ACTERO PHARMA PVT. LTD.

SY.NO. 407 (PART) AND 411, VELIMINEDU VILLAGE,
CHITYAL MANDAL, NALGONDA DISTRICT, TELANGANA

RISK ASSESSMENT REPORT

SUBMITTED TO
MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE
GOVERNMENT OF INDIA
INDIRA PARYAVARAN BHAWAN, JOR BAGH ROAD, NEW DELHI

7.0 RISK ASSESSMENT AND DAMAGE CONTROL

7.0 Introduction

This chapter presents the risk assessment study results for the plant operations, transport and storage of raw materials, and identifies maximum credible accident scenarios to draw the emergency management plan addressing various credible scenarios identified.

7.1. Objectives and Scope

The production of Synthetic Organic chemicals (bulk drug and intermediates) involves usage of many chemicals which are both hazardous and toxic in nature. The risks associated with the chemical industry are commensurate with their rapid growth and development. Apart from their utility, chemicals have their own inherent properties and hazards. Some of them can be flammable, explosive, toxic or corrosive etc. The whole lifecycle of a chemical should be considered when assessing its dangers and benefits. In order to ensure the health and safety of persons at or near the facilities, Govt. has approved some regulations. The regulation requires Employers to consult with employees in relation to:

- Identification of major hazards and potential major accidents
- Risk assessment
- Adoption of control measures
- Establishment and implementation of a safety management system
- Development of the safety report

The involvement of the employees in identification of hazards and control measures enhances their awareness of these issues and is critical to the achievement of safe operation in practice. In order to comply with regulatory authorities, M/s Actero Pharma Pvt. Ltd., have entrusted Team Labs and Consultants, Hyderabad to review and prepare Hazard analysis and Risk assessment for their facility along with an approach to on-site emergency preparedness plan as required under the acts and rules. (Manual on emergency preparedness for chemical hazards, MOEF, New Delhi). In this endeavor, the methodology adopted is based on;

- visualizing various probable undesirable events which lead to major accidents
- detailed and systematic assessment of the risk associated with each of those hazards, including the likelihood and consequences of each potential major accident event; and
- identifying the technical and other control measures that are necessary to reduce that risk to a level that is as low as reasonably practicable

The strategy to tackle such emergencies, in-depth planning and person(s) or positional responsibilities of employees for implementation and coordination of timely and effective response measures are described in onsite detail in Emergency Plan.

7.2 Project Details

The plant site of 11.275 acres is located at Survey No. 407 (Part) and 411, Veliminedu Village, Chityal Mandal, Nalgonda District, Telangana State. The site is located at the intersection of 17°13'34" (N) latitude and 79° 2'38" (E) longitude. The plant site elevation above mean sea level (MSL) is in the range of 329 - 338 m. The plant site is surrounded by open agricultural land in west direction, proposed expansion site of Dasami Lab Pvt. Ltd., in west direction, road connecting Pittampalli village to national highway in north direction and VSK Laboratories Pvt. Ltd. In south direction. The nearest habitation from the plant is Pittampalli village located at a distance of 2.1 km in southwest direction. The main approach road connecting to National Highway 9 - Hyderabad - Vijayawada Road adjacent to site in north direction. National Highway 9 - Hyderabad - Vijayawada is at a distance of 0.5 km in north direction. The nearest town Chityal is at a distance of 8.4 km in northeast direction. The nearest railway station Ramannapet is at a distance of 7.6 km in northeast direction and nearest airport is Rajiv Gandhi International Airport (Hyderabad) located at a distance of 65 km in northwest direction. Seasonal nala Chinna Vagu is flowing from northwest to southeast direction at a distance of 6.5 km in southwest direction. There are two reserve forests in the impact area of 10 km radius of the study area. Chityal RF at a distance of 6.1 km in east direction, Shivanenigudem RF at a distance of 9.1 km in northeast direction. There is no national park, wildlife sanctuary, ecologically sensitive area, biosphere reserve, tiger reserve, elephant reserve, critically polluted areas and interstate boundary within 10 km radius of the site. The manufacturing capacities of the proposed bulk drug and intermediates is presented in **Table 7.1** and **Table 7.2** Chemical inventory is presented in **Table 7.3**

Table 7.1 Manufacturing Capacity

S.No	Name of Product	CAS. No	Capacity	
			Kg/day	TPM
1	Abiraterone Acetate	154229-19-3	16.7	0.5
2	Afatinib	850140-72-6	23.3	0.7
3	Anastrazole	120511-73-1	10	0.3
4	Bicalutamide	3543-75-7	33.3	1
5	Bendamustine HCl	153559-49-0	16.7	0.5
6	Bexarotene	90357-06-5	313.3	9.4
7	Bosutinib	380843-75-4	10	0.3
8	Capecitabine	154361-50-9	366.7	11
9	Carfilzomib	868540-17-4	16.7	0.5
10	Ceritinib	1032900-25-6	500	15
11	Cyclophosphamide	50-18-0	200	6
12	Dasatinib	302962-49-8	83.3	2.5
13	Docetaxel	114977-28-5	808.3	24.25
14	Enzalutamide	915087-33-1	33.3	1
15	Erlotinib HCl	183319-69-9	133.3	4
16	Gefitinib	184475-35-2	350	10.5
17	Gemcitabine HCl	122111-03-9	13.3	0.4
18	Ibrutinib	936563-96-1	8.3	0.25
19	Imatinib Mesylate	220127-57-1	50	1.5
20	Lapatanib	388082-78-8	533.3	16
21	Lenvatinib	417716-92-8	13.3	0.4
22	Olaparib	763113-22-0	8.3	0.25
23	Palbociclib	571190-30-2	6.7	0.2
24	Pazopanib	444731-52-6	75	2.25
25	Sorefinib	284461-73-0	800	24
26	Sunitinib	341031-54-7	753.3	22.6
27	Tamoxifene	10540-29-1	366.7	11
Total Worst Case: 22 Products on campaign basis			**5500**	**165**

