preparing the Off-site Emergency Plan.

An off-site emergency plan organization has essentially two parts:

- Formation of the Local Crisis Group: This Group is headed by the Deputy Collector or the Magistrate of the Industrial area and is responsible for the management of any industrial emergency confined to the local area.
- Formation of the District Crisis Group: This Group is headed by the District Collector of the District and is responsible for any major Industrial emergency affecting Local and beyond any industrial area of the District.

The typical structure of the Offsite Emergency Crisis group is provided vide ***Figure 7-36.***

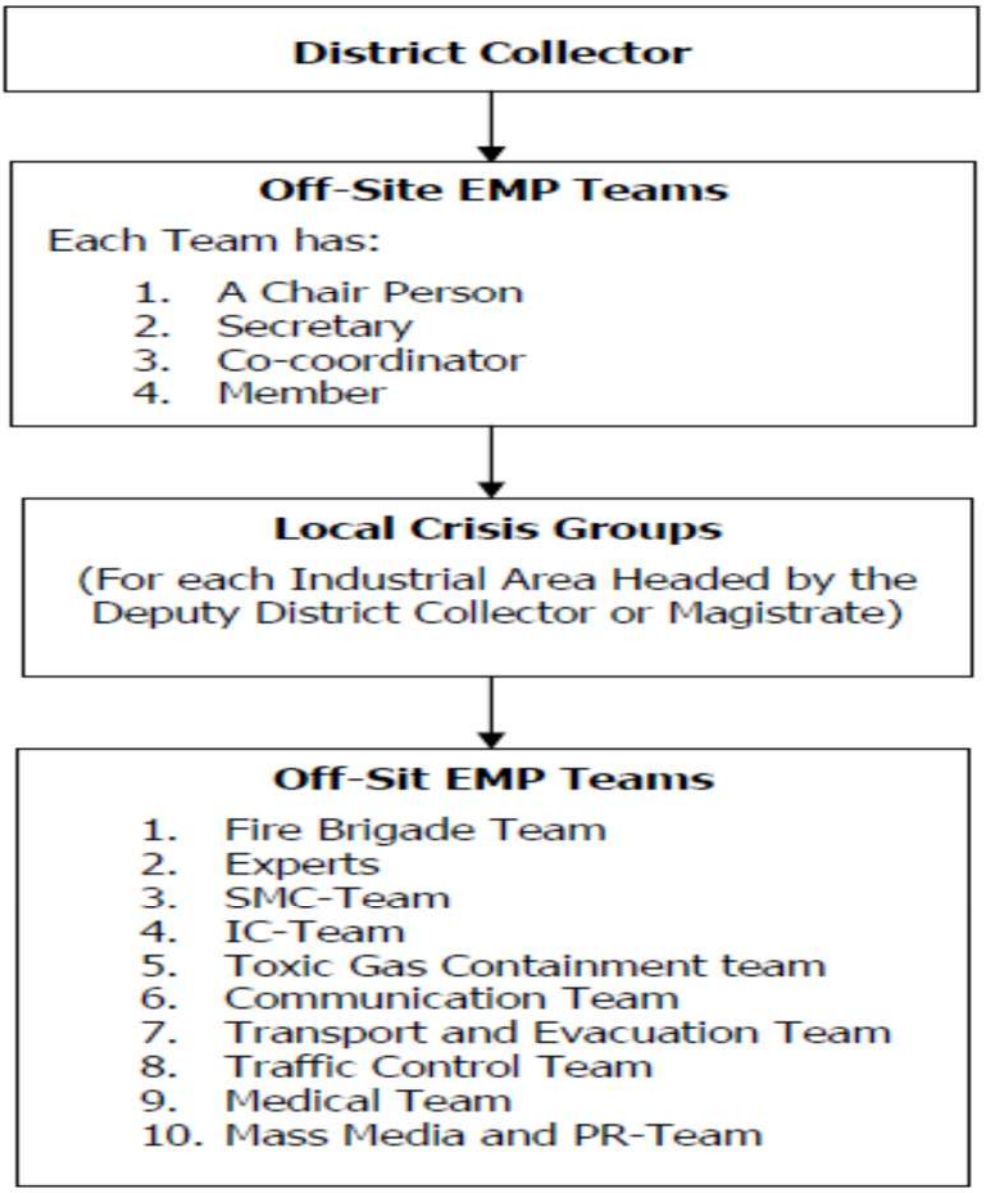

Figure 7-36: Composition of Off-Site Crisis Group

7.3.16 Checking and Corrective Action

Monitoring and Measurement

Monitoring of the planned arrangements and the implementation of the EP are essential to deliver the required output and enhance emergency preparedness. This includes:

- Provisions for NDT, FMECA and other tests to identify failure of critical equipment, before it actually takes place.
- Monitoring compliance to permits and statutory requirements laid down by regulatory authorities.

- Conducting mock drills (including fire drills and toxic release drills) to check whether the planned arrangements are working as per the required norms or not.
- Testing of critical equipment, and
- Identifying minor leaks, accidents, near misses and other incidents that can lead to emergencies.
- A detailed monitoring checklist requires being prepared and the required actions carried out, prior to start of work.

