1.1 RISK ASSESSMENT

HPM Chemicals and Fertilizers Ltd. handle various hazardous chemicals, some of which are hazardous in nature by virtue of their intrinsic chemical properties or their operating temperatures or pressures or a combination of them. Fire and explosion or combinations of them are the hazards associated with plants using hazardous chemicals. More comprehensive, systematic and sophisticated methods of Safety Engineering, such as, Hazard Identification and Qualitative/ Quantitative Risk Assessment have been developed to improve upon the integrity, reliability and safety of industrial plants, the same has been discussed in detail under their respective headings.

1.1.1 Objective of the Study

The principle objective of this study is to identify major risks in the manufacturing process and to evaluate On-site & Off-site consequences of identified hazard scenarios. To give effective mitigation of hazards in terms of suggestions for effective disaster management, suggesting minimum preventive and protective measures & change of practices to ensure Occupational Health and Safety.

1.1.2 Details of Storage Facilities

Table 1.1: Existing Tanks

Tank. No.	Name of Hazardous Chemical	Physical state	Number of storage tanks (In Nos.)	Capacity of Storage Tank (KL*) each	Type of Storage Tank (#)	Above ground/ Underground	Operating Tempratur re (°C)	Operating Pressure (bar)	Dyke/Bund area (m^2)	Dyke/Bund Height (m)
1-3	Heavy Aromatics	Liquid	3	15	MS	UG	35	Atm.*	NA	NA
4-8	Mixed Xylene	Liquid	5	20	MS	UG	35	Atm.*	NA	NA
9	Solvent -C-9	Liquid	1	20	MS	UG	35	Atm.*	NA	NA
10	Empty	-	1	20	MS	UG	35	Atm.*	NA	NA
11	Solvent -C-9	Liquid	1	20	MS	UG	35	Atm.*	NA	NA
20	Acetic Unhydride	Liquid	1	20	MS	AG	35	Atm.*	21	2
21	Dimethyl Sulphate	Liquid	1	20	MS	AG	35	Atm.*	21	2
22	Ammonia Solution -20 %	Liquid	1	7	HDPE	AG	35	Atm.*	10.5	2
23	Ammonia Solution -20 %	Liquid	1	7	HDPE	AG	35	Atm.*	10.5	2

*Atm= Atmospheric

Table 1.2: Proposed Tanks

Tank. No.	Name of Hazardous Chemical	Physical state	Number of storage tanks (In Nos.)	Capacity of Storage Tank (KL*) each	Type of Storage Tank (#)	Above ground/ Underground	Operating Tempratur re (°C)	Operating Pressure (bar)	Dyke/Bund area (m^2)	Dyke/Bund Height (m)

12	Ethyl Acetate	Liquid	1	10	MS	AG	35	Atm.*	10.5	2
13	Chloroform	Liquid	1	10	MS	AG	35	Atm.*	10.5	2
14	Methanol	Liquid	1	10	MS	AG	35	Atm.*	10.5	2
15	Acetone	Liquid	1	10	MS	AG	35	Atm.*	10.5	2
16	Toluene	Liquid	1	10	MS	AG	35	Atm.*	10.5	2
17	Dimethyl Formamide	Liquid	1	20	MS	AG	35	Atm.*	21	2
18	N-Butanol	Liquid	1	15	MS	AG	35	Atm.*	14	2
19	N-Hexane	Liquid	1	15	MS	AG	35	Atm.*	14	2

1.1.3 Physico-chemical properties of Chemicals

S. No	Hazardous Chemicals	State	Formula	CAS Number	Color	Odor	Mol. Wt (g/mole)	Boiling Point (°C)	Melting Point (°C)	Flash Point (°C)	LEL %	UEL %	IDLH (ppm)	LD50	LC50	Hazard
1	Acetic acid	Liquid	C_2-H_4-O_2	64-19-7	Colorless. Clear (Light.)	Pungent, vinegar-like, sour (Strong.)	60.05	118.1	16.6	39	4	19.9	50	(LD50): Acute: 3310 mg/kg [Rat]	(LC50): Acute: 5620 ppm 1 hours [Mouse]	Flammable
2	Sulphuric acid	Liquid	H_2SO_4	7664-93-9	Colorless	Odorless, but has a choking odor when hot	98.08	270	-35	Not applicable	Not applicable	Not applicable	3.74	ORAL (LD50): Acute: 2140 mg/kg [Rat.]	(LC50): Acute: 510 mg/m 2 hours [Rat].	Corrosive
3	Hydrochloric acid	Liquid	HCL	Mixture	Colorless to light yellow	Pungent. Irritating	Not applicable	50.5	-62.25	Not applicable	Not applicable	Not applicable	50	(LD50): 900 mg/kg [Rabbit]	(LC50): Acute: 4701 ppm 0.5 hours [Rat]	Corrosive
4	Hexane	Liquid	C_6-H_{14}	110-54-3	Clear Colorless	Gasoline-like or petroleum-like (Slight.)	86.18	68	-95	-22.5	1.15	7.5	1100	ORAL (LD50): Acute: 25000 mg/kg [Rat]	(LC50): 48000 ppm 4 hours [Rat]	Flammable
5	Methanol	Liquid	CH_3OH	67-56-1	Colorless	Alcohol like. Pungent when crude	32.04	64.5	-97.8	12	6	36.5	6000	ORAL (LD50): Acute: 5628 mg/kg [Rat]	(LC50): Acute: 64000 ppm 4 hours [Rat]	Flammable
6	Sodium metabisulfite	Solid	Na2S2O5	7681-57-4	White to yellowish	odor of sulfur dioxide	190.13	Not available	Decomposition temperature: 150	Not applicable	Not applicable	Not applicable	-	(LD50): Acute: 1131 mg/kg	-	Irritant

S. No	Hazardous Chemicals	State	Formula	CAS Number	Color	Odor	Mol. Wt (g/mole)	Boiling Point (°C)	Melting Point (°C)	Flash Point (°C)	LEL %	UEL %	IDLH (ppm)	LD50	LC50	Hazard
														[Rat]		
7	Toluene	Liquid	C_7H_8	108-88-3	Colorless	Sweet	92.14	-95	110.61	4.44	1.27	7.1	500	ORAL (LD50): Acute: 636 mg/kg [Rat]	(LC50): Acute: 49000 mg/m 4 hours [Rat].	Flammable and Toxic
8	Methyl Acetate	Liquid	CH3COOCH3	79-20-9	Colorless	Fragrance like	74.08	57	-98.05	-5.56	3.1	16	3100	ORAL (LD50): Acute: 5001 mg/kg [. Rat]	-	Flammable.
9	Chloroform	Liquid	CHCl3	67-66-3	Colorless	Pleasant. Sweetish. Etheric. Non-irritating	119.38	61	-63.5	NA	NA	NA	500	ORAL (LD50): Acute: 695 mg/kg [Rat].	LC50): 47702 mg/m 4 hours [Rat]	Toxic
10	Acetone	Liquid	C3-H6-O	67-64-1	Colorless	Fruity. Mint-like. Fragrant. Ethereal	58.08	56.2	-95.35	-9	2.6	12.8	2500	ORAL (LD50): Acute: 5800 mg/kg [Rat	(LC50): Acute: 50100 mg/m 8 hours [Rat]	Flammable
11	Dimethyl Formamide	Liquid	HCON(CH3)2	68-12-2	Colorless to light yellow	Amine like	73.09	153	-61	57.77	2.2	15.2	3500	ORAL (LD50): Acute: 2800 mg/kg [Rat]	(LC50): 9400 1 hours [Mouse].	Flammable
12	Butanol	Liquid	CH3(CH2)2CH2OH	71-36-3	Colorless	Vinous	74.12	117.7	-89.5	28.9	1.4	11.2	1400	ORAL (LD50): Acute: 790 mg/kg [Rat.].	(LC50): 8000 4 hours [Rat.].	Flammable

S. No	Hazardous Chemicals	State	Formula	CAS Number	Color	Odor	Mol. Wt (g/mole)	Boiling Point (°C)	Melting Point (°C)	Flash Point (°C)	LEL %	UEL %	IDLH (ppm)	LD50	LC50	Hazard
13	Xylene	Liquid	C6H4(CH3)2	1330-20-7	Colorless	Sweetish	106.17	138.5	-47.4	24	1	7	data unavailable	ORAL (LD50): Acute: 4300 mg/kg [Rat]	(LC50): 5000 4 hours [Rat]	Flammable
14	Dimethyl Sulphate	Liquid	(CH3)2SO4	77-78-1	Colorless	Odorless	126.13	Decomposes	-31.8	83.3	NA	NA	7	ORAL (LD50): Acute: 205 mg/kg [Rat]	(LC50): Acute: 45 ppm 4 hour(s) [Rat]	Toxic
15	2-Heptanol	Liquid	C7-H16-O	543-49-7	Colorless	Slight	116.2	161	Not available	71	Not available	Not available	-	ORAL (LD50): Acute: 2580 mg/kg [Rat]	-	Combustible
16	Acetic anhydride	Liquid	(CH3CO)2)	108-24-7	Light	Strong	102.09	139.9	-73.1	49	2.7	10.3	200	(LD50): 1780 mg/kg [Rat]	(LC50): 1000 4 hours [Rat]	Flammable and Toxic
17	Tetra-n-butylammonium bromide	Solid	C16H36NBr	1643-19-2	Not Available	Not Available	322.38	Decomposes	103.5	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	Irritant
18	2-Chloro-5-(Chloromethyl) Thiazole (CCMT)	Liquid	C4H3Cl2NS	105827-91-6	Light yellow to yellow liquid	Not Available	168.04	Not Available	31	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	Irritant
19	Caustic Flakes (NaOH)	Solid	NaOH	1310-73-2	White	Odorless	40	1388	323	Not applicable	Not applicable	Not applicable	6.11	Not Available	Not Available	Irritant
20	3-Methyl-4-nitroiminoperhydro-1,3,5-oxadiazine	Solid	C4H8N4O3	153719-38-1	-	-	160.131	290.9	141-143	129.8	-	-	-	-	-	Irritant
21	2-	Solid	-	5465-	Off-	-	-	Not	210-213	Not	Not	Not	Not	Not	Not	Irritant

S. No	Hazardous Chemicals	State	Formula	CAS Number	Color	Odor	Mol. Wt (g/mole)	Boiling Point (°C)	Melting Point (°C)	Flash Point (°C)	LEL %	UEL %	IDLH (ppm)	LD50	LC50	Hazard
	(Nitroimino)imidazolidine			96-3	white			Applicable		Applicable	Applicable	Applicable	Applicable	Applicable	Applicable	
22	Potassium carbonate	Solid	K2CO3	584-08-7	White	Odorless	138.21	Decomposes	891	Not Applicable	Not Applicable	Not Applicable	-	(LD50): Acute: 1870 mg/kg [Rat].	-	Irritant
23	Hydrogen peroxide	Liquid	H2O2	7722-84-1	Clear Colorless	Odorless	Not Applicable	108	-33	Not Applicable	Not Applicable	Not Applicable	75	Acute: 4060 mg/kg [Rat]	(LC50): Acute: 2000 mg/m 4 hours [Rat].	Toxic
24	Oxalyl chloride	Liquid	(ClCO)2	79-37-8	Clear Colorless	Not available	126.93	64	-12	Not applicable	Not Available	Not Available	-	Not Available	Not Available	Irritant
25	Sodium Cyanide	Solid	NaCN	143-33-9	White	Faint almond-like odor	49.01	1496	563	Not available	Not available	Not available	12.47	(LD50): Acute: 6.44 mg/kg [Rat].	-	Toxic
26	m-phenoxy benzaldehyde	Solid	C13H10O2	39515-51-0	-	-	198.22	392	13	156	-	-	-	-	-	Irritant
27	Sodium carbonate	Solid	Na2-C-O3	497-19-8	White	Odorless	105.99	Not available	851	Not applicable	Not applicable	Not applicable	-	(LD50): Acute: 4090 mg/kg [Rat]	(LC50): Acute: 2300 mg/m 2 hours [Rat]	Irritant
28	Isopropyl alcohol	Liquid	C3-H8-O	67-63-0	Colorless	Pleasant	60.1	82.5	-88.5	11.667	2	12.7	2000	ORAL (LD50): Acute: 5045 mg/kg [Rat]	(LC50): 160008 hours [Rat].	Flammable
29	Bifenthrin Alcohol	Liquid	C14H14O	76350-90-8	White	Odorless	198.25	-	72 - 72.5	177	-	-	-	-	-	Irritant
30	Thionyl	Liquid	Cl2OS		Colorle	Suffocatin	118.98	76	-104.5	Not	Not	Not	-	-	LC50):	Corrosiv

S. No	Hazardous Chemicals	State	Formula	CAS Number	Color	Odor	Mol. Wt (g/mole)	Boiling Point (°C)	Melting Point (°C)	Flash Point (°C)	LEL %	UEL %	IDLH (ppm)	LD50	LC50	Hazard
	chloride			7719-09-7	ss to light yellow	g				applicable	applicable	applicable			Acute: 500 ppm 1 hours [Rat]	e
31	Ethylene dichloride	Liquid	C2H4Cl2	107-06-2	clear colorless	chloroform-like	98.96	182.3	-31.5	56	6.2	15.9	50	ORAL (LD50): Acute: 670 mg/kg [Rat]	(LC50): Acute: 1414.2 ppm 4 hour(s) [Rat]	Flammable and Toxic
32	3,5,6-Trichloropyridin-2-ol sodium	Solid	C5HCl3NNaO	37439-34-2	Not available	Not available	220.42	Not available	Not available	Not available	Not available	Not available	Not available	Not available	Not available	-
33	Ethyl acetate	Liquid	C4-H8-O2	141-78-6	Colorless	Ethereal. Fruity	88.11	77	-83	-4.4	2.2	9	2000	ORAL (LD50): Acute: 5620 mg/kg [Rat]	(LC50): Acute: 45000 mg/m 3 hours [Mouse]. 16000 ppm 6 hours [Rat]	Flammable
34	Tetrabutylammonium bromide	solid	$C_{16}H_{36}NBr$	1643-19-2	White	Odourless	322.4	99.8	96.7	100	Not available	Not available	-	2142.38 mg/kg (Rat)	-	Combustible
35	Ethanol	Liquid	CH3CH2OH	64-17-5	Colorless	Mild to strong	46.07	78.5	-114.1	12.78	3.3	19	3000	ORAL (LD50): Acute: 7060 mg/kg [Rat].	(LC50): Acute: 20000 ppm 8 hours [Rat].	Flammable
36	Sodium hydrosulfite	Solid	Na2S2O4	7775-14-6	Grayish white	Sulfurous	174.11	Not available	Decompos	Not availabl	Not availabl	Not availabl	-	ORAL (LD50):	-	Combustible