Table 7.2 List of By-products

S. No	Name of the Product	Stage	Name of the By Product	Quantity (Kg/day)
1	Docetaxel	I	2,2,2-Trichloro ethyl formate	355.6

Table 7.3 List of Raw Materials and Inventory *(Terms of Reference No. 3(iv) & (3(v))*

S.No	Name of the Raw Material	Maximum storage (Kgs)	Physical Form	Type of Hazard	Mode of Storage	Mode of Transport
1	(S)-2-Amino--4-methyl-1-((R)-2-methyloxiran-2-yl)pentan-1-one 2,2,2-trifluoroacetate	164	Solid	Irritant	Bags	By Roads
2	(S)-3-Hydroxy tetrahydrofuran	44	Liquid	Irritant	Drums	By Roads
3	1-(2-hydroxyethyl)piperazine	300	Liquid	Irritant	Drums	By Roads
4	1-(4-hydroxyphenyl)-1,2-diphenyl-1-butene	2396	Liquid	Flammable	Drums	By Roads
5	1H-Benzimidazol-1-methyl-5-amino-2-butanoic acid ethylester	128	Solid	Irritant	Bags	By Roads
6	2-(2'-Hydroxyphenyl)benzoxazole	70	Powder	Irritant	Bags	By Roads
7	2-(6-chloro-6-methyl pyrimidin -4ylamino)-N-(2-chloro-6-methyl phenyl) thiazole-5-carboxamide	909		Irritant		By Roads
8	2-(Methanesulfonyl) ethylamine	968	Liquid	Flammable	Drums	By Roads
9	2,2'-(5-Methyl-1,3-phenylene-di(2-methylpropionitrile)	193	Liquid	Flammable	Drums	By Roads
10	2,3-di-o-acetyl-5-deoxy-5-fluorocytidine	3222	Liquid	Carcinogenic	Drums	By Roads
11	2,4-dichloro-5-methoxyaniline	101		Irritant		By Roads
12	2,5-dichloro-N-(2-(isopropylsulfonyl) phenyl)pyrimidin-4-amine	4195		Irritant		By Roads
13	2-chloro-N,N-diethylethanamine	859		Irritant		By Roads
14	2-deoxy-2,2-difluoro pentofuranos-3,5-dibenzoate	149	Crystalline	Combustible	Bags	By Roads
15	2-Fluoro-4-nitrobenzoic acid	348	Solid	Irritant	Bags	By Roads
16	2-Fluoro-5-formylbenzonitrile	55	Solid	Irritant	Bags	By Roads
17	2-isopropoxy-5-methyl-4-(piperidin-4-yl) aniline dihydrochloride	3893	Crystalline	Corrosive	Bags	By Roads
18	3-(4-Phenoxyphenyl)-1H-pyrazolo[3,4-d]pyrimidin-4-amine	90	Liquid	Flammable	Drums	By Roads
19	3-Amino-1-propanol	894	Viscous	Corrosive	Drums	By Roads
20	3-chloro-4-(3-cyclopropylureido)phenol	58	Liquid	Toxic	Drums	By Roads

21	3-Chloro-4-fluoro aniline	1514	Powder	Toxic		By Roads
22	4(2-(N-Methylcabamoyl)-4-pyridyloxy)aniline	3120	Liquid	Flammable	Drums	By Roads
23	4-(4-Methylpiperazino methyl) benzoic acid dihydrochloride	578	Solid	Irritant	Bags	By Roads
24	4,6-bis[[(2,2,2-trichloroethoxy)carbonyl] oxy]substituted docetaxel	6000	Liquid	Flammable	Drums	By Roads
25	4-Amino-2-(trifluoromethyl)benzonitrile	184	Solid	Irritant	Bags	By Roads
26	4-Chloro-3-(trifuoromethyl)phenyl isocyanate	2505	Powder	Irritant	Bags	By Roads
27	4-Chloro-6-(3-morppholinopropoxy)-7-methoxyquinazoline	3506	Liquid	Flammable	Drums	By Roads
28	4-chloro-6,7-bis(2-methoxy ethoxy) Quinazolinone	970	Liquid	Flammable	Drums	By Roads
29	4-Dimethylamino pyridine	10	Crystalline	Toxic	HDPE Bags	By Roads
30	4-Chloro-7-methoxy-6-quinolinecarboxamide	61	Solid	Carcinogenic	Bags	By Roads
31	4-fluorothiophenol	76	Liquid	Flammable	Drums	By Roads
32	5-[4-({3-chloro-4-[(3-fluorophenyl)methoxy]phenyl} amino)quinazolin-6-yl]furan-2-carbaldehyde	3729	Liquid	Flammable	Drums	By Roads
33	5-Amino-2-Methyl Benzene sulphonamide	255	Solid	Non hazard	Bags	By Roads
34	5-fluoro-1,3-dihydro-indol-2-one	2182	Crystalline	Combustible	Bags	By Roads
35	5-formyl-2,4-dimethyl-1H-pyrrole-3-carboxylicacid-(2-diethylamino-ethyl)-amide	3829	Solid	Corrosive	Bags	By Roads
36	6-Bromo-2-chloro -8-Cyclopentyl-5-methylpyrido[2,3-d] pyrimidin-7(8H)-one	258	Solid	Corrosive	Bags	By Roads
37	7-(3-chloropropoxy)-6-methoxy-4-oxo-1,4-dihydroquinoline-3-carbonitrile	157	Liquid	Flammable	Drums	By Roads
38	Acetic acid	15000	Liquid	Flammable	Storage Tanks	By Roads
39	Acetic anhydride	55	Liquid	Flammable	Drums	By Roads
40	Acetone	30000	Liquid	Flammable	Storage Tanks	By Roads
41	Acetone cyanohydrin	118	Liquid	Toxic	Drums	By Roads
42	Acetonitrile	8000	Liquid	Flammable	Drums	By Roads
43	Acryloyl chloride	20	Solid	Corrosive	Bags	By Roads
44	Activated carbon	4466	Solid	Flammable	Bags	By Roads