Records

Records are a means of evaluating performance. Records include (but are not limited to):

- Regulatory records, such as permits and related documents
- Monitoring and test records
- Correspondence with relevant offsite and onsite agencies

Site management will ensure that records are properly maintained and available. It is desirable to keep copies of all records at the site, to prevent their loss. Legal records should be kept permanently.

EP Audit, Non Conformance and Corrective Action and Preventive Action

Since this EP has been designed as a dynamic document, it is required that its performance be audited at regular intervals. Ideally, persons auditing the EP should be external auditors (i.e. not employed at the site being audited). The audit should result in a set of findings that are put before the site management for review.

7.3.17 Review of Emergency Performance

The Site / Office Management will review the findings of the audit and the non-compliances. It will consider whether the EP is providing adequate safety assurance to the management, delivering performance as desired, and whether it continues to be in the spirit of Environment, Health and Safety Policies, and changing requirements. On the basis of these, the Management will record its steps and consider modifying the EP, as deemed appropriate.

7.3.18 Emergency Contact Number

A list of important places / people with respect to the emergency situation, is provided in ***Table 7-49***.

Table 7-49: List of Telephone Numbers of District Administration

Sr. No.	Location	Telephone No.
1	Director, Industrial Safety & Health, Ahmedabad	(079) 226 84249 / 54
2	Dy. Director, Industrial Safety & Health, Bharuch	240421 (O) / 225 838 (R)
3	District Collector, Bharuch	243499 / 240600
45	Dy. Collector, Bharuch	240900 / 241980
6	DSP, Bharuch	269303 / 269333
7	Police Station, Dahej	256 233
8	Mamlatdar, Vagara	225 221
9	Fire Brigade, Nagarpalika, Bharuch	240 008
10	Fire Brigade, GNFC, Bharuch	247001,2,3 / 249828
11	Primary Health Centre, Dahej	256 223
12	Bharuch Hospital, Bharuch (Patel Welfare)	244 880
13	Civil Hospital, Bharuch	241759 / 243515
14	Bhailal Amin, Vadodara	(0265) 2380300 / 2381301

Sr. No.	Location	Telephone No.
15	Doctors of surrounding Inds. – IPCL	256 666
16	Doctors of surrounding Inds. – Birla Copper	256 004 – 06 / 09
17	GPCB, Bharuch	246333
18	Chief Controller of Explosives, Nagpur	(0712) 510103 / 510580 Fax: (0712) 510577
19	Controller of Explosives, Vadodara	(0265) 2420512 / 2540922
20	Disaster Management Centre, Dahej	(02641) 256 670 Mobile: 98244 75575
21	Boiler Inspector, Bharuch	250 280
	Boiler Inspector, Baroda	(0265) 243 5125
	Chief Inspector of Boiler, Ahmedabad	(079) 2268 5205 / 2268 5206
22	GEB, 220KV Sub-station, Dahej	256 523
23	GEB, 200 KV Haldarva, Bharuch	246 271
24	Electrical Inspector, Bharuch	243 770
25	Central Excise & Custom Dept., Bharuch Range, Bharuch	249389
26	Oriental Insurance Company Ltd., Baroda	(0265) 242 7075 / 242 6380
27	Mutual Aid Organizations	
a	IPCL Gandhar Complex, Dahej	256272 (D), 256373 – 77 Ext: 101, 2400, 2401
b	GACL, Dahej	256315 / 16 / 17 / 18 Ext: 101 / 203 (02642) 248213 (R)
c	Birla Copper, Dahej	(02641) 256004,06,09
d	GCPTCL,	(02641) 256604-05
e	PETRONET LNG	(02641) 257249
f	WELSPUN	(02641) 256011
g	Gujarat Florochem Ltd.	(02641) 256073
h	GACL, Dahej	(02641) 256013,131

Along with this the company / HSE cell shall maintain following emergency equipment:

- Chain Pulley Blocks,
- Mobile Generator Sets,
- Portable Radio Sets,
- Shovel,
- Spade,
- Tasala,
- Manila Rope,
- Search Torches,
- Fire Blankets

The company / HSE cell shall also maintain following firefighting facilities:

- Foam Tenders
- Foam Extinguishers
- Fire Extinguishers
- Fire Water Network (Fire water pumps, Fire Water Storage Tanks etc.),
- Communication Facility,
- Stretcher, Hose Pipe,
- Safety Harness,

- Ladder,
- Gum-boots,
- Rubber Hand Gloves,

7.3.19 Mutual Aid

In certain cases of emergency it is possible that one may fall short of equipment / materials required for tackling emergency. It is also beneficial to enter into an understanding with the neighboring industries, so that resources available with them will be made available during emergencies. This arrangement also helps in avoiding duplication and overstocking.

7.3.20 Fire Fighting Equipments/Items

Table 7-50: List of Fire Fighting Equipments

S. No.	Name of Item
1	Fog Nozzle
2	Flat Nozzle
3	Jet and Spray Nozzle
4	Jet Nozzle (Big Size)
5	Jumbo Curtain Nozzle
6	Dividing Breech
7	Collecting Breech
8	Male – Male Coupling
9	Hydrant Hose
10	Toxic Gas Emergency Handling Kit
11	Mechanical Tool Box