S. No	Hazardous Chemicals	State	Formula	CAS Number	Color	Odor	Mol. Wt (g/mole)	Boiling Point (°C)	Melting Point (°C)	Flash Point (°C)	LEL %	UEL %	IDLH (ppm)	LD50	LC50	Hazard
									ition temperature: 20	e	e	e		Acute: 500 mg/kg [Rat].		
37	N-Propyl Bromide	Liquid	C3H7Br	106-94-5	Pale yellow liquid	Characteristic odour	123	71	-110	-10	3.5	9.7	-	540 mg/kg	7100 ppm	Flammable
38	Ammonium bicarbonate	Solid	NH4HCO3	1066-33-7	White	Ammoniacal	79.06	Not available	107.5	Not applicable	Not applicable	Not applicable	-	Not available	Not available	Irritant
39	Thiourea	Solid	NH2CSNH2	62-56-6	Not available	Not available	76.12	Decomposes	177	Not available	Not available	Not available		ORAL (LD50): Acute: 125 mg/kg [Rat]	-	combustible
40	Cuprous chloride	Solid	CuCl	7758-89-6	White	Not available	99	1490	430	Not applicable	Not applicable	Not applicable	-	ORAL (LD50): Acute: 140 mg/kg [Rat]	-	Irritant
41	Benzoic acid	Solid	C6H5COOH	65-85-0	Not available	Not available	122.12	249.2	122.4	121	Not available	Not available	-	ORAL (LD50): Acute: 1700 mg/kg [Rat]	-	Combustible
42	Formic acid	Liquid	Not applicable	Mixture	Clear Colorless	Pungent	Not applicable	100	8.4	69	18	57	30	1100 mg/kg [Rat]	(LC50): Acute: 6200 mg/m 0.25 hours	Toxic and Combustible
43	Sodium thiocyanate	Solid	NaCNS	540-72-7	Not available	Not available	81.07	Decomposes	287	Not available	Not available	Not available	-	ORAL (LD50): Acute: 764	-	Combustible

S. No	Hazardous Chemicals	State	Formula	CAS Number	Color	Odor	Mol. Wt (g/mole)	Boiling Point (°C)	Melting Point (°C)	Flash Point (°C)	LEL %	UEL %	IDLH (ppm)	LD50	LC50	Hazard
														mg/kg [Rat].		
44	Dimethylamine	Gas	C2H7N	124-40-3	Colorless	fishy ammonia-l	45	6.9	-92.2	20	2.8	14.4	500	698 mg/kg (Rat)	11000 ppm/1h (Rat)	Flammable and Toxic
45	Methyl Chloroformate	Liquid	C2-H3-CL-O2	79-22-1	Colorless	Strong	94.5	71.4	-81	22.78	6.7	-	-	60 mg/kg [Rat]	44 ppm 4 hour(s) [Rat].	Flammable
46	O-Phenylenediamine	Solid	C6H8N2	95-54-5	Yellowish-brown	Not available	108.14	257	103.5	156	1.5	-	-	LD50): Acute: 510 mg/kg [Rat]	(LC50): Acute: 2648.8 ppm 4 hour(s) [Mouse]	Irritant
47	Methoxy Acetyl Chloride	Liquid	C3H5ClO2	38870-89-2	Light yellow	Not available	108.5	112.0 - 113.0	-	28	Not available	Not available	-	Oral 2456 mg/kg	-	Flammable
48	Ethyl chloroformate	Liquid	ClCO2C2H5	541-41-3	Colorless to light yellow	Irritant.	108.53	94	-81	16	Not available	Not available	-	(LD50): Acute: 270 mg/kg [Rat]	LC50): Acute: 72.5 ppm 4 hour(s) [Rat]	Flammable
49	4-Dimethylamino pyridine	Solid	C7-H10-N2	1122-58-3	White	Odorless	122.17	162	110	110	Not available	Not available	-	LD50): Acute: 250 mg/kg [Rat]	-	Combustible
50	Propargyl chloride	Liquid	C3H3Cl	624-65-7	Not available	Not available	74.51	57	-77	32	Not available	Not available	-	Not available	Not available	Flammable
51	Chloroacetyl Chloride	Liquid	C2-H2-Cl2-O	79-04-9	Colorless to light yellow	Pungent	112.95	105	-22	Not available	Not available	Not available	-	208 mg/kg [Rat].	662 mg/kg [Rat]	Irritant
52	Sodium	Solid	Na2WO4.2H2	10213	Not	Not	329.86	Not	692.22	Not	Not	Not	-	Not	Not	Irritant

S. No	Hazardous Chemicals	State	Formula	CAS Number	Color	Odor	Mol. Wt (g/mole)	Boiling Point (°C)	Melting Point (°C)	Flash Point (°C)	LEL %	UEL %	IDLH (ppm)	LD50	LC50	Hazard
	tungstate		O	-10-2	available	available		available		applicable	applicable	applicable		available	available	
53	Vanadyl sulfate	Solid	VOSO4.xH2O	27774-13-6	Blue	Not available	163.01	Not available	Decomposes	Not applicable	Not applicable	Not applicable	-	ORAL (LD50): Acute: 4450 mg/kg [Rat]	-	Irritant
54	Cyanuric Chloride	Liquid	C3Cl3N3	108-77-0	Colorless	Strong	184.41	194	150	Not available	Not available	Not available	-	ORAL (LD50): Acute: 485 mg/kg [Rat]	(LC50): Acute: 2.7 ppm 4 hour(s) [Mouse].	Irritant
55	Isopropylamine	Liquid	C3-H9-N	75-31-0	Colorless	Ammonia-like	59.1	33.5	-101	-35	2	10.4	750	ORAL (LD50): Acute: 111 mg/kg [Rat	(LC50): Acute: 4000 ppm 4 hours [Rat].	Flammable and Toxic
56	Monomethylamine	Liquid	CH3 NH2	74-89-5	Colorless	Fishy ammonia	45.09	-6.3	-93.5	0	4.9	20	100	Not available	8000 ppm (Rat)	Flammable and Corrosive
57	Benzyltriethylammonium chloride	Solid	C13H22NCl	56-37-1	Not available	Not available	227.8	Not available	Decomposition temperature: 185	Not available	Not available	Not available	-	Not available	Not available	Combustible
58	Carbon tetrachloride	Liquid	CCl4	56-23-5	Not available	Not available	153.82	76.54	-23	Not applicable	Not applicable	Not applicable	200	ORAL (LD50): Acute: 2350 mg/kg [Rat]	(LC50): Acute: 8000 ppm 4 hour(s) [Rat]	Toxic
59	Acrylonitrile	Liquid	C3-H3-N	107-13-1	Clear Colorle	Mild Peach	53.06	77.3	-82	-1.11	3.1	17	85	ORAL (LD50):	(LC50): Acute:	Flammable

S. No	Hazardous Chemicals	State	Formula	CAS Number	Color	Odor	Mol. Wt (g/mole)	Boiling Point (°C)	Melting Point (°C)	Flash Point (°C)	LEL %	UEL %	IDLH (ppm)	LD50	LC50	Hazard
					ss.	kernels								Acute: 78 mg/kg [Rat]	333 ppm 4 hours [Rat]	
60	Isobutelene	Liquid	C4H8	115-11-7	Colorless	Sweetish	56	-6.9	-140.3	-80	1.8	8.8	-	-	-	Flammable
61	Chloro Acetic Acid	Solid	C2H3ClO2	79-11-8	white	No data available	94.5	189	60	126	8	-	-	Oral - Rat 90.4 mg/kg	Rat - 180 mg/m3	Irritant
62	p-Toluenesulfonic Acid	Liquid	Not applicable	Mixure	Clear Colorless	Not available	Not applicable	56.2	-95.35	-20	2.6	12.8	-	(LD50): 2840 mg/kg (Mouse)	-	Flammbale
63	Diethyl Ketone	Liquid	C5H10O	96-22-0	colorless	Acetone like	86.13	101.5	Not available	7	Not available	Not available	-	Oral - rat - 2.140 mg/kg	-	Flamable
64	Heavy Aromatics	Liquid	C10	64742-94-5	Clear	NA	NA	190	NA	62	NA	NA	NA	NA	NA	Flammable

1.1.4 Scenarios for Simulation

#	Full name of the Raw Material	Hazard involved	No. and Size of storage tank/ Cylinder		Maximum Operating Pressure	Types of Failure Possible	Consequences Considered
			Nos.	Capacity (KL) each			
1.	Hexane	Flammable	1	15	Atmospheric (1.0 kg/cm2)	2 mm dia hole leak in tank	Pool Fire, explosion
						Catastrophic Rupture of storage tank	Pool Fire, Explosion
2.	Dimethylformamide	Flammable	1	20	Atmospheric (1.0 kg/cm2)	5 mm dia hole leak in tank	Pool Fire, explosion
						Catastrophic Rupture of storage tank	Pool Fire, Explosion
3.	Toluene	Flammable	1	10	Atmospheric (1.0	2 mm dia hole leak in tank	Pool Fire, explosion &

		& Toxic			kg/cm2)		Toxic Dose
						Catastrophic Rupture of storage tank	Pool Fire, explosion & Toxic Dose
4.	Acetone	Toxic	1	10	Atmospheric (1.0 kg/cm2)	2 mm dia hole leak in tank	Pool Fire, explosion
						Catastrophic Rupture of storage tank	Pool Fire, Explosion

1.2 QUALITATIVE RISK ASSESSMENT

Many a times risk involved in various processes / process equipments cannot be addressed completely by consequence analysis. As a conservative approach, these risks have been considered separately under this topic. The approach is to identify hazards associated in operation of equipments as well as in processes, assessing its impacts, ranking the risk posed by it and finally to propose remedial actions/mitigation measures such that the risk is minimized to tolerable level. The Risk Matrix presented below should be referred in evaluating this assessment.

In Qualitative Risk Assessment, risk has been analyzed using methodology called HIRA-Hazards Identification & Risk Assessment. In HIRA, major manual activities carried out by plant personnel as well as contract labors have been considered.

Qualitative Risk Assessment has been carried out for the following areas:

- Storage and Handling of Solid chemicals like Sodium metabisulfite, Sodium Carbonate, Thiourea, Cuprous chloride *etc*.
- Storage and Handling of Corrosive chemicals like Sulphuric acid, Hydrochloric acid, Thionyl Chloride *etc*.
- Storage and Handling of Toxic chemicals like Di methyl sulphate, Dimethyl Formamide, Toulene *etc*.

Risk involved in various processes / process equipment cannot be addressed completely by consequence analysis. As a conservative approach, these risks have been considered separately under this topic. The approach is to identify hazards associated in operation of equipment as well as in processes, assessing its impacts, ranking the risk posed by it and finally to propose remedial actions/mitigation measures such that the risk is minimized to tolerable level. The Risk Matrix presented in Table 1.3, is referred in evaluating the assessment. Risk acceptability criteria given in Table 1.4.

Table 1.3: Risk Matrix for Qualitative Risk Assessment

LIKEHOOD/ PROBABILITY		SEVERITY				
		Catastrophic (Death/ System Loss)	Major/ Critical (Serious injury/ Illness)	Moderate (Less Serious Injury/ Illness)	Minor/ Marginal (Minor Injury/ Illness)	Insignificant/Negligible (No injury /illness)
		5	4	3	2	1
Almost Certain	E	H	H	H	M	M
Likely	D	H	H	M	M	L
Possible	C	H	M	M	M	L
Unlikely	B	M	M	M	L	L
Impossible	A	M	M	L	L	L

Table 1.4: Risk Acceptability Criteria

Risk Range	Risk Acceptability Criteria	Remarks
H	Unacceptable/ High	Management"s Decision/Action Plan Required. Potential off-site Impact.
M	Medium	Generally Minor Impact. Acceptable with Management"s Review. Specific monitoring or SOP to be followed.
L	Low	Acceptable without Review. Manage through Routine Procedure.

- **Storage and Handling of Solid Chemicals like Sodium metabisulfite, Sodium Carbonate, Thiourea, Cuprous chloride *etc*.**

S. No.	Process Or Activity	Associated Hazards	Health & Safety Impact (Risk)	Initial Risk			Mitigation Measures	Residual Risk		
				Severity	Likelihood	Risk		Severity	Likelihood	Risk
1	Handling Chemical bags	Chemical Exposure	Skin/Eye/ Lung irritation.	3	C	M	Operators/Workers to be trained for Safe Work Practices. Chemical handling bags to be labeled properly Availability of Eye wash and Safety shower station nearby Chemicals shall be stored in an isolated storage rooms having provision for natural & forced ventilation. Shall be stord in cooled place and equipment containig material shall be grounded. Certified Dust respirator shall be used. Use of suitable protective clothing like apron, Helmet and hand gloves Keep away from incompatibles such as oxidizing agents, metals, moisture. Sodium Carbonate Donot store above 24°C, Sodium tungstate Do not store above 25°C	1	B	L
2	Cleaning of Chemical Spillage.	Fumes Inhalation. Dust Exposure. Splashing	Severe irritation to eyes, skin.	3	C	M	Spillage shall be cleaned or neutralized with suitable media. Vapor and dust respirator, Dust mask shall be used. Suitable protective clothing, gloves, boots shall be used as per the MSDS.	1	B	L

- **Storage and Handling of Corrosive chemicals like Sulphuric acid, Hydrochloric acid, Thionyl Chloride *etc.***

S. No.	Process Or Activity	Associated Hazards	Health & Safety Impact (Risk)	Initial Risk			Mitigation Measures	Residual Risk		
				Severity	Likelihood	Risk		Severity	Likelihood	Risk
1	Acids Loading & Unloading.	Exposure to acid fumes (due to leakage in pipe/ container/ valves etc.).	Skin/Eye irritation.	4	C	M	Loading & Unloading activity shall be carried out in well-ventilated area under chemical engineer supervision. Training for lifting and chemical transporting technique from one location to another location shall be provided	1	B	L
		Splash over body	Toxic Vapor inhalation etc.				Periodic Inspection of flanges/ferrule joints shall be carried out.			
		Spillage.	Acid burns				Eye wash and Safety shower station shall be at proximal location.			
							Neutralization media shall be kept available in areas where acids are stored/ handled/ used.			
							PPEs like chemical safety goggles or full face shield, Rubber or neoprene gloves and additional protection including impervious boots, apron shall be used.			
							Respirators shall be used.			
2	Working in Storage Area.	Exposure to acid fumes.	Severe irritation to eyes, skin.	4	C	M	Acid proof floorings shall be constructed.	2	B	L
			Body burns.				In case of spillage, neutralization shall be done immediately with soda ash/lime or spill shall be absorbed in sand or by suitable adsorbent.			
							PPEs like chemical safety goggles or full face shield, Rubber or neoprene gloves and additional protection including impervious boots, apron shall be used.			
							Respirators shall be used.			
							Eye wash stations & Safety Shower shall be installed			

							in near vicinity.				
							Only trained personnel shall be allowed to work in this area.				
3	Tank overflow/leakage from joints etc.	Exposure to acid fumes.	Severe irritation to eyes, skin.	4	B	M	Level indicator shall be provided. Provision of adequate Dyke wall. PPEs like chemical safety goggles or full face shield, Rubber or neoprene gloves and additional protection including impervious boots, apron shall be used. Respirators shall be used. Eye wash stations & Safety Shower shall be installed in near vicinity.	2	B	L

- **Storage and Handling of Toxic chemical like Di methyl sulphate, Dimethyl Formamide, Toulene *etc*.**

S. No.	Process Or Activity	Associated Hazards	Health & Safety Impact (Risk)	Initial Risk			Mitigation Measures	Residual Risk		
				Severity	Likelihood	Risk		Severity	Likelihood	Risk
1	Chemical handling / Loading & Unloading	Exposure to fumes (due to leakage from joints, corroded lines failure etc.).	Skin burn. Eye irritation Intestine disorder and respiratory disorder.	3	C	M	Dyke will be provide. Shall be stored in well-ventilated area. Eye wash station and Safety Shower shall be installed in nearby location. Maintenance shall be carried as per schedule. Employee will be provided with impervious clothes, gloves, face shield (eight-inch minimum), respirators, dust and splash proof safety goggles, chemically resistant safety shoes, etc. Proper trainings to be provided to the operators/ workers. SOPs to be prepared and followed the same. Spill control procedure is available.	2	B	L
2	Working in Storage Area	Exposure to fumes due to spillage.	Severe irritation to eyes, skin etc. Internal body burns.	4	C	M	PPEs like cartridge face mask, gloves, goggles, *etc*. shall be worn by concerned person. Eye wash station or Safety Shower shall be	2	B	L

							installed in storage area.			
							Provision of an automatic leak detection system for toxic fumes.			
							Display of Safety warning postures/signs inside the area.			
3	Tank overflow	Chemical Exposure	Eyes and Skin irritation.	4	B	M	Level indicator shall be installed and the same shall be checked for its proper operation.	2	B	L
							Dyke wall shall be available to contain the spill.			
							Periodic inspection to be carried for all the related accessories of level indicator.			