45	Ammonium bi carbonate	1050	Solid	Irritant	Bags	By Roads
46	Ammonium Chloride	1647	Solid	Corrosive	Bags	By Roads
47	Ammonium hydroxide	396	Liquid	Toxic	Drums	By Roads
48	Anhydrous Magnesium sulfate	280	Crystalline	Combustible	Bags	By Roads
49	Anhydrous Sodium sulfate	700	Granules	Non-Hazard	Bags	By Roads
50	Bis-(2-chloroethyl)amine Hydrochloride	1693	Powder	Irritant	Bags	By Roads
51	BOC Piperazine	52	Crystalline	Irritant	Bags	By Roads
52	Carbon	84	Solid	Non-Hazard	Bags	By Roads
53	Celite	3500	Liquid	Flammable	Drums	By Roads
54	Chloroform	5250	Liquid	Carcinogenic	Drums	By Roads
55	Citric acid	105	Liquid	Combustible	Drums	By Roads
56	Cyclohexane	1400	Liquid	Flammable	Drums	By Roads
57	Cyclopropane carbonyl chloride	17	Liquid	Flammable	Drums	By Roads
58	1,8-Diazabicyclo[5.4.0]undec-7-ene	56	Liquid	Toxic	Drums	By Roads
59	Dehydroepiandrosterone-3-acetate	379	Solid	Non-Hazard	Bags	By Roads
60	Di isopropyl ethylalcohol	70	Liquid	Flammable	Drums	By Roads
61	Dichloromethane	30000	Liquid	Carcinogenic	Storage Tanks	By Roads
62	Diethyl (3-pyridyl)borane	169	Solid	Irritant	Bags	By Roads
63	Diisopropyl azodicarboxylate	60	Liquid	Carcinogenic	Drums	By Roads
64	Diisopropylether	8000	Liquid	Flammable	Drums	By Roads
65	Diisopropyl ethyl amine	490	Liquid	Flammable	Drums	By Roads
66	Dimethyl formamide	30000	Liquid	Flammable	Storage Tanks	By Roads
67	Dimethyl sulfoxide	665	Liquid	Flammable	Drums	By Roads
68	Dimethyl(3-oxo-1,3-dihydroisobenzfuran-1-yl)phosphonate	89	Solid	Corrosive	Bags	By Roads
69	Dimethylacetamide	1225	Liquid	Carcinogenic	Drums	By Roads
70	Ethylene dichloride	70	Liquid	Toxic	Drums	By Roads
71	Ethanol	30000	Liquid	Flammable	Storage Tanks	By Roads
72	Ethyl acetate	30000	Liquid	Flammable	Storage Tanks	By Roads
73	Ethyl acetate.HCl	242	Liquid	Flammable	Drums	By Roads
74	Ethylene Oxide (Gas)	50	Gas	Flammable	Cylinders	By Roads
75	Ethynylbenzenamine	364	Liquid	Toxic	Drums	By Roads

76	Hexane	6195	Liquid	Flammable	Drums	By Roads
77	Hexamethyl disilazine	210	Liquid	Flammable	Drums	By Roads
78	Hydroxybenzotriazole	18	Solid	Flammable	Bags	By Roads
79	Hydrazine hydrate	18	Liquid	Flammable	Drums	By Roads
80	Hydrochloric acid	4799	Liquid	Corrosive	Drums	By Roads
81	Hydrogen gas	50	Gas	Flammable	Cylinders	By Roads
82	Hydrogen Peroxide	20	Liquid	Corrosive	Drums	By Roads
83	Hyflo	42	Solid	Non - Flammable	Bags	By Roads
84	Isopropanol	30000	Liquid	Flammable	Storage Tanks	By Roads
85	L-Cysteine	32	Crystalline	Non hazard	Bags	By Roads
86	Lithium bis(trimethylsilyl)amid	350	Solid	Flammable	Bags	By Roads
87	Maleic acid	2020	Solid	Combustible	Bags	By Roads
88	Methanesulfonic acid	114	Liquid	Non - Flammable	Drums	By Roads
89	Methane sulfonyl chloride	45	Liquid	Toxic	Drums	By Roads
90	Methanol	30000	Liquid	Flammable	Storage Tanks	By Roads
91	Methanolic ammonia	1167	Liquid	Flammable	Drums	By Roads
92	Methyl ((S)-2-(2-chloroacetamido)-4-phenylbutanoyl)-L-leucyl-L-phenylalaninate	236	Powder	toxic	Bags	By Roads
93	Methyl[4-(5,6,7,8-tetrahydro-3,5,5,8,8-pentamethyl-2-naphthalenyl)carbonyl] benzoate	2867	Solid	Irritant	Bags	By Roads
94	Methyltriphenyl phosphoniumbromide	2812	Powder	Irritant	Bags	By Roads
95	Morpholine	39	Liquid	Flammable	Drums	By Roads
96	N- Methyl pyrrolidine	700	Liquid	Carcinogenic	Drums	By Roads
97	N-(2-Chloropyrimidin-4-yl)-N,2,3-trimethyl-2H-indazol-6-amine	394	Solid	Irritant	Bags	By Roads
98	N-(3-Chloro-4-fluorophenyl)-7-fluoro-6-nitroquinazolin-4-amine	167	Liquid	Flammable	Drums	By Roads
99	N-(2-Methyl-5-aminophenyl)-4-(3-pyridyl)-2-pyrimidne amine	522	Solid	Flammable	Bags	By Roads
100	N,N,N',N'-Tetramethyl-O-(1H-benzotriazol-1-yl) uronium hexafluoro phosphate	83	Solid	Flammable	Bags	By Roads