1.3 QUANTITATIVE RISK ASSESSMENT

Quantitative Risk Assessment (QRA) is a structured approach to identifying and understanding the hazards and risks associated with Storage and Handling of flammable/ toxic chemicals. The assessment starts by taking into account an inventory of hazardous chemicals stored, likelihood of leakage/ spillage associated with it and selecting the worst case scenario for consequence estimation. Finally, suggesting the measures to minimize or mitigate risks to meet appropriate acceptability criteria. The planning for emergency evacuation shall be borne in mind whilst interpreting the results.

Consequence analysis

In a plant handling hazardous chemicals, the main hazard arises due to storage and handling of hazardous chemicals as mentioned above. If these chemicals are released into the atmosphere, it may cause damage due to resulting fires or vapor clouds. Blast overpressures depend upon the reactivity class of material between two explosive limits.

Damage criteria

In consequence analysis studies, in principal three types of exposure to hazardous effects are distinguished:

1. Heat radiation, from jet fire, pool fire, a flash fire or a BLEVE
   - Explosion
   - Toxic effects, from toxic materials or toxic combustion products.

The chosen damage criteria are given and explained as per the Guidelines for QRA – PHAST Software, version 6.7 (DNV) & Purple Book for QRA released by Centre for Chemical Process Safety (CCPS).

Planning

Hazards that can lead to accidents in operations are discussed in this section. Important hazardous events are classified in Table 1.5.

Table 1.5: Event Classification

Type of Event	Explanation
BLEVE	Boiling Liquid Evaporating Vapor Explosion; may happen due to catastrophic failure of refrigerated or pressurized gases or liquids stored above their boiling points, followed by early ignition of the same, typically leading to a fire ball
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 (Vapor 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:

Table 1.6: Damage due to Radiation Intensity

Radiation (kW/m2)	Damage to Equipment	Damage to People
1.2	Solar heat at noon	-
1.6	-	Minimum level of pain threshold
2.0	PVC insulated cable damage	-
4.0	-	Causes pain if duration is longer than 20 sec. But blistering is unlikely.
6.4	-	Pain threshold reached after 8 sec. Second degree burns after 20 sec.
12.5	Minimum energy to ignite wood with a flame; melts plastic tubing.	1% lethality in one minute. First degree burns in 10 sec.
16.0	-	Severe burns after 5 Sec.
25.0	Minimum energy to ignite wood at identifying long exposure without a flame.	100% lethality in 1 min. Significant injury 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.

Table 1.7: Overpressure Damage

Overpressure (bar)	Damage
0.001 0.002 0.003	Annoying noise (137 dB if of low frequency 10-15 Hz) Loud noise (143 dB, sonic boom glass failure Occasional breaking of large glass windows already under strain
0.007	Breakage of small windows under strain
0.010 0.020	Typical pressure for glass breakage projectile limit; some damage to house ceilings; 10% window glass broken
0.027	Limited minor structural damage
0.034 0.034 to 0.068	Large and small windows usually shattered; occasional damage to window frames
0.048 0.068 0.068 to 0.136	Minor damage to house structures Partial demolition of houses, made uninhabitable Corrugated asbestos shattered; corrugated steel or aluminum panels, fastenings fail, followed by buckling, wood panels (standard housing) fastenings fail, panels blown in

Overpressure (bar)	Damage
0.088 0.136 0.136 to 0.204	Steel frame of clad building slightly distorted Partial collapse of walls and roofs of houses Concrete of cinder brick walls, not reinforced, shattered
0.157	Lower limit of serious structural damage
0.170 0.204 0.204 to 0.272	50% destruction of brickwork of houses Heavy machines (3,000 lb) in industrial building suffered little damage; steel frame building distorted and pulled away from foundations. Frameless, self -framing steel panel building demolished; rupture of oil storage tanks
0.272 0.340	Cladding of light industrial buildings ruptured Wooden utility poles snapped; tall hydraulic press (40,000 lb) in building slightly damaged
0.340 to 0.476 0.476	Nearly complete destruction of houses Loaded train wagons overturned
0.476 to 0.544 0.612 0.680 20.414	Brick panels, 8-12 inches thick, not reinforced; heavy machine tools (7,000 lb) moved and badly Loaded trains boxcars completely demolished Probable total destruction of buildings; heavy machines tools (7,000 lb) moved and badly damaged, very heavy machines tools (12,000 lb) survived. Limit of crater lip

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)

Following are some of the common terms used to express toxicity of materials.

- 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.
- 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 (*eg.* 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 a death in human or animals.
- 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 teratogenic effect in humans or animals.
- Emergency Response Planning Guidelines 1 (ERPG1): 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 odor.
- Emergency Response Planning Guidelines 2 (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 Guidelines 3 (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.

Meteorology

Atmospheric stability plays an important role in the dispersion of the chemicals. “Stability means, its ability to suppress existing turbulence or to resist vertical motion”.

Atmospheric stability plays an important role in the dispersion of chemicals. “Stability means, its ability to suppress existing turbulence or to resist vertical motion”.

Variations in thermal and mechanical turbulence and in wind speed are greatest in the atmospheric layer in contact with the surface. The air temperature has influenced these turbulences greatly and air temperature decreases with the height. The rate at which the temperature of air decreases with height is called Environment Lapse Rate (ELR). It will vary from time to time and from place to place. The atmosphere is said to be stable, neutral or unstable according to ELR less than, equal to or greater than Dry Adiabatic Lapse Rate (DALR), which is a constant value of 0.98 ºC per 100 meters.

Pasquill Stability Classes

Pasquill has defined Six (6) stability classes.

A - Extremely unstable.

B - Moderately unstable

C - Slightly unstable.

D - Neutral

E - Slightly stable.

F - Moderately stable.

Three prime factors that defines Stability

Solar radiation

Night-time sky over

Surface wind

When the atmosphere is unstable and wind speeds are moderate or high or gusty, rapid dispersion of vapors will occur. Under these conditions, air concentrations will be moderate or low and the material will be dispersed rapidly. When the atmosphere is stable and wind speed is low, dispersion of material will be limited and air concentration will be high.

Weather Conditions

Following Weather conditions are selected for consequence analysis

Table 1.8: Weather Condition Selected

Time	Remarks	Weather Condition		
		Temperature in °C	Wind speed m/s	Stability Class
Day Time	Prevalent during the day, most times of the year	29	1.5	D
Night Time	Prevalent during the night, most times of the year	23	1.5	F
Monsoon Period	Prevalent during the monsoon months	31	5	D

Consequences Analysis

The consequences of the release of Hazardous substances by failures or catastrophes and the damage to the surrounding area can be determined by means of models. Models help to calculate the physical effects resulting from the release of hazardous substances and to translate the physical effects in terms of injuries and damage to exposed population and environment. To assess the damage level caused by the various accidental events, it is essential to firm up the damage criteria with respect to different types of accidents *e.g.* thermal radiation, toxicity, explosion overpressure *etc.*

Consequence analysis involves the application of mathematical, analytical and computer models for calculation of effects and damages subsequent to a hydrocarbon release accident. Consequence models are used to predict the physical behavior of the hazardous incidents. The techniques used to model the consequences of hydrocarbon and other hazardous material releases cover the following:

- Modeling of discharge rates when holes develop in process equipment/pipe work/pipeline.
- Modeling of the size and shape of flammable and toxic gas clouds from releases in the atmosphere
- Modeling of the flame and radiation field of the releases that are ignited and burn as jet fire, pool fire, flash fire and BLEVE/ Fire ball
- Modeling of the explosion fields of releases, which are ignited away from the point of release

The information normally required for consequence analysis includes meteorological conditions, failure data of equipment and components, ignition sources, population characteristics within and outside the plant, acceptable levels of risk *etc*.

Assumption

For consequence analysis, assumptions regarding Meteorological, Pasquil Stability Classes, Wind velocity, Ambient Temperature, Relative Humidity, Inventory, Ground Roughness, Model used etc. are very important. In this report, the following assumptions have been considered.

Meteorological Paste other tables

- Atmospheric Conditions: No Inversion
- Ambient Temperature: 35°C has been considered as MCA approach.

Pasquil Stability Classes

- Pasquil Stability category D, F & D is considered as conservative approach.

Other assumptions:

- Inventory: Release of 100% of the inventory has been considered. For this, failure of the container has been considered from the bottom.
- Storage conditions: Storage conditions have been considered as they are practically stored at site.

Input data for software (modeling)

For consequence analysis, input data considered are as below:

1. Volume inventory (Quantity of material)
2. Scenario
    - Leak
    - Catastrophic Rupture
3. Leak size
    - 2, 5,10 mm hole in tank
4. Storage conditions
    - Pressure
    - Temperature
5. Bund details
    - Bund height
    - Bund area
6. Weather condition:
    - Wind speed
    - Pasquil stability
    - Atmospheric temperature
    - Relative humidity

MCAS Development Techniques

As a first step towards risk assessment is to identify the possible release scenarios based on available information about scenario development for Maximum Credible Accident Scenarios (MCAS).

Selection of Maximum Credible Loss Scenarios (MCLS')

Following points are considered while selecting the release scenarios:

- Flash point for flammable chemicals
- IDLH of Toxic chemicals
- Operating/ Storage Temperature and Pressure of the material
- Total inventory of the material

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. Contours are presented on plant layout.

1.3.1 Hexane

Radiation level effect distance and overpressure effect distance due to the release of Hexane are presented below:

Table 1.9: Effect Distance due to Release of Hexane

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level			Overpressure Distances in Meters		
				4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2	0.02 bar	0.13 bar	0.2 bar
Hexane	2 mm Leak	Pool Fire, explosion	1.5/F	**8.81**	5.90	2.99	-	-	-
			1.5/D	7.71	5.29	2.85	-	-	-
			5.0/D	6.67	5.19	3.31	-	-	-
	Catastrophic Rupture	Pool Fire, explosion	1.5/F	20.85	11.95	4.20	97.83	47.56	43.58
			1.5/D	21.35	12.17	4.20	110.48	54.63	51.32
			5.0/D	**23.15**	15.39	5.08	**125.19**	58.71	54.48

The contour for effect distance generated for the release of Hexane is presented below;

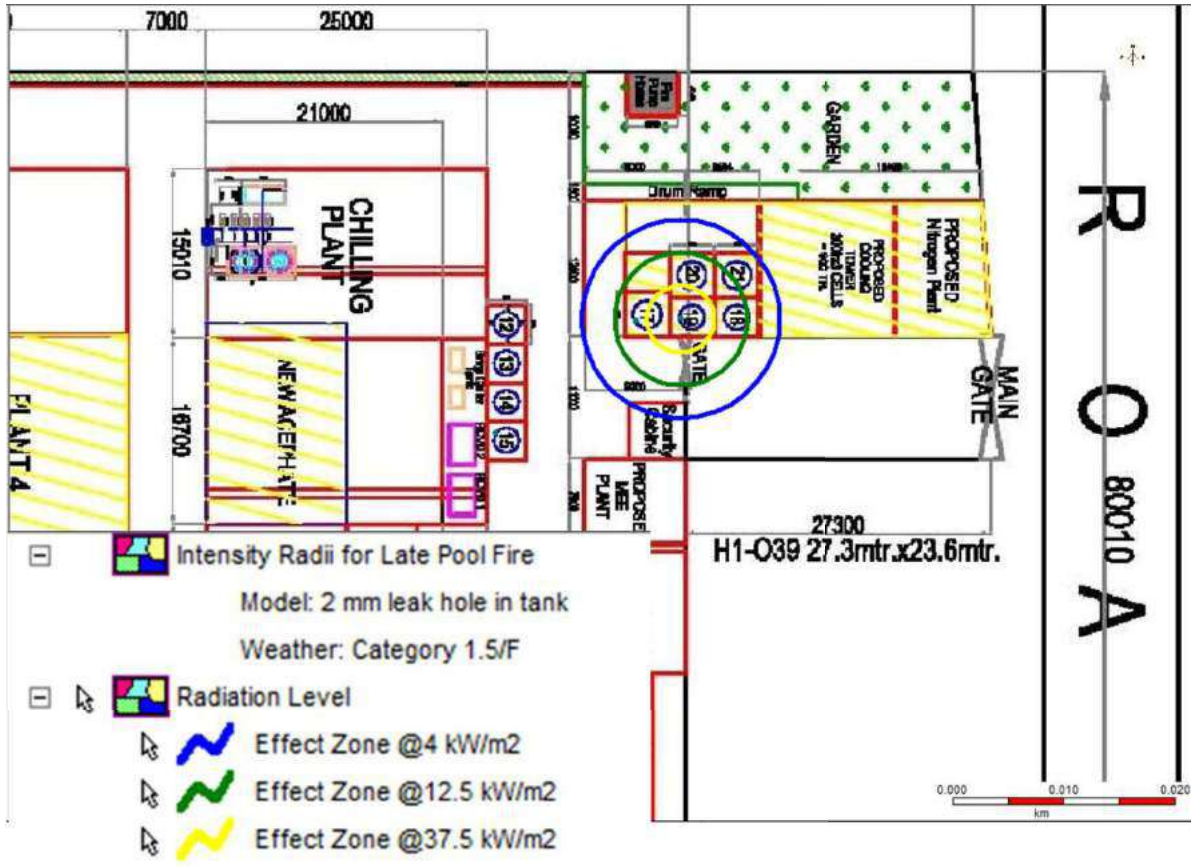

Figure 1.2 Late Pool Fire effect distance Contour due to 2 mm dia hole in storage tank at weather condition 1.5/F

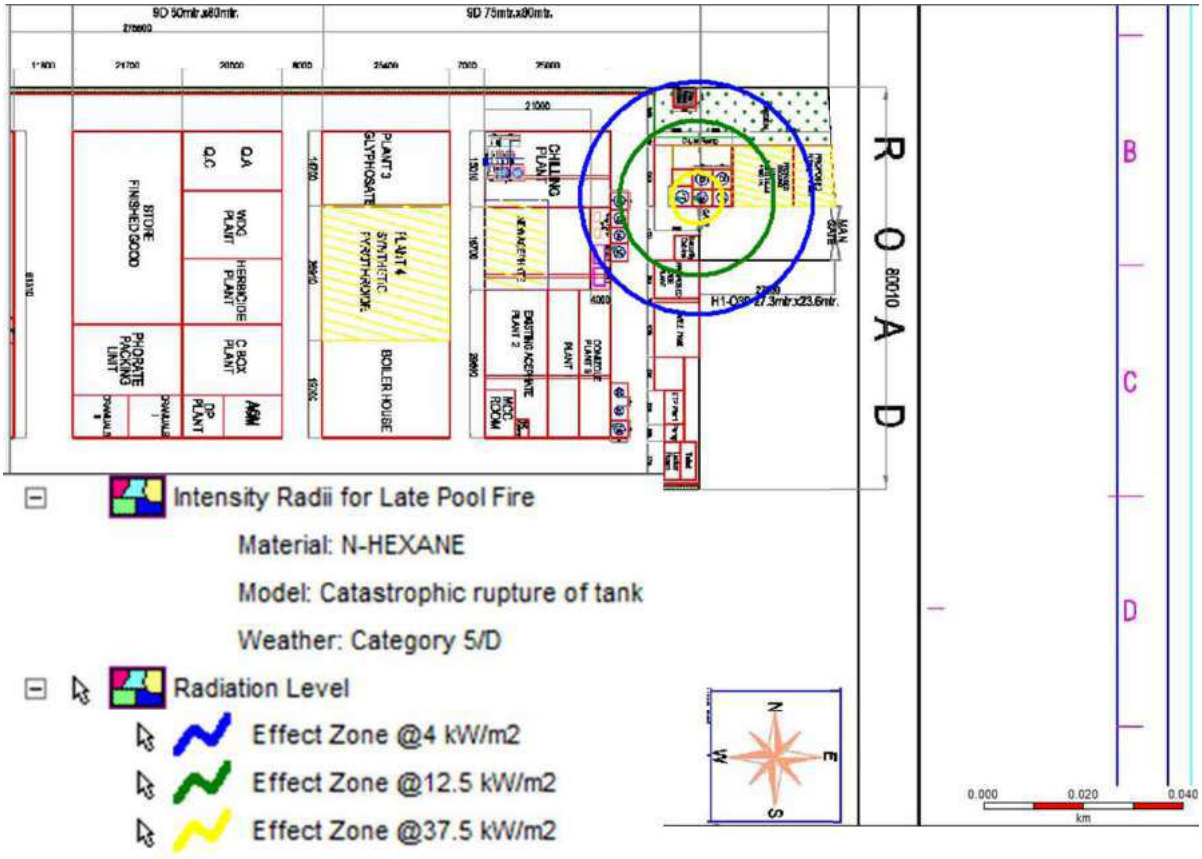

Figure 1.3: Late Pool Fire effect distance Contour due to Catastrophic rupture of storage tank at weather condition 5.0/D