101	N,N-Diisopropylethylamine	5950	Liquid	Flammable	Drums	By Roads
102	N,N-Dimethyl formamide	560	Liquid	Flammable	Drums	By Roads
103	N.N′-Carbonyldiimidazole	2076	Solid	Corrosive	Bags	By Roads
104	N-[4-Cyano-3-(trifluoromethyl)phenyl]-3-[4-fluorophenyl)thio]-2-hydroxy-2-methylpropanamide	161	Powder	Irritant	Bags	By Roads
105	N-Acetyl cytosine	60	Liquid	Irritant	Drums	By Roads
106	N-Bromo Succinamide	152	Solid	Corrosive	Bags	By Roads
107	n-Butanol	6000	Liquid	Flammable	Drums	By Roads
108	n-Hexane	770	Liquid	Flammable	Drums	By Roads
109	N-Hydroxybenzotriazole	560	Solid	Flammable	Bags	By Roads
110	N-methyl morpholine	26	Liquid	Flammable	Drums	By Roads
111	N-methyl piperazine	36	Liquid	Corrosive	Drums	By Roads
112	n-Pentyl Chloroformate	1474	Solid	Flammable	Bags	By Roads
113	n-Propanol	8000	Liquid	Flammable	Drums	By Roads
114	Oxalyl chloride	68	Liquid	Toxic	Drums	By Roads
115	Pd/C	717	Solid	Irritant	Bags	By Roads
116	Pd(dppf)cl2 in DCM	11	Solid	Carcinogenic		By Roads
117	phosphorous oxychloride	82	Liquid	Corrosive	Drums	By Roads
118	Phosphorylchloride	1830	Liquid	Toxic	Drums	By Roads
119	Potassium hydroxide	1425	Solid	Corrosive	Bags	By Roads
120	Potassium Iodide	16	Solid	Irritant	Bags	By Roads
121	Potassium tertiary butoxide	84	Solid	Flammable	Bags	By Roads
122	Potassiumhexamethyl disilazide	882	Liquid	Irritant	Drums	By Roads
123	p-Toluenesulfonic acid	2752	Liquid	Flammable	Drums	By Roads
124	Pyridine	395	Liquid	Flammable	Drums	By Roads
125	Pyrrolidine	140	Liquid	Flammable	Drums	By Roads
126	Sodium chloride solution	2561	Solid	Corrosive	Bags	By Roads
127	Silica gel	48	Beads	Non-Flammable	Bags	By Roads
128	Methyl amine	23	Liquid	Corrosive	Drums	By Roads
129	Sodium Bicarbonate	2335	Crystalline	Irritant	Bags	By Roads
130	Sodium carbonate	430	Crystalline	Irritant	Bags	By Roads

131	Sodium hydroxide	5745	Liquid	Corrosive	Drums	By Roads
132	Sodium iodide	45	Crystalline	Irritant	Bags	By Roads
133	Sodium sulphate	42	Granules	Non-Hazard	Bags	By Roads
134	Sodium Triazole	78	Powder	Carcinogenic	HDPE Bags	By Roads
135	Sulphuric acid	14	Liquid	Corrosive	Drums	By Roads
136	t-Butyl Methyl Ether	8500	Liquid	Flammable	Drums	By Roads
137	t-butylmethylether .HCl	490	Liquid	Flammable	Drums	By Roads
138	tert-butyl (S)-3-hydroxypiperidine-1-carboxylate	59	Solid	Irritant	Bags	By Roads
139	Tert-butyl 4-(6-aminopyridin-3-yl) piperazine-1-carboxylate	210	Crystalline	Irritant	Bags	By Roads
140	Tetrahydrofuran	6000	Liquid	Flammable	Drums	By Roads
141	Thionyl chloride	469	Liquid	Toxic	Drums	By Roads
142	Thiophosgene	114	Liquid	Toxic	Drums	By Roads
143	Toluene	30000	Liquid	Flammable	Storage Tanks	By Roads
144	Trans-4-dimethyl amino crotonic acid	60	Solid	Corrosive	Bags	By Roads
145	Triacetoxy sodium borohydride	735	Solid	Flammable	Bags	By Roads
146	Triethyl amine	3848	Liquid	Flammable	Drums	By Roads
147	Trifluoromethanesulfonic anhydride	324	Liquid	Corrosive	Drums	By Roads
148	Trimethyl Chlorosilane	18	Liquid	Flammable	Drums	By Roads
149	Trimethyl silyl trifluoro methane sulphonate	245	Liquid	Flammable	Drums	By Roads
150	Triphenylphosphine	77	Solid	Irritant	Bags	By Roads
151	Triphenylphosphine palladium chloride	5	Crystalline	Irritant	Bags	By Roads
152	Vinyl butyl ether	40	Liquid	Flammable	Drums	By Roads
153	Zinc	2800	Solid	Flammable	Bags	By Roads

7.3 Process Description

The manufacturing process for all the products is presented in Chapter 2. (**Page No. 2-2 to 2-83**) of the report.

7.4 Plant Facilities

The manufacturing facility shall be provided with

1) Production blocks
2) Utilities
3) Quality Control, R&D lab
4) Effluent Treatment plant
5) Warehouses
6) Tank farm area
7) Cylinder Storage
8) Administrative Office
9) Solvent recovery area
10) Coal and Ash Storage Area

The production facilities shall be designed for proper handling of materials and machines. Safety of operators, batch repeatability and process parameter monitoring shall be the major points of focus in the design of facility. The current Good Manufacturing Practices (GMP) guidelines shall be incorporated as applicable to synthetic organic chemicals manufacturing facilities.

7.4.1 Production Blocks:

The Production blocks will consist of SS and glass lined reactors, storage tanks, shell & tube heat exchangers, evaporators, vacuum pumps, packed columns, Agitated Nutche Filter and Dryers, crystallizers, layer separators etc. The area shall be provided with proper concealed drainage facility and all process facilities shall be performed under protective environment.

7.4.2 Utilities:

It is proposed to establish coal fired boilers of capacity of 2 x 8 TPH to meet steam requirement for process and ZLD system. The DG sets required for emergency power during load shut down is estimated at 5000 KVA and accordingly 1 x 1500, 2 x 1000, 3 x 500 kVA DG set are proposed. The list of utilities is presented in the following **Table 7.4**.

Table 7.4 List of Utilities

S.No	Utility	Capacity
1	Coal Fired Boilers (TPH)	2 x 8
2	DG Sets (KVA)*	1 x 1500 2 x 1000 1 x 500

**DG sets will be used during load shut down periods only*

7.4.3 Quality Control, R&D Lab

The QC department shall comprise of an in-process lab with instruments like HPLC, GC etc. It will be maintained by highly qualified and trained people. The activities include:

- In-process quality check during manufacturing
- Validation of facilities
- Complaint handling

Also a process development laboratory shall be provided for in-house process development, initial evaluation of process technology in case of technology transfer, back-up for production department to address any issues arising during commercial production

7.4.4 ETP and Solid waste storage

The total effluents segregated into two streams High COD/ TDS and Low COD/ TDS streams based on source of generation. These effluents are treated in Zero Liquid Discharge system and the treated effluents are reused for cooling towers and boiler make-up.

7.4.5 Ware Houses:

The plant shall have sufficient storage facility for safe handling of raw materials. All solid raw materials shall be stored in marked areas with proper identification. Liquid raw materials and solvents like which are available in drums will be stored according to material compatibilities and flammability. Adequate fire fighting facilities shall be provided as per NFPA norms.

7.4.6 Tank Farm Area:

A separate tank farm area shall be provided for storing liquid raw materials, especially solvents with high inventory and also for toxic, corrosive chemicals. Dykes shall be provided to ensure safety in case of tank failure. Acid proof lining for the dykes shall be provided for acid storage tanks. Condensers for low volatile solvent storage tanks vents.

7.4.7 Cylinders storage Area:

Gas cylinders storage should conform to SMPV-Unfired rules-1981. Hydrogen cylinders should be stored in approved Gas Storage pad. Chained and capped when not in use. Operational cylinder should be firmly secured. Pressure regulator, metal piping, non-return valve, and safe residue bleed off arrangement should be incorporated in installation design. Strict hot work control and display of danger signs should be ensured.

7.4.8 Administrative Office:

An Administrative office shall be provided at the entrance of the factory to ensure the entry of authorized personnel only into the premises.

7.4.9 House Keeping:

A regular house keeping schedule with adequate preventive maintenance shall be ensured so that the plant is consistently maintained as per GMP standards.

7.4.10 Coal and Ash Storage:

Coal will be stored under covered shed with water sprinkler system in emergency. Ash silos will be provided for storage and handling of ash generated from combustion of coal.

Water sprinkling system shall be installed on stocks of coal in required scales to prevent spontaneous combustion and consequent fire hazards. The stack geometry shall be adopted to maintain minimum exposure of stock pile areas towards predominant wind direction

7.4.11 Facility layout and design:

The layout of all the various areas required for the facility, as mentioned above is considered. In laying out the above areas, isolation of the various process areas from the utilities and non-process areas is considered in view of both containment and cGMP. A tentative plant layout is shown in **Fig 7.1.**