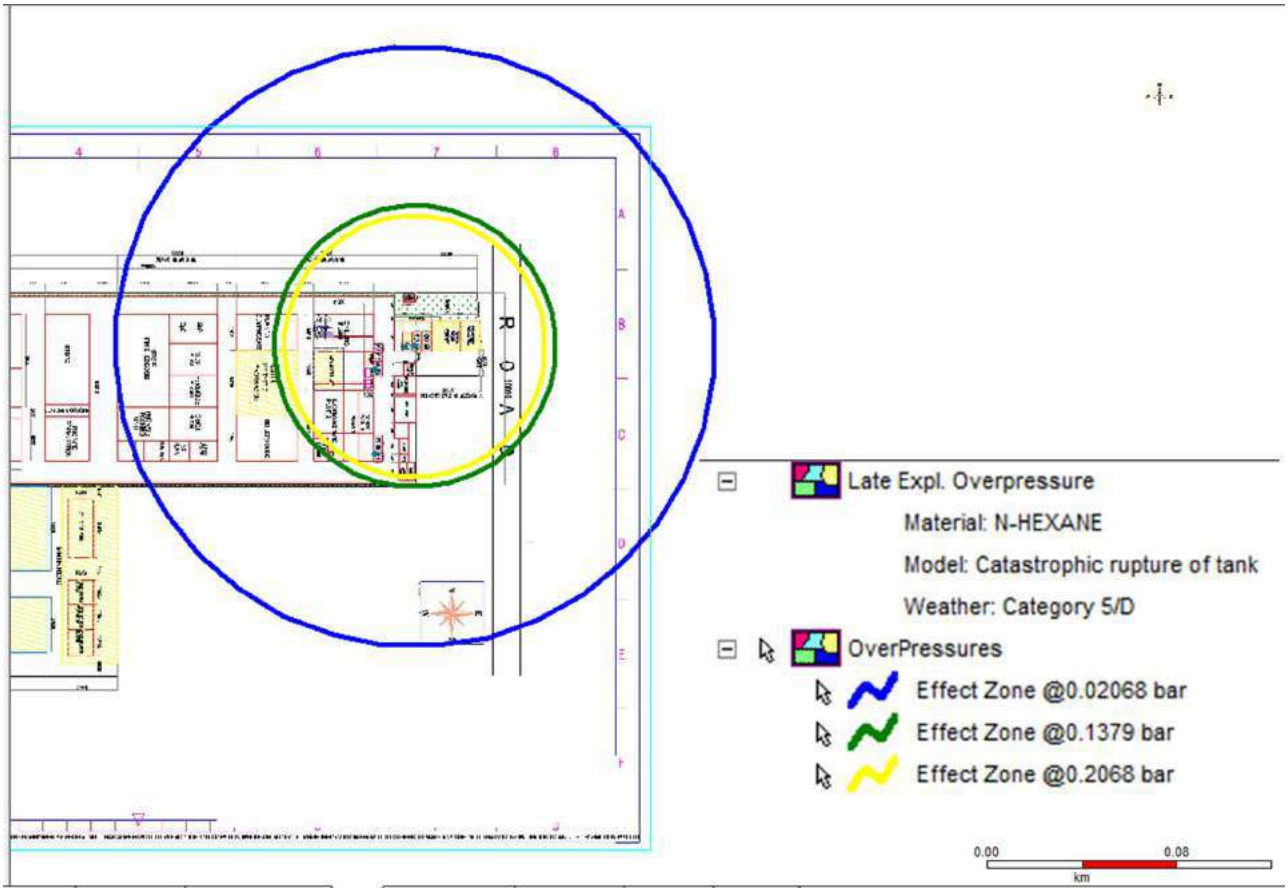

Figure 1.4: Late Explosion effect distance Contour due to Catastrophic rupture of storage tank at weather condition 5.0/D

1.3.2 Dimethylformamide

Radiation level effect distance and overpressure effect distance due to the release of Dimethylformamide are presented below:

Table 1.10: Effect Distance due to Release of Dimethylformamide

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
				4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2
Dimethylformamide	5 mm Leak	Pool Fire, Explosion	1.5/F	20.52	12.75	7.53
			1.5/D	**20.90**	12.97	7.63
			5.0/D	20.54	13.75	9.33
	Catastrophic Rupture	Pool Fire, Explosion	1.5/F	20.52	12.75	7.53
			1.5/D	**20.90**	12.97	7.63
			5.0/D	20.54	13.75	9.33

The contour for effect distance generated for the release of Hexane is presented below;

1.3.3 Toluene

Toxic dose level effect distance due to the release of Toluene is presented below:

Table 1.11: Effect Distance due to Release of Toluene

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level			Overpressure Distances in Meters			Effective Distance in meter to Toxic Level			
				4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2	0.02 bar	0.13 bar	0.2 bar	EPRG 1 (50 ppm)	EPRG 2 (300 ppm)	EPRG 3 (1000 ppm)	IDLH (500 ppm)
Toluene	2 mm Leak	Pool Fire, explosion & Toxic Dose	1.5/F	**12.47**	7.94	3.64	-	-	-	53.15	11.11	2.13	**8.21**
			1.5/D	12.07	7.72	3.59	-	-	-	21.35	6.12	2.69	5.11
			5.0/D	11.16	7.91	4.05	-	-	-	14.67	4.55	2.66	3.89
	Catastrophic Rupture	Pool Fire, explosion & Toxic Dose	1.5/F	17.43	10.41	3.93	37.41	17.09	15.49	178.51	50.33	14.23	**41.13**
			1.5/D	17.79	10.59	3.97	42.90	18.52	16.59	60.44	22.89	12.84	20.79
			5.0/D	**18.91**	12.66	4.87	**52.78**	20.07	18.57	47.87	24.78	9.07	21.65

The contour for effect distance generated for the release of Toluene is presented below;

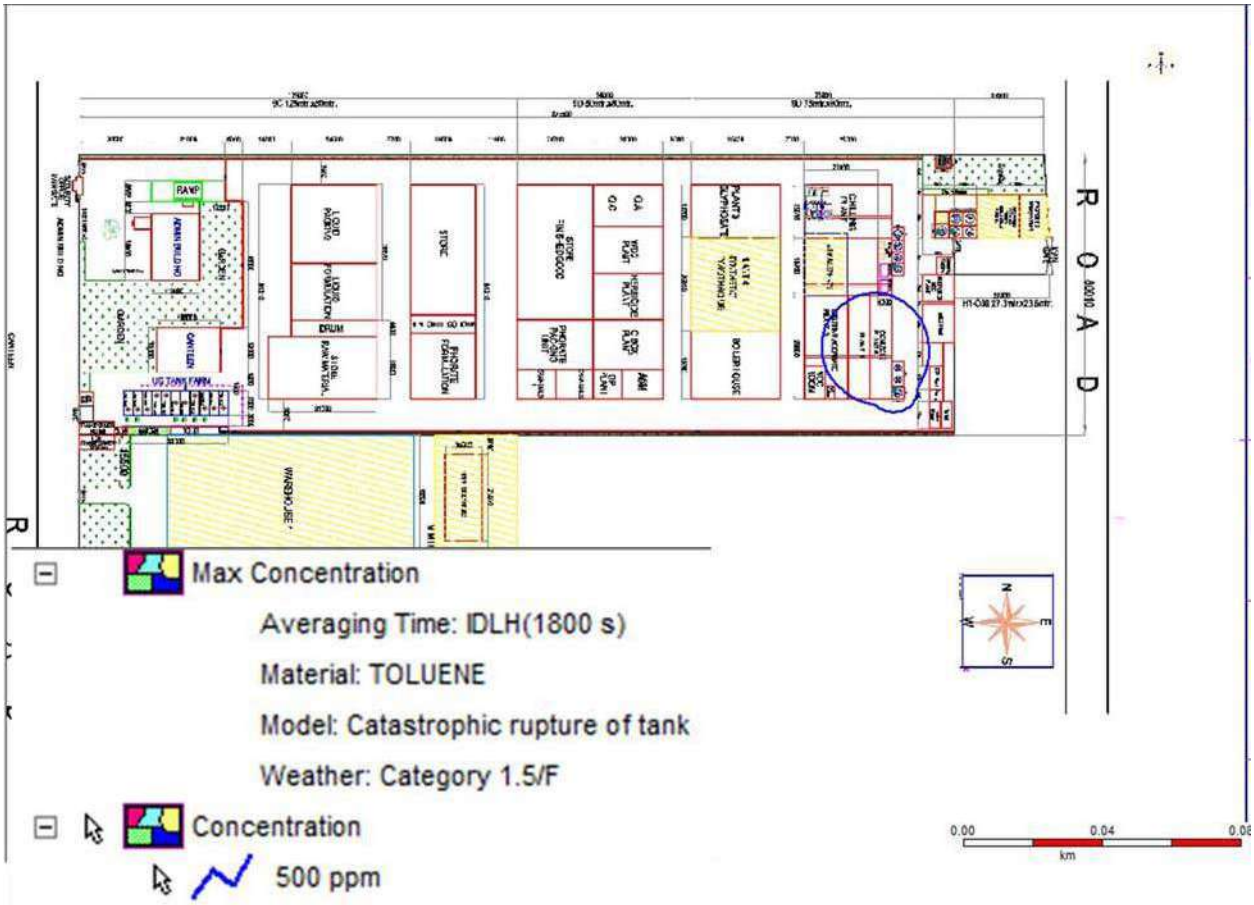

Figure 1.10: Toxic effect distance Contour due to catastrophic rupture of storage tank at weather condition 1.5/F

1.3.4 Acetone

Toxic dose level effect distance due to the release of Acetone are presented below:

Table 1.12: Effect Distance due to Release of Acetone

Chemical (Storage Tank)	Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level			Overpressure Distances in Meters		
				4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2	0.02 bar	0.13 bar	0.2 bar
Acetone	2 mm Leak	Pool Fire, explosion	1.5/F	**5.25**	3.07	2.76	-	-	-
			1.5/D	4.69	2.79	2.79	-	-	-
			5.0/D	4.30	2.82	NR	-	-	-
	Catastrophic Rupture	Pool Fire, explosion	1.5/F	12.30	7.09	2.82	116.43	52.37	47.31
			1.5/D	12.54	7.20	2.82	115.26	59.48	55.07
			5.0/D	**13.45**	8.99	2.82	**118.62**	54.11	50.92

The contour for effect distance generated for the release of Acetone is presented below;
NR-Not Reached

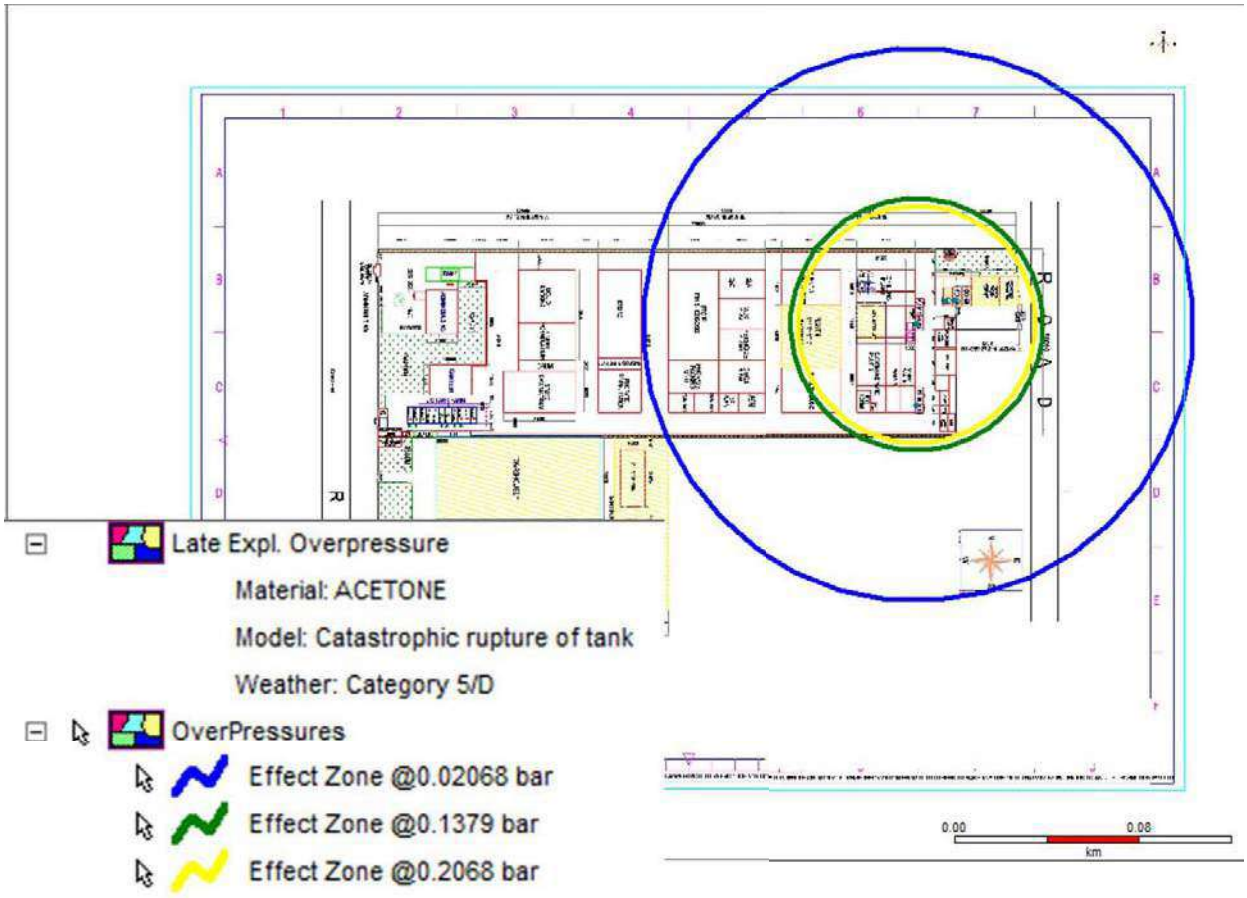

Figure 1.13: Late Explosion effect distance Contour due to Catastrophic rupture of storage tank at weather condition 5.0/D

1.3.5 Results of Consequence Analysis

Summary of effect distance (in meter) for worst case scenario of hazardous chemical considered for consequence analysis are given below:

Chemical/ Scenario	Effect Distance in Meters at specific Weather condition		
	At Radiation Level 4 kW/m^2	At Overpressure 0.02 bar	At IDLH Concentration (in ppm)
Hexane	**23.15 (5.0/D)**	**125.19 (5.0/D)**	-
Dimethylformamide	20.90 (1.5/D)	-	-
Toluene	18.91 (5.0/D)	52.78 (5.0/D)	**41.13 (1.5/F)**
Acetone	13.45 (5.0/D)	118.62 (5.0/D)	-

- It can be seen from the above summarized table that the risk of late pool fire in worst case scenario is in release of Hexane *i.e.* 23.15 m in 5.0/D weather condition for 4 kW/m^2 radiation level which is within plot boundary.
- In worst case scenario the risk of toxic dose in release of Toluene *i.e.* 41.13 m in 1.5/F weather condition for maximum IDLH concentration in ppm which is within plot boundary.
- Over all Hexane is the most hazardous chemical of the proposed expansion project and its overpressure effect distance is within 1 kilometer distance which can be controlled by specific mitigation measure at place.

1.3.6 Specific mitigation measures for safety at storage area for Hazardous chemicals

❖ **Toluene**

Following mitigation measures will be followed in case of Toulene Leakage:

- Evacuate the employees immediately.
- Do not direct water at spill or source of leak, stop leak entry in to guttars.
- Use Toluene emergency kit to attend the leak.
- Absorb with DRY earth, sand or other non-combustible material.
- Only trained workers are/will be allowed to work in this area.
- In Case of a Large Spill SCBA will be provided to avoid inhalation.

Following Safety Measures will be made available to avoid Emergencies related to Toluene Leakage:

- Toluene handling area will be well ventilated.
- Toluene Emergency kit shall be kept ready at Toluene shed.
- DRY earth, sand or other non-combustible material is/will be provided at shed.
- SCBA set is/will be kept ready at Toluene handling area.
- Oxygen Cylinder is/will be available.
- Safety shower and eye wash station is/will be available in Toluene shed area.
- Working of zero static charge generation will be ensured.
- Full body protection suite and other PPEs shall be kept ready.
- Safe Operating procedures and Emergency Response Procedures will be followed strictly.
- Only trained workers and employers shall be allowed to work for tank loading and unloading.
- Regular worksite inspection will be carried out.
- Jumper setting to inlet and out let pipeline will be provided.
- Bund tank will be provided for emergency situation.

❖ **Hexane**

- To provide dump tank, for collection of material during emergency
- To provide quartzite bulb (QB) sensor in storage area for fire detection
- To provide earthing system to tanks and pipelines.

Based on the risk assessment analysis following precautionary mitigation measures are recommended for the project.

- The installation of all the equipment is/will be as per guidelines of provision of Rajasthan Factories Rule, 1951.
- For any case of fire emergency, standard type of Firefighting equipments and fire extinguishers will be provided in the storage area as well as required places in the plant.
- Smoking will be strictly prohibited inside the plant premises.
- Personnel protective equipments meeting OSHA"s standards will be provide to workers.
- First Aid facility and First-aid trained person will be available at the time of chemical handling operation.

1.4 SAFETY MEASURES FOR TRANSPORTATION, STORAGE AND HANDLING OF CHEMICALS

A. General safety measures for transportation, storage & handling are listed below.

- Layout and location of hazardous chemical storage area shall be based on natural and Mechanical ventilation.
- Spare barrels of sufficient quantity is/will be kept ready for any emergency spillage or leakage.
- Regular inspection of all the drums of hazardous chemicals shall be carried out and damaged drums shall be separated and disposed to avoid the possibility of catastrophic rupture.
- Display Boards shall be provided on all storage drum which include the name of the chemicals, material of construction, Calibration of tanks and date of Painting.

- The level indicators shall be placed on all storage drums to know the exact liquid level inside the drum and to avoid the accidental spillage or overflow.
- All equipments related to hazardous chemical storage shall be maintained and calibrated regularly.
- Drum trolley is/will be used for the movement of drums of hazardous chemicals to avoid accident due to manual error.
- SOP for handling hazardous chemicals is/will be displayed in local language for safe operating procedure.
- Proper inventory of hazardous chemicals is/will be maintained and buffer stock will be kept as minimum as possible.
- Standard procedure for unloading will be in place and will be implemented for safe unloading of road tanker.
- Static earthing provision is/will be made for tanker unloading.
- Water showering system (Automated sprinkling system) is/will be provided to the flammable liquid storage area, wherever required to avoid the vaporization due to increase in atmosphere temperature.
- On-site detectors for fire based on heat or smoke detection with alarm system is/will be provided as required.
- Adequate firefighting system is/will be provided as required along with the fire water tank having capacity 50 KL.
- First aids boxes is/will be provided at prominent places in the plant.
- Area is/will be declared as “NO SMOKE ZONE”.

- **Specific Safety measures for storage and handling of other chemicals and gas cylinders are given as follows.**

i. Storage and Handling of other Chemicals

- It will be labeled properly and stored in a cool, well-ventilated and fire resistant area in a tightly closed container.
- Material Safety Data Sheet is/will be displayed in front of respective chemicals.
- Proper training and knowledge is/will be provided to workers for physical and chemical characteristics of the each chemical they are using.
- Proper PPEs is/will be provided to the workers.
- Proper firefighting equipments is/will be installed at storage yard and maintenance and calibration for that equipment will be carried out on regular basis.

ii. Storage and Handling of gas cylinders

- Store cylinders upright with valve outlet seals and valve protection caps in place.
- Store cylinders in accordance with ISO Standard 11625.
- Full and empty cylinders should be segregated and stored separately.
- Visually inspect stored cylinders on a routine basis, or at least weekly, for any indication of leakage or problems
- Use of approved regulators for the specific gas.
- Move cylinders using a suitable hand truck or cart.
- Use a cylinder cage or cradle to lift a cylinder

B. Process Safety Measures

Safety measures are the most important aspect of selection of process technology to ensure safety in production unit. For the safety in production area some important critical safety measures must be provided within the process technology/equipment itself.

The details of the general safety measures for process unit are as below;

- Process parameters control should be provided vide Standard Operating Procedures.
- All reaction vents should be connected to either vapor condensers system or gaseous scrubber system.

- Trained person should be engaged for handling of hazardous materials.
- Proper safety precautions should be taken during handling of hazardous materials.
- Further all the vessels should be examined periodically by a recognized competent person.
- All the vessels and equipments should be well earthed and well protected against Static Electricity. Also for draining in drums, proper earthing facilities should be provided.
- Reaction column pressure and temperature data should be regularly monitored and assessment of properties of flammable chemicals should be evaluated periodically to avoid fire/explosion scenarios.
- Temperature indicators should be provided near all reactors.
- Caution note, safety posters, stickers, periodic training & updation in safety and emergency preparedness plan must be displayed and conducted.
- Total reaction should be carried out in closed jacketed vessel having cooling water supply to control temperature in case of run-away reaction.
- Emergency reactor shutdown system should be implemented.

C. Safety Measures for Drum Storage and Handling

- Drums should be stored at designated location or secured in a safety storage cabinet.
- Approved methods of equipping a drum and dispensing liquids from it should be followed.
- Drums, carboys and related accessories should be inspected on regular basis for maintenance purpose.
- All the vessels and equipments should be earthed properly and protected against static electricity. Also, proper earthing facilities shall be provided for drums.
- Materials should be transferred by pumping through pipeline or by vacuum from drums.
- Drums for flammable liquids should have proper closures that can withstand the expected handling conditions without leaking.

D. Safety Measures for Preventive Maintenance

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

- Make sure equipment is empty and fluxed with nitrogen and air.
- Use of proper PPE will be ensured by safety officer.
- Check VOC content for flammable vapours and make sure that no flammable vapour contents.
- Keep proper and adequate fire extinguisher near work area.
- Check all motors are disconnected and fuse pulled out before maintenance.
- Work in any equipment must be conducted in presence of supervisor.
- Make sure all process lines are disconnected.
- Do not work on equipments without permission from plant head and maintenance head.
- Do not allow any employment without pre medical checkup or without checking fitness.

E. Safety Measures for Chemical Fume hood

- Verify exhaust system is operating before working in the hood. Monitor the dial to verify continued operation. Normal operating pressure is 0.1 Pascal.
- Procedures which involve the liberation of volatile, flammable or toxic materials must be performed in a fume hood.
- Work well inside the hood: minimally, 6 inches from the face.
- Maintain a sash height as feasible within the guidelines of the inspection for the manipulations performed.
- Do not block the air exit slots at the lower rear of the hood.
- Large equipment in the hood creates potentially dangerous zones of turbulence. If this use is necessary, the hood should be so dedicated and not used for other purposes.

- Keep your head outside the fume hood.
- Do not overcrowd or clutter the fume hood.
- Do not store chemicals in the fume hood.

Additional safety measures in form of the checklist covering Do's & Don'ts of preventive maintenance, strengthening of HSE, manufacturing utility staff for safety related measures is/will be updated timely and will be made available to all concern department & personnel.

1.4.1 Safety Precautions system for visitor

Visitor card to be provided to each visitor with gate pass & Visitor badge; which will contain the Rules & Information as below:

ID Badges: ID Badges must be worn and visible at all times. They are to be returned to the reception desk/security gate when leaving the premises.

Mobile phone: Mobile phones with a camera function must not be used on these premises. The use of mobile phones is strictly prohibited in designated areas

Electronic devices: Electronic devices may not be connected to the company network without authorization

Smoking is prohibited: Smoking is prohibited on the company premises. The sale and consumption of tobacco products, alcohol and other narcotic substances is forbidden

Personal protective equipment (PPE): PPE must be worn in many areas of site. For your own safety you must wear the appropriate protective equipment when entering these areas.

Alarm Signal: Obey alarm signals and follow the instructions of the fire safety team. A triggered piezo siren signal indicates a fire system alarm and alerts the fire safety team. However, piezo sirens emitting a continuous tone indicate that you must evacuate the building immediately.

Emergency Call: To report an accident or environmental incident, please call our internal emergency number on XXXX/XXXXXX. Please contact the emergency services; if there is any immediate danger. Emergency personnel will provide further instructions. Manual call points can be used to alert the fire brigade directly in the event of a fire.

Emergency Exit: Please leave the danger zone immediately and warn people at risk. In the event of fire, try to put out the fire with a fire extinguisher, if possible. Escape routes are marked in green on the emergency and evacuation plans displayed inside buildings. In the event of an evacuation, please proceed to the appropriate assembly point.

Assembly Point: Make your way to one of the designated assembly points and await further instructions. Report any missing colleagues to management at the assembly point.

First aid boxes: First aid boxes are provided for treating injuries, and qualified first aiders are on hand during working hours.

1.5 FIRE FIGHTING SYSTEM / FIRE CONTROL PLAN

By looking to the hazardous nature of process and the chemicals that are handled and processed, the chances of outbreak of fire cannot be totally ignored. Hence to tackle such a situation, company has developed proposed, well-resourced and adequate fire protection system. The management has proposed to keep the following extinguishers at site:

- Flame detectors, smoke / temperature actuated heat detectors with alarms, automatic sprinkler system, shall be installed at conspicuous locations as per the requirements.

- Company is/will have Fire Water Tank of adequate capacity to combat the emergency, if arise, RIICO water reservoir shall also be made available, if required.
- Working staff is/will be trained to operate Foam, DCP and CO_2 extinguishers.
- DG set is/will be available as a separate power backup for fire network.
- Company has/will do tie up with RIICO Fire Brigade and nearby companies, for handling emergency situations.
- Electric driven alarms and sirens is/will be placed at the conspicuous locations. Hand Bell shall be used in case of power failure.
- Proponent had provided separate entry and exists with adequate margin all around the periphery for unobstructed easy movement of the emergency vehicle / fire tenders without reversing back.

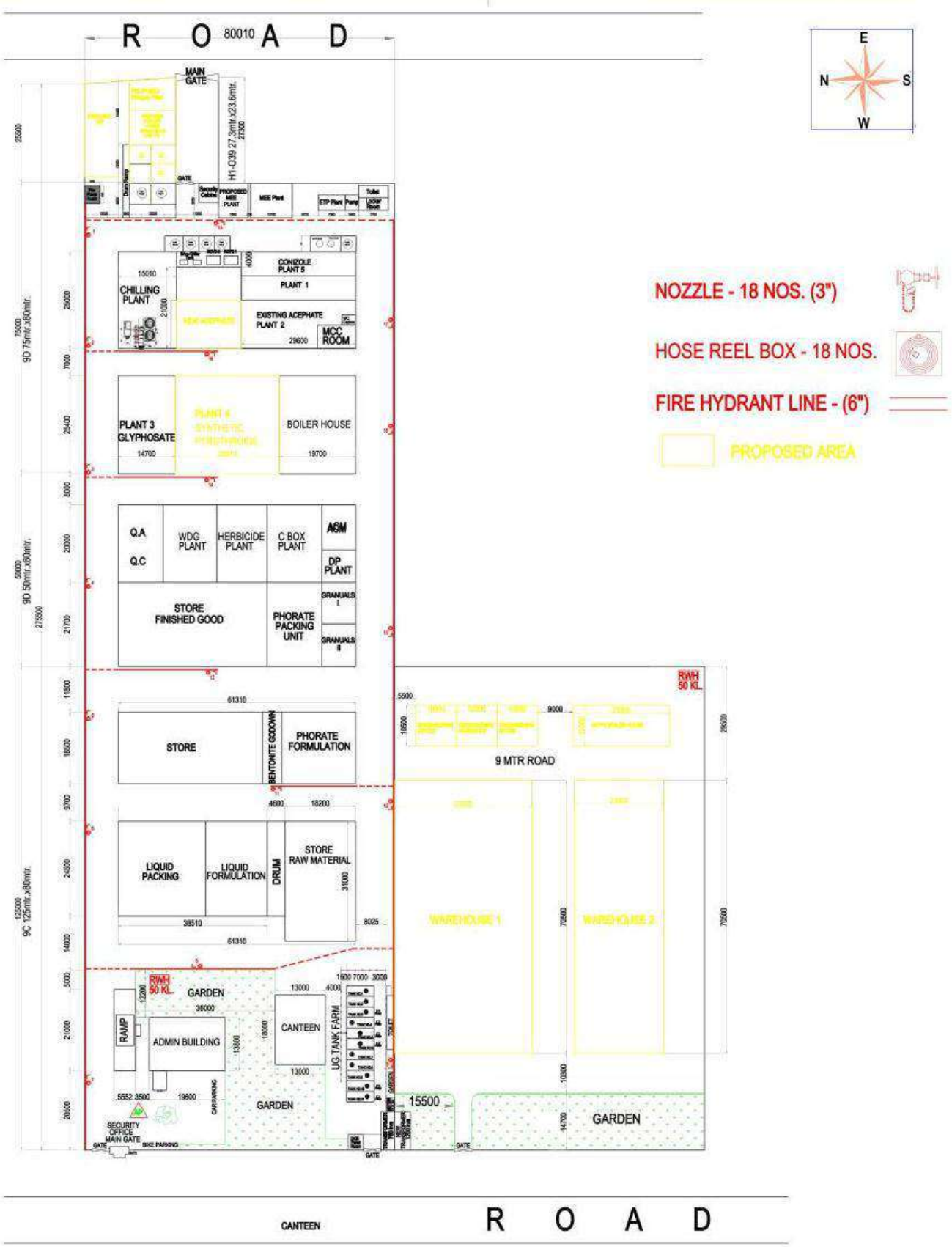

Figure 1.14: Fire Hydrant Layout Plan

1.6 DISASTER MANAGEMENT PLAN (DMP)

In order to be in a state of readiness to face any accident or disaster caused by the project operation, a Disaster management plan is required to be prepared. The plan will cover possible disaster, On and Off-site emergency preparedness plans, establishment of emergency Control Centre (ECC), Location of emergency services and duties of officers / staff during emergency.