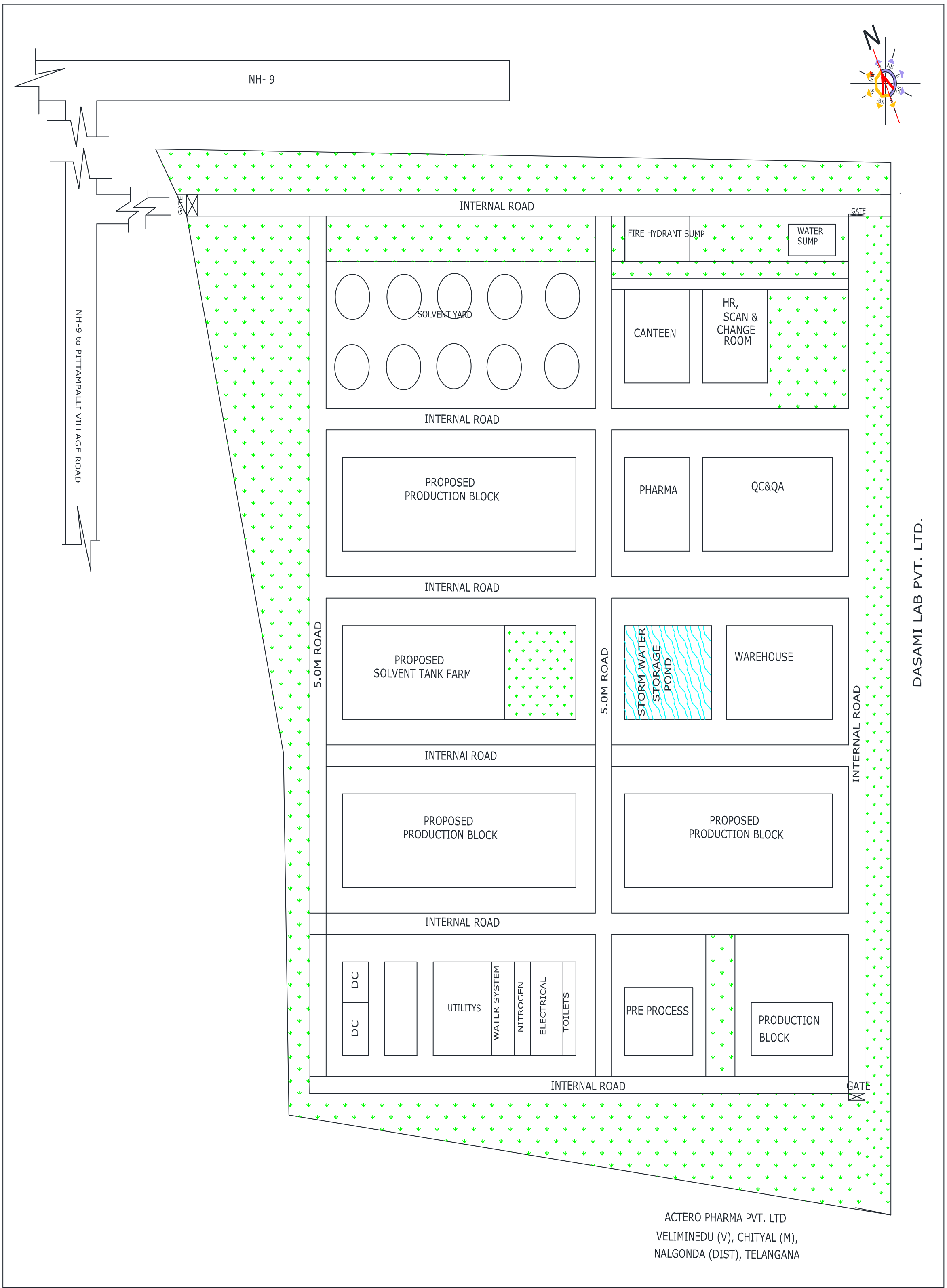

Fig 7.1 Plant Layout of Actero Pharma Pvt. Ltd.

Table 7.5 Risk Control Measures

Significant Risks	Control Measures
Solvent Tank Farm and Chemical Tank Farm	
Fire/ Explosion	• Solvent Tank Farm licensed by PESO. • Restrict inventory to licensed quantities in Solvent Tank Farm. • Fenced Solvent Tank Farm. • Fenced Solvent Tank Farm capable of being locked when not in use. • Access Control and control of visitors • Control of ignition sources. • All electrical equipment and fittings to be flameproof as per area classification. • Provision of foam cover to cover the largest dyke area • Water spray cooling arrangements for all tanks • Fire hydrants and fire monitors • Solvent Storage Tanks to have N_2 blanketing • Earthrite system for earthing of tankers carrying solvents. • Spark arresters on vehicles • Wetting of road and tyres before unloading • NO dry grass inside the fenced area • No parking inside/ near the tank farm. • No obstruction on the road for free movement of fire tender. • No solvent pumping in night shift – Daytime operations only.
Loss of Containment and Spillage	• Dykes for all tanks (Dyke capacity to be min. 110% of tank capacity and dyke distance from tank to be min half the tank height). • Tanker unloading area (road) to be dyked. • Availability of the Spill control kit.
Injury at the time of loading/ unloading	• Provision of PPE to stores personnel. • Operations by trained stores personnel only.
Bulk Materials Store (liquid chemicals) Drum Yard and Special Chemicals Store	
Fire/ Explosion	• Fenced area, Access Control and control of visitors • Building capable of being locked when not in use. • Control of ignition sources. • Control of inventory to minimum possible • Segregation of materials. • Smoke/ Heat detection system (non-electricity based) • No water based fire fighting setup around the store. • Adequate CAUTION displays • Fire hydrants and fire monitors • Provision of foam • No electrical installation inside the Store • Adequate natural light and ventilation. • Daily night inspection by Shift Manager.

Significant Risks	Control Measures
	• No dry grass inside the fenced area • Emergency exit.
Loss of Containment Spillage	• Arrangements of drums in rows of two (two levels max) and a gap of at least 2 feet between rows and from the walls all around. • Storage in open area on hard impervious floor surrounded by a dyke/ sill. (*For Bulk Materials Store and New Solvent Drum Shed*) • Availability of the Spill control kit
Ergonomics – Poor posture leading to illness/ injury. Injury at the time of loading/ unloading	• Provision of PPE to stores personnel. • Loading/ unloading only by trained stores personnel.
Raw Materials Warehouse, Finished Goods Warehouse, Packing Materials Warehouse, and Engineering Store	
Fire	• Access Control and control of visitors • Fenced area • Building capable of being locked when not in use. • Control of ignition sources. • Control of inventory to optimal levels • Segregation of flammable materials. • Segregation of materials. • Battery charging not to be done inside the warehouse except for penicillin warehouse, that too during daytime only. • Installation of Smoke/ Heat detectors • Adequate hydrant points outside/around the building • NO dry grass in open areas. • Daily night inspection by Shift Manager. • Emergency exit. • Availability of DCP, Foam and CO_2 fire extinguishers, Spill Control kit.
Spillage	• Availability of the Spill control kit
Falling Objects	• Mandatory head and foot protection when inside the warehouse.
Ergonomics – Poor posture leading to illness/ injury. Injury at the time of loading/ unloading	• Provision of other PPE to stores personnel. • Loading/ unloading only by trained stores personnel.

7.5 Hazard Analysis and Risk Assessment

7.5.1 Introduction.

Hazard analysis involves the identification and quantification of the various hazards (unsafe conditions) that exist in the plant. On the other hand, risk analysis deals with the identification and quantification of risks, the plant equipment and personnel are exposed to, due to accidents resulting from the hazards present in the plant.

Hazard and risk analysis involves very extensive studies, and requires a very detailed design and engineering information. The various hazard analysis techniques that may be applied are hazard and operability studies, fault-tree analysis, event-tree analysis and failure and effects mode analysis.