1.6.1 Definitions and Classification of Emergency

An Incident: Undesired event giving rise to death, ill health, injury, damage or other loss.

A Major Incident: Is a sudden, unexpected, unplanned event, resulting from uncontrolled developments during an industrial activity, which causes or has the potential to cause. Serious adverse effects immediate or delayed (death, injuries, poisoning or hospitalization) to a number of people inside the installation and / or to persons outside the establishment, or significant damage to crops, plants or animals or significant contamination of land, water, air or an emergency intervention outside the establishment (e.g. Evacuation of local population stopping of local traffic) or significant change in the process operating conditions, such as stoppage or suspension of normal work in the concerned plant for a significant period of above, or any combination of the above effects.

Emergency: An emergency is an abnormal event, which could result in danger to personnel, property and environment. It could be due to fire, Explosion, Heavy spillage of hazardous liquid, toxic gas release etc.

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

Note: Emergency due to operating conditions, uncontrolled reaction, small fire, small gas leak, spill, failure of power, water, air, steam, cooling media, scrubbing media etc. and which can be locally handled by plant personnel alone (without outside help) is not considered as major emergency.

Disaster: Is a catastrophic situation in which the day-to-day life patterns are, in many instances, suddenly disrupted and people are plunged into helplessness and suffering and as a result need protection, clothing, shelter, medical and social care other necessities of life, such as: Disasters resulting from natural phenomena like earthquakes, volcanic eruptions, storm surges, cyclones, tropical storms, floods, landslides, fierce fires and massive insect infestation. Also in this group, violent drought which will cause a creeping disaster leading to famine, disease and death must be included.

Second group includes disastrous events occasioned by man, or by man's impact on the environment, such as armed conflict, industrial accidents, factory fires, explosions and escape of toxic releases of chemical substances, river pollution, mining or other structural collapses, air, sea, rail and road transport accidents, aircraft crashed, collisions of vehicles carrying inflammable liquids, oil spills at sea and dam failures.

Hazard: Source or situation with a potential for harm in terms of injury or ill health, damage to property, damage to the workplace environment or a combination of these.

Risk: Combination of the likelihood and consequence(s) of a specified hazardous event occurring

Classification of Emergency:

LEVEL – 1

The incident or emergency which are confinable, controllable within the plant premises, which under normal circumstances does not affect area outside the said plant battery limit and controlling does not involve / require external help. This situation is called emergency stand by and affected unit / plant have to handle emergency

It may be due to

- Small pipe/valve rupture or similar leakages that do not affect outside premises.
- Release of toxic chemicals for short duration.
- Small fire in the plant.

LEVEL – 2

When the incident or emergency is not controlled within 10 to 15 minutes or does not come under control within 10 to 15 minutes, incident controller, site main controller reviews the situation and decides if situation is Worsening.

It may arise due to -

- Leakage of toxic chemicals for long duration.
- Medium scale explosion confined to the factory premises.
- Medium scale fire inside the factory premises.

LEVEL – 3

After surveying off-site implications of level – 2 emergencies if there is a likely hood of chemical/material gas cloud formation and spreading of cloud in down wind direction affecting neighboring population of industry and villagers and / or in case of following incident IC and SMC are of the opinion that there will be off-site implications.

It may arise due to -

- Heavy / Profuse leakage of toxic / Flammable gases for a long duration.
- Explosion of high magnitude affecting the adjacent area.
- Major fire inside the factory premises.

Note: Level-I and Level- II shall normally be grouped as onsite emergency and Level- III as off- site emergency.

Mode of Emergency:

Man made	Natural Calamities	Extraneous
• Heavy Toxic Leakage/ Spillage • Fire • Explosion • Failure of Critical Control system • Design deficiency • Unsafe acts • In-adequate maintenance	• Flood • Earthquake • Cyclone • Outbreak of Disease • Tsunami	• Riots/Civil Disorder/Mob Attack • Terrorism • Sabotage • Bomb Threat • War/Hit by missiles • Food Poisoning/Water Poisoning

1.6.2 On-Site Emergency

The On-site emergency plan: deals with, measures to prevent and control emergencies within the factory and not affecting outside public or Environment.

Table 1.13: On-Site Emergency Planning

#	Code of Practice	Objective	Line of Action
1	In Case of Fire at Factory/Hazardous chemicals storage area/ Diesel/ LDO or storage area.	To deal with Fire efficiently and quickly at different locations in the factory including diesel storage tank and electrical Panel	• Any person notices any sign of fire shall start shouting FIRE, FIRE (Aag, Aag) to seek assistance and also immediately take steps to give warning by blowing the siren continuously and take steps to extinguish the fire by using fire extinguishers available near the site of fire • After giving information reach the spot, remove Man & Machinery and take steps to tackle the fire in accordance with the firefighting instructions. Inform at security office to get Ambulance if required.
2	In case of Heavy Spillage, Leakage of hazardous chemicals.	To deal with the incidence of hazardous chemicals spillage or leakage efficiently	• Any person who notices any leakage or spillage of hazardous chemicals from storage tank, pipe

		and quickly	line or from any equipment should try to warn the nearby persons and report to the shift supervisor without any delay. • The Person should not go near the spill unless he is wearing a proper PPE and has been fully trained to handle the chemicals leaks.

1.6.3 Off-Site Emergency

The Off-site emergency plan: deals with, measures to prevent and control emergencies affecting public and the environment outside the premises.

Objective

- In the effects of the accident or disaster inside the plant is felt outside its premises, it calls for an off-site emergency plan, which would prepared and documented in advance in consultation with the district authorities.
- The off-site emergency plan prepared herein will deal with those incidents identified under Level – 3 in the on-site plan, which have the potential to harm persons or the environment outside the boundary of the factory premises.
- The most significant risk to outside areas is that associated with a large release flammable and toxic chemicals. Spread of its effected outside the works may require traffic control, evacuation, shelter arrangement.
- Off-site emergency plan has been drawn up with a view to mobilize resources and integrate with district contingency plan for an effective system of command and control in combating the emergency.
- Thus in brief the two main purpose of the off-site emergency plan are:
  - To provide the local / district authorities, police, fire brigade, doctors, surrounding industries and the public, the basic information of risk and environment impact assessment and to appraise them of the consequences and the protection prevention measures and control plans and to seek their help to communicate with the public in case of major emergency
  - To assist the district authorities for preparing the off-site emergency plan for the district or particulate area and to organize rehearsal from time to time and initial corrective action based on the lesson learnt.

Structure of the off-site emergency plan:

- This off-site emergency plan is/will be integrated properly with the district contingency plan to tackle any kind of emergency. The site main controller is/will keep liaison for this purpose with the district authorities.
- External telephone facilities from HPM Chemicals and Fertilizers Ltd. to Local Fire Station, Mutual Aid Members, and Disaster Prevention & Management Centre (DPMC) Tijara is/will be established for quick communication.
- The names of the key persons are/will be defined to establish contacts and Co-ordinate the activities with the help of the collectorate and disaster management center in case of major emergency.
- An on-site emergency control room has been identified by HPM Chemicals and Fertilizers Ltd, which can be activated / used for emergency control and manned round the clock.
- As far as off-site emergencies are concerned, information shall be received first by the police control room, Tijara on telephone next information to local fire brigade on telephone and to DPMC – Tijara. The police / fire brigade control room shall in turn inform DSP, collector.
- The safety department and individual plant has already the list of quantities of resources like breathing air sets, rescue masks, fire extinguishers, water resources *etc.* available with various industries in the vicinity which can be spread under Mutual Aid System to tackle such emergencies after receiving call from them.
- The District Superintendent of Police, Alwar District will be in overall charge of security, evacuation and rescue operations at the time of emergency.

Arrangement made for off- site emergency

- Considering distance from district Head Quarters, other nearby external emergency control organization. Following arrangements will be arranged in consultation with DY. DISH, district collectorate, mamlatdar.
- Disclosure of information to neighboring organization and population:

- HPM CHemicals & Fertilizers Ltd. will prepare booklet and circulate among neighboring organization and population containing hazardous operation and chemicals. First aid, emergency treatment, probable types of emergencies that can arise. Preventive steps will be taken to control emergency. Emergency warning siren code system, to make them aware in advance. HPM CHemicals & Fertilizers Ltd. will carry out group get together, acquaintance round, meeting with neighboring public, population to train, brief the and make them aware about our operation and preparedness.
- The same groups along with external emergency control organization were invited during mock drill, rehearsals for training and acquaintance.

Local crisis group:

- As per central government notification and DISH office for preparation of offsite emergency plan and HPM CHemicals & Fertilizers Ltd. will become member of local level crises group, will set up disaster management center of industrial area using existing available facility of industries in the area with facility and emergency contact phone numbers.
- During emergency with in local group reach in and around industrial area any one can contact DMC – control room situated in both the factories and manned round the clock will initiate actions and arrange to organize resource mobilization and communication

Local crisis group consists of:

Chairman	: Dy. Collector
Member Secretary	: Asst. Directorate – Industrial Safety & Health, Alwar
Member	: Factory manager of all industries
Member	: Transport contractors
Member	: Safety Manager, HPM CHemicals & Fertilizers Ltd.
Member	: Police Inspector, HPM CHemicals & Fertilizers Ltd.
Member	: TDO, HPM CHemicals & Fertilizers Ltd.
Member	: Civil defense inspector, HPM CHemicals & Fertilizers Ltd.
Member	: Medical officer, PHC, HPM CHemicals & Fertilizers Ltd.
Member	: Press reporter
Member	: Community leader, Sarpanch, nearby village
Member	: NGO, Lions club, nearby village
Member	: Local social worker, nearby village

- Local crisis group will prepare local emergency response plan and will submit to Directorate – Industrial Safety & Health, Alwar.
- Rehearsal of local off-site emergency response plan will be carried out involving industries nearby as per mutual aid arrangements.
- Local crisis group will have to start emergency control action before arrival of and activation of district off site emergency plan and involvement of district crisis group.
- Any escalation need of further help will activate full district level off site control room.
- All type of emergencies like village fire, chemical accident, natural calamities and industrial accidents will be covered in the scope of local crisis group action plan

District level crisis group:

Under chairmanship of collector district level crisis group will be formulated to aim at:

- Update off-site emergency plan regularly
- To organize, initiate action for mock drill
- To run central control room
- To coordinate for training need of all member government officials
- To maintain communication link among members through central control room.
- To monitor preparation of industrial organization and adequacy of on-site emergency plan.
- Dy. Director – Industrial Safety & Health hold responsibility of member secretary for district level crisis group.

Communication and warning by Disaster Management Center:

- When a disaster occurs, the industry affected by the disaster will immediately inform the disaster management center with all available information, the DPMC will act as per the contingency plan and DPMC will also communicate immediately to district Collectorate. The integration of on – site plan with district contingency plan and various functions to be carried out are mentioned in chart OFF – SITE emergency plan as follow:

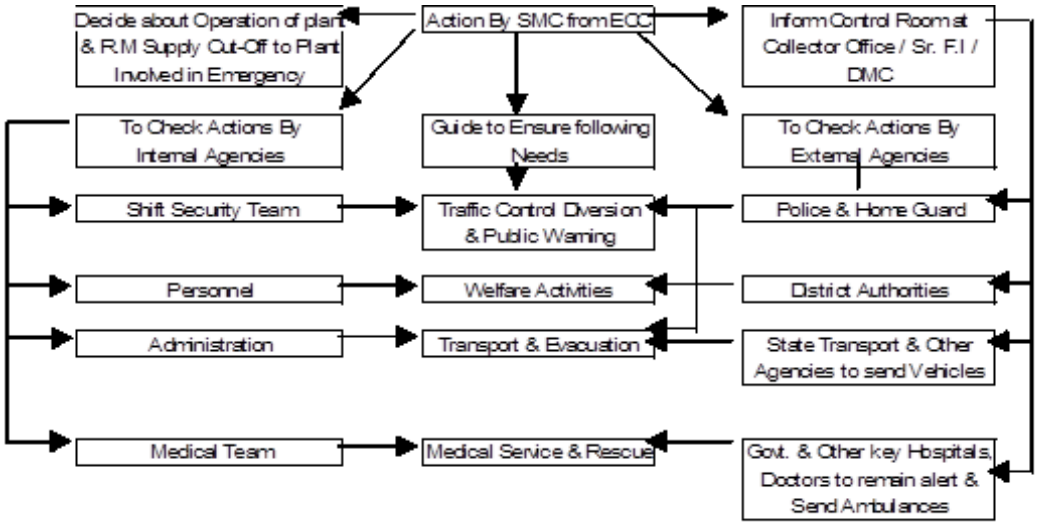

Figure 1.15: Off-Site Emergency Plan

1.6.4 Structure of Emergency Management System

HPM CHemicals & Fertilizers Ltd. shall develop an Emergency Management Team. The management structure shall include the following personnel"s;

- Site Main Controllers
- Incident Controllers and Deputy Incident Controllers
- Key Personnel"s
- Essential Workers

The other elements of Emergency Plan shall be:

- Assembly points
- Emergency control center
- Fire control arrangements
- Medical arrangements
- Other arrangements

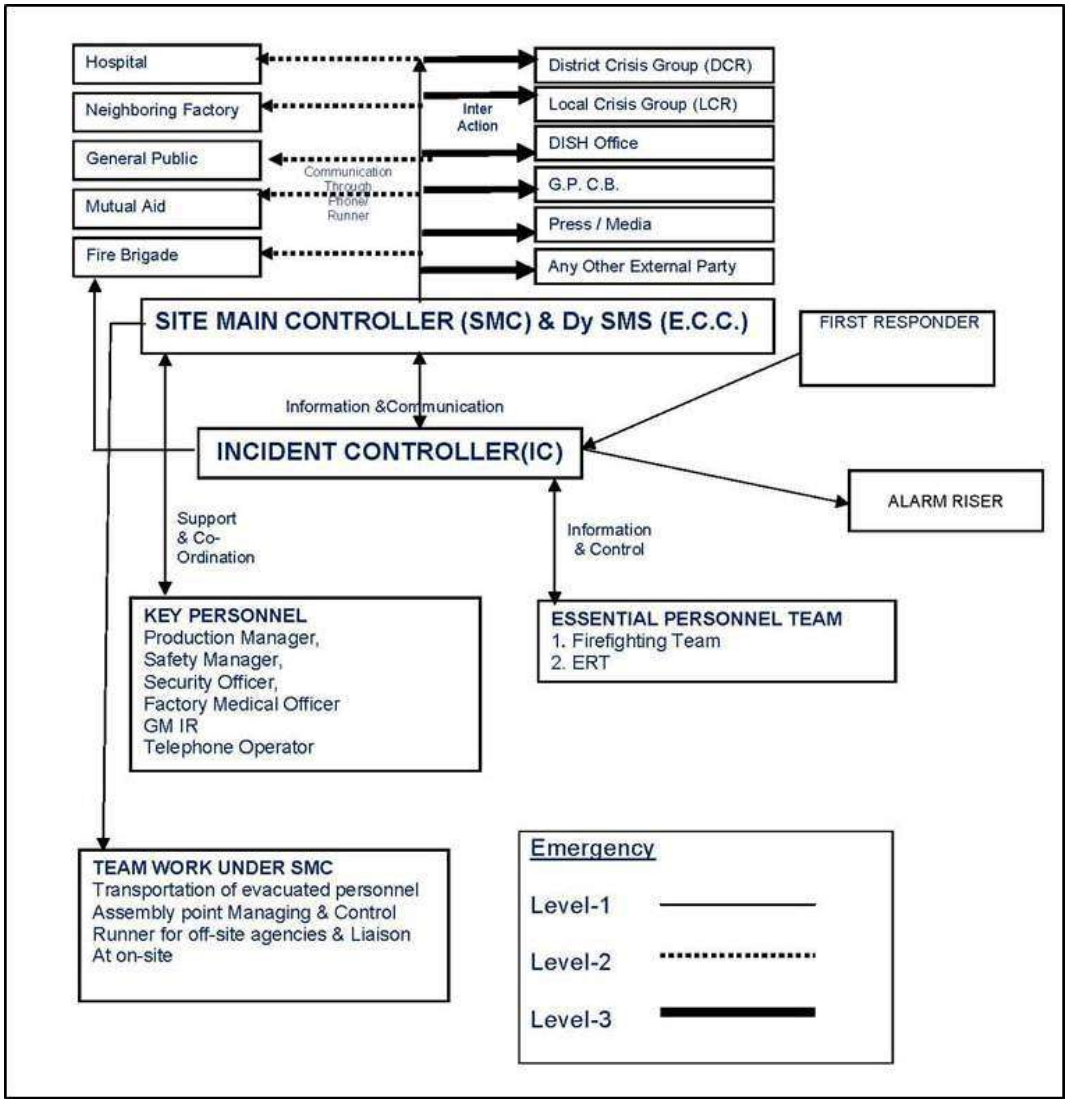

Figure 1.16: Emergency Organization Chart

A. Role & Responsibility of Emergency Management Team

Site Main Controller (SMC)

Senior most Executives (*i.e.* Director & Supervisor) of the company shall be nominated as SMC. His task will be to co-ordinate all internal and external activities from the Emergency Control Centre (ECC) at Main Security Gate, from where all operations will be directed. He shall:

- Immediately on being informed of the emergency and its location, will arrive at the site, review the situation and control further actions.
- Direct all Emergency Operations within the approved area with the following priorities:

  1. Personnel Safety,
  2. Plant, Property and Environment Safety and
  3. Minimum loss of production.

- Co-ordinate to avail services from external agencies like fire brigade, hospitals *etc*, if called for, following the declaration of major emergency. If necessary, major installations in the vicinity may also be informed of the situation.
- Exercise direct operational control of the unaffected section of the plant.
- In consultation with the advisory team, expedite the shutting down of loading / unloading operations of tankers and if necessary, instruct the supervisor / security personnel to evacuate tankers.
- Ensure that all employees are evacuated from the affected area and the casualties, if any, are given necessary medical attention. Instruct P & A Assistant / Security for rushing casualties to hospitals if required.

- Liaise with fire and police officials, pollution control board officials and other statutory bodies and advise them of all possible consequence effects outside the premises.
- Arrange for relief of personnel when emergency is prolonged.
- Issue authorized statement or press release to the news – media.
- Ensure preservation of evidence for enquiries to be conducted by statutory authorities.
- Authorize the sounding of “All Clear” and “Evacuation Siren”.
- Arrange for obtaining the head – count of all personnel within the premises and cross-checking with the data from records available for no. of persons within the premises.
- Nominate a person from advisory team, to maintain chronological log of event during the entire period of emergency.

Role of Incident Controller (IC) and Deputy Incident Controller (DIC):

Respective Shift In-charge of the Plant (Site) & Department holds the responsibility of the Incident Controller, if the incident is in their plant/area. Two Production officers in each shift will be identified as Deputy Incident Controllers.

His primary duties shall be to take charge at the scene of the incident. In the initial stage he may be required to take decisions involving the operation of the other plants or to stop or continue any process and to take technical decisions to control the incident. The deputy incident controller will take the charge of incident controller, if he is not available due to any reason. They will be always available in each shift and can take charge of the incident.

Responsibilities/Duties of Incident Controller and Deputy Incident Controller:

- He shall take charge at the scene of incident.
- He shall immediately assess the gravity of risk and alert panel and field operators to start controlling their respective section.
- if the emergency is minor, try to prevent by using internal resources like fire extinguishers in case of fire, and cover the spillage by sand in case of liquid spillage.
- He will work under the direction of the SMC, but till his arrival he may have to execute following responsibilities.
    - He will ensure that all the Key Personnel are called.
    - Direct for evacuation of plant and areas likely to be affected by the emergency.
    - He shall communicate to the SMC the type of outside help needed.
    - He shall direct all emergency operations within the affected area with the following priorities.
    - Personnel safety, including of surrounding community.
    - Minimum damage to Plant, Property and Environment.
    - Appropriate actions to minimize loss of Production and Material.
    - Give information to the head of firefighting and rescue team and other emergency services.
    - Depending on the incident, instruct partial or total shut down, isolations, depressurization, Nitrogen purging, firefighting and rescue operations.
    - Instruct upstream/downstream units to take emergency shutdown /cutting off supply and other appropriate actions and emergency evacuation help etc.
    - Direct for search of casualties.
    - Evacuate non-essential workers/visitors/contractors to safe assembly points.
    - Brief site main controller and keep him informed about the developments.
    - Preserve evidences. This will be necessary for investigation for cause and concluding preventive measures.

Key Personnel

Senior officers of various departments like Fire, Security, Safety, Administration, Engineering, Project, Production, Transport, Pollution control, Technical Services and Stores shall be nominated as Key Personnel in their respective fields. As necessary, they shall decides the actions needed to shutdown plants, evacuate personnel, carryout emergency engineering work, arrange for supplies of equipment"s, utilities, carryout environment monitoring, provide catering facilities, liaise with police, fire brigade and other local authorities, relative of casualties, hospital, press & neighboring industries, action at assembly points, outside shelters and mutual aid center under the direction of the SMC. All the key personnel and other

called in so to assist, shall report to the ECC. They shall be available at any time on duty or on call or on holidays.

The responsibilities and duties of key personnel are as follows:

Production Manager

- To keep in touch with IC & SMC in assessing/ controlling the emergency.
- To guide essential personnel team.
- To guide personnel for safe close down of the plant.
- To guide transport for safe shifting of materials from one place to other.
- To guide mutual aids services and the teams.
- To keep informed the SMC about developments.
- To make arrangement like emergency light, water etc.
- To assess the emergency & evacuate the neighboring factory workers and neighboring population through SMC.
- To inform the effect of emergency and steps to be taken to avoid the effects of a radiation *etc*.

Safety Manager

- To assist incident controller in controlling emergency.
- To help site main controller in communication.
- To provide necessary equipment like FFE (Firefighting Equipments), PPE & RPE.
- To guide transport for safe shifting of materials from one place to other.
- To guide mutual aids services and the teams.
- To keep informed the site main controller about developments.
- To make arrangement like emergency light, water etc.
- To assess the emergency & evacuate the neighboring factory workers and neighboring population through SMC.
- To inform the effect of emergency and steps to be taken to avoid the effects of a Fire etc.

Security officer

- To help incident controller & site main controller at the time of emergency.
- To cordon the area and inform incident controller or site main controller about the development of emergency.
- To fight the fire with available internal FFE.
- To make arrangement for evacuating workers from the place of accident and guide non- essential workers towards company assembly point.
- To carry out head counting at assembly point & search of missing persons.
- To ensure that the roadway to plant is clear for emergency vehicles. Obtain assistance to keep roadway clear and to stop non-emergency traffic from entering.
- To direct their personnel (Response force & Task force) for evacuation of non-essential workers & Crowd control.
- To liaise with mutual aid services for their help and guide to them.
- To blow emergency siren & all clear siren on receiving message from IC/SMC through telephone office.

Factory Medical Officer

- To take charge of Occupational Health Centre.
- To provide treatment/ first aid to the affected persons and if necessary, send them to hospitals for further treatment.
- To keep liaison with hospitals and inform them about the type of emergency help required as per discussion with Site main control.
- Arrangement for adequate stock of antidotes, lifesaving drugs and special medicines.
- To keep the record of persons given first aid/ treatment and send them to hospitals with their name.
- To keep ready the list of blood groupings.
- To inform site main controller about the developing situation.
- To guide/instruct first aider, first aid and rescue team in case of any emergency.
- To keep ready the list of first aider.

- To identify of all the hospitals for facilities to render medical aid to victims of exposure to dangerous chemical substances, burns and other specific injuries. (State authorities, local authorities, ESICS, Private, Railways/Voluntary institutions, trusts *etc*.) and report to SMC
- To keep provisions of buffer stock of essential medicines like intravenous fluids, dressing materials, splints, oxygen cylinders, suction apparatus *etc*. Keeping in view the large number of third degree burns, heat radiation.

General Manager-IR

- To assist site main controller and incident controller in controlling emergency.
- To guide mutual aids services and the teams.
- To keep informed the site main controller about developments.
- To make arrangement like emergency light, water, etc.
- To arrange external help like Medical, Fire, etc
- To assess the emergency and evacuate the neighboring factory workers and neighboring population through SMC.
- To inform the effect of emergency and steps to be taken to avoid the effects of a Fire etc.
- To deal with external communication like media and external agencies

Adjacent Plant In-charge

- To assist site main controller and incident controller in controlling emergency
- To help site main controller in communication.
- To guide mutual aids services and the teams.
- To keep informed the site main controller about developments.

Telephone Operator

He will guide all visitors of admin building to move at assembly point.

Essential Workers (EW)

Essential Workers shall be those who shall be trained in Fire Fighting and First Aid. One Supervisor and two helpers from each shift will be identified as EW"s & shall supposed to report at EMERGENCY SITE to take instructions from IC or DyIC. IC/ DyIC work instructions will include:

- To rush at the site for help with fully equipped i.e. firefighting equipment, SCBA sets, *etc*.
- To decide line of action in consultation with incident controller and Key personnel and take appropriate measures to extinguish the fire and to control spillage.
- Firefighting and spill control till a Fire Brigade takes the charge.
- To help the Fire Brigade and mutual aid teams, if it is required.
- Shutting down plant and making it safe.
- Emergency engineering work e.g. isolating equipment, material process, providing temporary by-pass lines, safe transfer of materials, urgent repairing or replacement, electrical work, etc.
- Provision of emergency power, water, lighting, instruments, equipments, materials, etc.
- Movement of equipment, special vehicle and transport to or from the scene of the accident.
- Search, evacuation, rescue and welfare.
- The injured will be given First Aid.
- To help and assist Factory Medical officer.
- Moving tankers or other vehicles from area of risk.
- Carrying out atmospheric test and pollution control.
- Manning of assembly points to record the arrival of evacuated personnel. Manning for outside shelters and welfare of evacuated persons there.
- Assistance at causalities reception areas to record details of causalities.
- Assistance at communication centers to handle outgoing and incoming calls and to act as messengers if necessary.
- Manning of works entrances in liaison with the police to direct emergency vehicles entering the work, to control traffic leaving the works and to turn away or make alternative safe arrangements for visitors, contractors and other traffic arriving at the works.
- Informing surrounding factories and the public as well as directed by the Site Main Controller.
- Any special help required.

❖ Other Elements of DMP

Assembly Point:

In affected and vulnerable plants, all nonessential workers (who are not assigned any emergency duty) will be evacuated from the area and they shall report to specified assembly points. Assembly Points shall be located at a safe place, well away from area of risk and least affected by the down wind direction.

To ensure that workers will not have to approach the affected area to reach the assembly points, proper location and numbers will be marked at assembly points. Each assembly point shall be manned by a nominated person to record the names and dept. At each assembly point, duties of assembly point In-charge will also be displayed in brief. Before reaching an assembly point or subsequently, if it is required to pass through an affected area or due to presence of toxic substances, suitable PPE's including respirators, helmet *etc.*, shall be issued and made available with workers.

Proposed Emergency assembly point number 01 is in front of liquid packing section (EC1) and emergency assembly point number 02 is in the east south corner of factory near herbicide packing section.

Emergency Control Center (ECC):

The Emergency Control Center is the place or room from where the operations to handle the emergency are directed and coordinated. Safe and easily approachable room has been earmarked/identified as the Emergency Control Room.

Telephone and other facilities required with necessary documents shall be displayed in ECC for ready reference. Designated trained personnel will operate ECC. In case of Major Emergency, the Site Main Controller will operate from ECC.

The ECC center is/will be equipped with the following facilities.

- Internal and external telephone including STD facility
- Telephone directory/ Telephone nos. of mutual aid centers
- First Aid
- Muster roll of workers
- Identity card register
- Layout plan of the factory showing the location of hazardous materials, assembly point, first aid centers etc.
- Map of surrounding area with fire extinguishers location
- M.S.D.S
- Copy of ON SITE OFF SITE PLAN
- Stationeries like- note book, pen, pencils etc.
- S.B. Apparatus
- List of Government Agencies /Local press agencies with phone no.
- Sand Buckets & Hydrant Network
- Adequate numbers of PPE's

Fire Control Arrangements (Fire Fighting, Gas Leak Control and Rescue Operation)

Fire is classified in following three classes. The appropriate fire extinguishers are used to extinguish the different class of fire.

Class A: General Fire - Cotton Waste, Paper, Rubbish and Scrap: water, ABC powder type

Class B: liquid Fire - All solvents, Resin, Paints, LDO, HSD: Mechanical foam, ABC type

Class C: Gaseous /Electrical fire - Gaseous fire & panels *etc*.: CO_2, DCP/ABC

Sufficient number of fire hydrant valves and riser valves will be arranged to fulfill fire extinguishing need of the plant. Apart from this, fire extinguishers will be kept at various locations inside plant and those will be hydrostatically tested and refilled at intervals as specified by statutory body.

Code No.	Capacity	Type	Locations
1.	9 Ltr.	A	Packing Material Store
2.	9 Ltr.	A	Liquid Packing Unit(EC2)
3.	9 Ltr.	AB	Liquid Formulation Unit(EC1)

4.	9 Ltr.	AB	Liquid Formulation Unit(EC1)
5.	50 Ltr.	AB	Solvent Yard
6.	50 Ltr.	AB	Solvent Yard
7.	50 Ltr.	AB	Solvent Yard
8.	50 Ltr.	AB	C-box Plant
9.	9 Ltr.	AB	C-box Plant
10.	9 Ltr.	AB	WDG Formulation Unit
11.	9 Ltr.	AB	WDG Formulation Unit
12.	2 kg	CO_2	Carbofuran formulation Unit
13.	4 kg	CO_2	Phorate Formulation Unit
14.	2 kg	CO_2	Phorate Formulation Unit
15.	5 kg	DCP	Carbofuran formulation Unit
16.	5 kg	DCP	Carbofuran formulation Unit
17.	5 kg	DCP	Carbofuran formulation Unit
18.	5 kg	DCP	WDP/Phorate packing
19.	5 kg	ABC	Carbofuran formulation Unit
20.	5 kg	ABC	WDG Formulation Unit
21.	5 kg	ABC	WDG Formulation Unit
22.	5 kg	ABC	Phorate Formulation Unit
23.	5 kg	ABC	Phorate Formulation Unit
24.	5 kg	ABC	Phorate Formulation Unit
25.	5 kg	ABC	Packing Material Store
26.	5 kg	ABC	Raw Material Store
27.	5 kg	ABC	Raw Material Store
28.	5 kg	ABC	Raw Material Store
29.	5 kg	ABC	Raw Material Store
30.	5 kg	ABC	Raw Material Store
31.	5 kg	ABC	Canteen
32.	5 kg	ABC	OCB Penel Room
33.	5 kg	ABC	Meter Room
34.	5 kg	ABC	Main Gate
35.	5 kg	ABC	Recepetion
36.	5 kg	ABC	Recepetion
37.	2 kg	ABC	Q.A. Department
38.	2 kg	ABC	Q.A. Department
39.	2 kg	ABC	Q.A. Department
40.	5 kg	ABC	Liquid Formulation Unit(EC1)
41.	5 kg	ABC	Liquid Formulation Unit(EC1)
42.	5 kg	ABC	Liquid Packing Unit(EC2)
43.	5 kg	ABC	Liquid Packing Unit(EC2)
44.	5 kg	ABC	Liquid Packing Unit(EC2)
45.	5 kg	ABC	Liquid Packing Unit(EC2)
46.	5 kg	ABC	WDP/Phorate packing
47.	5 kg	ABC	WDP/Phorate packing
48.	5 kg	CO_2	WDP/Phorate packing
49.	5 kg	ABC	Recepetion

Fire drill is/will be carried out periodically by all the security guards apart from safety persons to keep them ready fortnightly. Sufficient amount of firefighting water will always be stored in storage tank for firefighting works. In case of power failure, diesel driven fire engine pump has arranged to generate the power for emergency lighting and to run water pump.