Risk analysis follows an extensive hazard analysis. It involves the identification and assessment of risks; the neighboring populations are exposed to as a result of hazards present. This requires a thorough knowledge of failure probability, credible accident scenario, vulnerability of population's etc. Much of this information is difficult to get or generate. Consequently, the risk analysis is often confined to maximum credible accident studies.

In the sections below, the identification of various hazards, probable risks, maximum credible accident analysis, consequence analysis are addressed which gives a broad identification of risks involved in the plant.

7.5.2 Hazard Identification *(Terms of Reference No. 3(ix))*

The Hazard identification process must identify hazards that could cause a potential major accident for the full range of operational modes, including normal operations, start-up, and shutdown, and also potential upset, emergency or abnormal conditions. Employers should also reassess their Hazard identification process whenever a significant change in operations has occurred or a new substance has been introduced. They should also consider incidents, which have occurred elsewhere at similar facilities including within the same industry and in other industries.

Hazard identification and risk assessment involves a critical sequence of information gathering and the application of a decision-making process. These assist in discovering what could possibly cause a major accident (hazard identification), how likely it is that a major accident would occur and the potential consequences (risk assessment) and what options there are for preventing and mitigating a major accident (control measures). These activities should also assist in improving operations and productivity and reduce the occurrence of incidents and near misses.

The chemical and process industries have been using a variety of hazard identification techniques for many years, ranging from simple screening checklists to highly structured Hazard and Operability (HAZOP) analysis. Each technique has its own strengths and weaknesses for identifying hazards. It is impossible to compare hazard identification techniques and come to any conclusion as to which is the best. Each technique has been developed for a specific range of circumstances taking many factors into account including the resources required to undertake the analysis, expertise available and stage of the process. While HAZOP is primarily a tool for hazard identification, the HAZOP process can also include assessment of the causes of accidents, their likelihood and the consequences that may arise, so as to decide if the risk is acceptable, unacceptable or requires further study. Moreover, a formal guidance for applying this technique is available. Collaboration between management and staff is fundamental to achieving effective and efficient hazard identification and risk assessment processes.

After identifying hazards through a qualitative process, quantification of potential consequences of identified hazards using simulation modeling is undertaken. Estimation of probability of an unexpected event and its consequences form the basis of quantification of risk in terms of damage to property, environment or personnel. Therefore, the type, quantity, location and conditions of release of a toxic or flammable substance have to be identified in order to estimate its damaging effects, the area involved, and the possible precautionary measures required to be taken.

Considering operating modes of the facility, and based on available resources the following hazard identification process chosen are:

a) Fire Explosion and Toxicity Index (FETI) Approach;
b) HAZOP studies;
c) Maximum Credible Accident and Consequence Analysis (MCACA);
d) Classification of Major Hazard Substances;
e) Manufacture Storage and Import of Hazardous Chemical Rules, 1989 (GOI Rules, 1989);
f) Identification of Major Hazardous Units.

The physical properties of solvents used in the process are presented in Table 6.2 which forms the basis for identification of hazards during storage and interpretation of the Manufacture, Storage and Import of Hazardous Chemical Rules, 1989 (GOI Rules, 1989)

The interpretation of "The Manufacture Storage and Import of Hazardous chemicals" issued by the Ministry of Environment and Forests, GOI, which guides the preparation of various reports necessary for safe handling and storage of chemicals shows that the present project requires preparation of safety reports before commencing operation and risk assessment is not mandatory. The applicability of various rules is presented in **Table 7.6.**

Table 7.6 Applicability of GOI Rules to Storage/Pipeline

S.No	Name of Chemical	Inventory KL	Threshold Quantity (T) For Application of Rules		Applicable Rules
			5,7-9, 13-15	10 - 12	
1	Acetic acid	15	1500	10000	4 (1) (a), (2), 5,15
2	Acetone	30	1500	10000	4 (1) (a), (2), 5,15
3	Dichloromethane	30	1500	10000	4 (1) (a), (2), 5,15
4	Dimethyl Formamide	30	1500	10000	4 (1) (a), (2), 5,15
5	Ethanol	30	1500	10000	4 (1) (a), (2), 5,15
6	Ethyl Acetate	30	1500	10000	4 (1) (a), (2), 5,15
7	Isopropyl alcohol	30	1500	10000	4 (1) (a), (2), 5,15
8	Methanol	30	1500	10000	4 (1) (a), (2), 5,15
9	Toluene	30	1500	10000	4 (1) (a), (2), 5,15

Table 7.7 Physical Properties of Raw Materials and Solvents

S.No	Name of Raw material	TLV (ppm)	Toxicity Level			Flammable Limit					Chemical Class (As per MSIHC Rules)
			LD50 Oral (mg/kg)	LD50 Dermal (mg/kg)	LC 50 (mg/1)	LEL (%)	UEL (%)	FP (^{O}C)	BP (^{O}C)	Class (As per Petroleum Classification	
1	Acetic acid	10	3310	1060	88	4	19.9	39	118	C	Flammable/Corrosive
2	Acetone	1000	5800	20000	5540	2.6	13	<-20	56.2	B	Flammable
3	Acetonitrile	40	3800	988	1000	3	17	2	81.6	B	Flammable
4	Chloroform	50	908	20000	47702	----	----	----	61	---	Toxic
5	Dichloro methane	50	670	2800	2270	6	11.4	13	40	B	Carcinogenic
6	Diethyl ether	400	1213	14268	2600	1.7	36	-40	34.6	B	Flammable
7	Diisopropyl ether	250	8470	14480	162000	1	21	-28	67	C	Flammable
8	Dimethyl formamide	10	2800	1500	15	2.2	16	58	153	C	Flammable
9	Dimethyl sulfoxide	50	14500	5000	40250	1.8	63	95	189	B	Non-Hazard
10	Ethanol	1000	1720	1025	20000	2.1	11.5	-4	77	B	Flammable
11	Ethylacetate	400	5620	18000	2500	2.1	11.5	-4	77	B	Flammable
12	Hexane	50	28710	2000	>20	1	8.1	-22	69	B	Flammable
13	Isopropyl alcohol	400	5045	12800	100000	2	12.7	12	82.4	B	Flammable
14	Methanol	200	5628	15800	64000	5.5	36.5	11	64.5	A	Flammable
15	n-Butanol	100	2733	2000	---	2.3	8.0	14	83	B	Flammable
16	Methyl t-butyl ether	50	4000	10000	23576	1.6	15.1	-33	55.2	C	Flammable
17	Tetrahydrofuran	200	1650	2000	2160	1.5	12.4	-21.5	66	B	Flammable
18	Toluene	200	636	12124	313	1.2	8	4	110.6	B	Flammable
19	Triethylamine	5	730	580	7.1	1.2	9.3	-11	90	B	Flammable