Sufficient number of fire hydrant valves and riser valves will be arranged to fulfill fire extinguishing need of the plant. Apart from this, fire extinguishers will be kept at various locations inside plant and those will be hydrostatically tested and refilled at intervals as specified by statutory body.

Role of Manager (Fire and Safety)/Shift In-Charge (Fire & Safety)

1. Incident Controller shall direct the firefighting and Emergency operation. His duties include…
2. Keep the constant touch with the SMC/In-charge - EHS.
3. Direct the crew members to the scene of emergency and arrange replenishment of Manpower/ equipment/ extinguishing media *etc*.

Role of EHS Representative:

1. On being notified about the location of fire/ gas leakage, he shall immediately proceeds to the help.
2. Decides his line of action in consultation with Incident controller and takes appropriate measures to handle the emergency.
3. Shall assess the severity of the incident & shall immediately report to emergency controller about the gravity of the situation.
4. He shall also assess the extra requirement required if any, from the neighboring industry.

Fire crew members

1. On hearing fire alarm & emergency siren, they shall immediately reports to control room and proceed to the scene of emergency and work under the direction of IC/ Dy IC.
2. The personnel availability at the scene of incident shall be made optimize.

Emergency Squad Members

1. On hearing Emergency Siren, they shall immediately reports to site main controller, safety in charge or incident controller.
2. They shall combat the emergency situation as per the direction of site main controller, safety in charge or incident controller.
3. They will help for safe evacuation.

Medical Services

The roles of Medical officers are as follows;

1. He will report immediately to the SMC/IC.
2. He will render necessary treatment, at Occupational Health Center.
3. He will arrange for Hospitalization and Treatment at outside hospitals, if required.
4. He will mobilize in getting the services of External medical agencies, other Para –medical services etc. and transportation services etc.
5. He will arrange for extra medical assistance/antidotes, from out, if required.
6. He will arrange for first-aid trained volunteers for necessary help.
7. He will liaise with the Government Health Authorities for treatment of the affected persons nearby.

Role of Security In-Charge (Security Officer)

1. On hearing the emergency siren, he shall find out the location of the incident (fire / gas leak / spill / explosion) and inform the location of the same to the key personnel coming to the plant.
2. He will depute the security guards for managing gates and traffic control at the incident site & send remaining guards to the site of incident.
3. He will prevent unauthorized entry in to the site
4. He will render assistance as demanded by the safety in-charge.
5. He will mobilize additional security force for help, if required.
6. He will direct ambulance(s) and emergency vehicle(s) to the scene of incident.
7. He will help evacuate persons within the scene of incident.
8. As directed by the site main controller, he may be required to address the public of surrounding villages for warning / evacuation.

Role of Mutual-Aid Members

1. Company will have Mutual Aid with various nearby factories.
2. On receiving the call, they shall proceed immediately with fire squad & fire tenders.
3. They will be guided to the place of the incident by the main gate security guard.
4. The fire squad in-charge will report to the safety in-charge of the unit in which the incident has occurred.

Other Arrangements

Other arrangements include external transport (transport center), heavy vehicles, lift/cranes, generator sets to supply emergency power, environment monitoring equipment, special instruments/equipment"s, rescue items etc. shall be made available (if required) from nearby Industries /locations, when available resources do not meet the requirements.

Standard Operating Procedure (Shall Be Followed During Emergency)

1. As soon as emergency alarm is heard, all essential workers shall report to IC or SMC.
2. They shall carefully listen to the instructions given by IC or SMC
3. According to the type of emergency/accident, they shall get equipped with PPE/Firefighting equipment and devices.
4. The runner among the workers shall inform SMC/IC and key personnel if they are not at site.
5. The messenger amongst the workers shall deliver messages to nearby units as per the instructions of SMC/IC.
6. The in-charge of medical arrangements shall prepare first-aid and other required facilities for the injured.
7. The other essential workers shall try to control the emergency as per the instructions given to IC.
8. IC would keep SMC informed about the status of control measures being taken at the site and ask for other requirements eg. Mutual aid, equipment etc. if he find necessary.
9. SMC would co-ordinate with outside agencies regarding control measures being taken, need for external help, evacuation, medical treatment etc.

Security system

1. A premise is covered by fully fencing and Main gate is secured by guard for 24 hours.
2. All transport vehicles are checked at the gate for driver licenses, MSDS, Emergency Information Panel and for any unwanted / undesired threat material etc.
3. Security staff takes round throughout the factory for security of plant & others.
4. CCTV camera installed at all critical locations.

Communication System

Communication System is a Crucial Factor while handling emergency. Company has quick & effective Communication System through which, any situation, which can lead to emergency, can be informed or known to…

1. All persons working inside the plant.
2. Key Personnel outside during normal working hours & during off-duty hours.
3. Outside emergency services, Statutory and Local Authorities &
4. Neighboring facilities and public leaving in vicinity.

Each and every section, Plant & Department of the Factory will be connected by internal telephones with SMC, Supervisor or IC"s. External Phone at Office and Residence and Mobile shall also be made available with Key Personnel and top executive of the factory. The Communication System shall begin with raising the alarm declaring the emergency, Telephone messages and Procedure to communicate the emergency to other persons & General Public.

Raising the Alarm

As soon as incident takes place inside the factory and is noticed by someone, the first step shall be to raise the nearest manual emergency bell to alert the nearby people. Next, he/she shall inform the security persons to raise the emergency siren located at the factory gate. The security personnel sound the siren. The alarm sound informs the I.C and the S.M.C that an emergency has been created and emergency organization plan to be activated. The I.C. rushes to the site and shall takes charge of the scene.

Telephone Message

A Telephone operator who is precise, sharp, attentive and quick in receiving and noting the message and subsequently effective in further Communication, shall be appointed. A form to record emergency telephone calls will be available with telephone operator or Person available in Emergency Control Center, who shall record such calls during emergency. Telephonic messages shall be given out by the telephone operator to Site main Controller and key personnel as per the instructions of the Incident Controller.

Telephonic messages will also be given to authorities and external agencies to describe the type of emergency. All details of emergency will be collected/ delivered according to this format, available with the telephone operator.

Emergency Time Activities

The probable emergency situation that can arise in the unit and the corresponding control actions as described below shall be followed:

Type of Emergency	Whom to Call	Directions/Procedures
Medical Emergencies	Factory Security 36 or 9694096386 (24 hrs)	Campus security will assist, contact EMS and direct them to your location. EASC and ENSC technologists are trained in First Aid.
Fire	Pull fire alarm (located near the main gate) Call 101.	Proceed to the nearest stairwell. DO NOT use elevators or stairwell by elevators. Once outside move away from the exit and do not reenter unless instructed to do so.
Chemical Spill	Factory Security 36 or 9694096386 (24 hrs)	Environmental Health and Safety will arrange for help with spill cleanup or provide advice on proper clean up procedures as per the operating procedures and MSDS of chemicals.

Emergency Services

S. No.	Description	Contact Number
1.	Fire Service	101, 01493-222700, 512101
2.	Police	100, 01493-250015
3.	Commissioner Police	0141-2606377
4.	S.P. Alwar (Superintendent of Police)	0144-2337453, 2337838
5.	Ambulance Service	01493-221700, 220377 ,108
6.	Personal Service	01493-223940 (Apex Fire)
7.	Ambulance Helpline	01493-221117,108
8.	Electricity Company	01493-250020, 09414706464
9.	Water company	01493-220811, 220728
10.	Telephone	01493-220001, 220003
11.	Taxi Service	01493-221185

❖ **Safety Awareness among the workers**

Details of training and periodic retraining programs for the personnel of safety and fire department

Security guards who act as firemen during fire emergency are trained, retrained and refreshed on regular basis. Safety professional is sent for external training and some training program also conducted at works site by external experts of the field.

Details of Training and retraining programs for the workers

Training programs on safety aspects with special attention to firefighting are regular feature of company. Plant organizes 3-4 sessions every month on safety aspects and cover good number of workmen in these programs.

All these training programs would at least include the following:

- Lectures
- Seminars and workshop
- Practical Exercises
- Distribution and practice safety instructions
- Safety quiz contests/competitions for individual as also for groups
- Display of safety posters and safety slogans at convenient and conspicuous places.

- Explanation of instructions (in the language easily understood by workers) about the possible hazards involved in handling of chemicals ad methods to deal with such hazards failing which possible emergency situation are likely to arise.
- Developing safety instructions for every job and ensuring practice to these instructions/ booklets or manuals by workers.
- Educating workers about the
- Physical and health hazards arising out from the exposure of handling substance
- Measures taken to ensure safety and control physical and health hazards.
- Measures to be taken by workers to ensure safe handling, loading and unloading.
- Storage and transportation of hazardous substances
- Meaning of various labels and marking used on containers of hazardous substances and to whom to report
- Measures to be taken in case of any spillage or leakage.

1.7 OCCUPATIONAL HEALTH & SAFETY PROGRAMME

HPM CHemicals & Fertilizers Ltd. has/will prepare the Occupational Health Surveillance Programme which shall be followed right from the project construction & erection phase and the same shall be updated for the upcoming new facility, if required.
The details of the same are described in the following sections.

1.7.1 Occupational Health

Occupational health needs attention both during construction & erection and operation & maintenance phases. However, the problem varies both in magnitude and variety in the above phases.

1.7.2 Hospital Facilities /Factory Medical Officer & OHC

- Company has/will make formal agreements with nearby hospitals having facilities to attend fire and toxic effect cases, emergency cases, attending the affected persons in the emergency arising out of accidents, if any, *etc*.
- A qualified doctor is/will be appointed as FMO on retainer ship basis. Apart from him, required medical facilities applicable as per Factories Act shall also be made available.
- All types of first aid related accessories, Medicines & Antidotes as prescribed by FMO, *etc.* shall be made available at conspicuous locations.

1.7.3 Ambulance Van & First Aid Box

An Emergency Vehicle shall be made available round the clock to be used as an Ambulance during emergency.
First Aid Boxes is/will be made available at Security gate, emergency room, ETP and process plants. Training is/will be given to employees for First Aid.

1.7.4 Plan for Periodic Medical Checkup

Periodic Medical Examination should be conducted as per the following schedule;
Workers employed should be examined by a Qualified Medical Practitioner/ Factory Medical Officer, in the following manner:

1. Before employment, to ascertain physical fitness of the person;
2. During employment, every six months (blood & physical examination) as per Gujarat Factories Rules, to ascertain physical fitness of the person to do the particular job;

1.7.5 Details of Occupational Health Impacts and Safety Hazards

Occupational Hazards Identification	Occupational Health Impacts
Exposure to Toxic & Corrosive Chemicals	Toxication, Irritation,
Exposure to Chemical Dust, Spillage/ leakage, Overflow	Severe irritation to eyes & skin, Respiratory disorder, Fatality, etc.

Slip/trip, fall, electric shock, etc.	Body Injury, Burns, Skin sensitization, Fall Injury, Electrocution, Damage to nearby equipment's, Fatality, etc.

Mitigation measures/ Safety Measures proposed to avoid the human health hazards are mentioned in additional studies. In addition to these safety measures, personal protective equipment (IS approved) will also be provided to the required personnel. List of PPE's given below.

Table 1.14 List of PPE's

S. No	Personal Protective Equipments (PPE's)	Numbers
1.	Safety Shoes	169
2.	Safety goggles	169
3.	Dust masks	169
4.	Cartridge Masks	40
5.	Hand gloves (Rubber, cotton, *etc*.)	169
6.	Refractive Jacket	20
7.	Ear Plugs	169
8.	Ear Muffs	169
9.	Safety helmet	169
10.	Others (PVC apron, SCBA Set, PVC pressure suit)	As per requirement

1.7.6 Details of Work Place Ambient Air Quality Monitoring Plan

Work zone monitoring will be carried out by independent competent third party every month. Records will be kept as per Gujarat Factories Rules. Location for samplings shall be identified. Ambient Air & Noise Monitoring shall be done as per GPCB Consent to operate requirements. Following information will be incorporated in the format for maintaining records of work zone monitoring:

- Location/ Operation monitored
- Identified contaminant
- Sampling instrument used
- Number of Samples
- Range of contaminant concentration as measured in sample.
- Average concentration
- TWA concentration of contaminant (As given in Second Schedule of Factories Act).
- Reference method used for analysis.
- Number of workers exposed at the location being monitored.
- Signature of the person taking samples.
- Other relevant details.

1.7.7 Monitoring of The Occupational Injury & It's Impact on Workers

Following action plan is/will be prepared & followed to monitor the occupational injury to workers:

- Each workplace is/will be evaluated for the existing work conditions.
- Unsafe Act & Unsafe Practices is/will be identified.
- Unsafe equipment's, unsafe areas, *etc*. is/will be identified.
- Area will be checked for proper Ventilation and Illumination.
- Air-borne concentration of toxic chemicals is/will be measured and records will be kept.
- Evaluation of training & on the job work.

Impact of the above mentioned unsafe conditions on workers will be studied and remedial measures for the same will be adopted.

1.7.8 Safety Trainings & Mock Drills

Safety trainings (on Safe Material Handling, First Aid, & all Safety Aspects) shall be provided every 15 days by the Safety Officers with the assistance of faculty members called from other Professional Safety Institutions and Universities. In addition to regular employees, limited contractor labors will also be given safety training. To create safety awareness, safety films shall be shown to workers and leaflets shall be distributed.

Mock Drills

To evaluate the effectiveness of emergency preparedness and to spread the awareness among employees mock drill will be carried out at the interval of every six months.

After completion of the mock drill, summary report shall be made and corrections will be done if any weakness has been observed.

Frequency of Mock Drills

On-site emergency: Once every 6 months

Off-site emergency: Once every year

1.8 SUMMARY

The expansion project falls in the notified induatrial area of RIIICO notified in the year 1994 vide gazette notification no. 4/6/Udyog/1/90 dtd. 26th August 1994. As per Office Memorandum No. J-11011/321/2016-IA.II(I) dtd 27th April 2018; the public consultation (PH) is not applicable to this project. Risk assessment study has been conducted on hazardous chemiclas stored at project site. Qualitative risk assessment study has been done for the solid, corrosive and toxic chemicals which are stored in drums and bags. Quantitave risk assessment study has been done on flammable and toxic chemicals which are stored in storage tanks at project site. Major hazardous chemicals stored at site are Hexane, Dimethylformamide, Toluene and Acetone on which worst case scenario has been considered. Quantitative risk study had concluded that the hexane is the most hazardous chemical as its overpressure effect distance is within 1 km distance which can be controlled by specific mitigation measure at place. Disaster Management Plan has been prepared by linking it to district disaster management plan.