7.5.3 Fire & Explosion Index (F & EI):

7.5.3.1 Methodology

Dow Chemical Company issued a guideline for hazard determination and protection. By this method a chemical process unit is rated numerically for hazards. The numerical value used is the Fire and Explosion Index (F&EI) which is most widely used for hazard evaluation in chemical process industries.

The guide applies to process unit only and not to auxiliary units such as power generating stations, plant water systems, control rooms, fired heaters, structural requirements, corrosive nature of material handled and personal safety equipment. These are regarded as basic features that do not vary according to the magnitude of the fire and explosion hazard involved. The guide also does not cover the processing and handling of explosives such as dynamite, TNT etc.

Computation of F&EI

The F&EI is calculated as a product of Material factor, General process hazard factor, and special process hazard factor The Material factor is a measure of the intrinsic rate of potential energy release from fire or explosion of most hazardous material or mixture of materials present in significant quantity, whether it is raw material, intermediate, product, solvent etc, by combustion or chemical reaction. "In significant quantity" here means such quantity that the hazard represented by the material actually exists. The National Fire Protection Agency of USA (NFPA) have specified standard values for material factor which should be used for F&EI calculations and are available in Dow's Hazard Classification Guide. In case it is not readily available, it can be calculated using the heat of combustion, flammability indices etc.

General process hazards are factors that play a primary role in determining the magnitude of loss of incident. It takes into account the nature of the reaction, ventilation of the unit, accessibility of the unit, drainage facilities etc., Special process hazards are

factors that contribute primarily to the probability of a loss of incident. They consist of specific process conditions that have shown themselves to be major causes of fire and explosion incidents. It takes into account toxicity of the material, operating pressure, operation near flammable range, quantity of material, joints and packing, use of hot oil exchange system etc., The F&EI index is calculated as a product of Material factor, General process hazard factor, and Special process hazard factor.

Hazard Ranking

The hazard ranking based on F&EI value is presented in **Table 7.8.**

Table 7.8 Degree of Hazard for F&EI

F&EI Index Range	Degree of Hazard
1 – 60	Light
61 – 96	Moderate
97 – 127	Intermediate
128 – 158	Heavy
159 & above	Severe

The estimated values of F&EI and hazard ranking are given in the **Table 7.9.** The radius of exposure is determined by 0.26 meter x respective F&EI. The estimated values of F&EI reflect light hazard in view of the low volume of chemicals.

The fire and explosion index evaluation can be very useful in developing plant layouts or adding equipment and buildings to existing plants. Evaluation of the F&EI calculations and layout considerations will result a safe, operable, maintainable and cost-effective arrangement of equipment and buildings.

Table 7.9 Fire & Explosion Index for Tank farm

S. No.	Name of Solvent	Fire & Explosion Index (F1*F2*MF)	Radius of Exposure (m) F&EIx0.26	Degree of Hazard
1	Acetic acid	71.58	18.61	Moderate
2	Acetone	76.78	19.96	Moderate
3	Dichloromethane	93.62	24.34	Moderate
4	Dimethyl Formamide	83.22	21.64	Moderate
5	Ethanol	64.48	16.76	Moderate
6	Ethyl Acetate	75.28	19.57	Moderate
7	Isopropyl alcohol	77.35	20.11	Moderate
8	Methanol	74.17	19.28	Moderate
9	Toulene	86.82	22.57	Moderate

F& E index value calculated considering the maximum storage capacity of chemical and values are found to be moderate for all other solvents storage reflecting the threshold limits as prescribed in MSHC rules.

7.5.4 Hazard and Operability Study (HAZOP)

Hazard and Operability Study (HAZOP) is a highly structured and detailed technique, developed primarily for application to chemical process systems. A HAZOP can generate a comprehensive understanding of the possible 'deviations from design intent' that may occur. However, HAZOP is less suitable for identification of hazards not related to process operations, such as mechanical integrity failures, procedural errors, or external events. HAZOP also tends to identify hazards specific to the section being assessed, while hazards related to the interactions between different sections may not be identified. However, this technique helps to identify hazards in a process plant and the operability problems. It is performed once the engineering line diagrams of the plant are made available. It is carried out during or immediately after the design stage. The purpose of the study is to identify all possible deviations from the way the design/operation is expected to work and all the hazards associated with these deviations. A multi-disciplinary team was constituted with chemical, mechanical and instrumentation engineers, R&D chemist and production manager. It is important to keep the team small enough to be efficient, while retaining a sufficient spread of skills and disciplines for all aspects of the study to be covered comprehensively. The group discussion is facilitated by a Chairman and the results of the discussion are recorded by a Secretary. Every investigation must be led by Chairman who is familiar with the HAZOP study technique, which is primarily concerned with applying, controlling the discussions and stimulating team thinking.

The preparative work for HAZOP studies consisted of four stages i.e., obtaining the data, converting into usable form, planning the sequence of the study and arranging the necessary meetings. The documents referred to for the study include process description, process flow diagrams, P&I diagrams plant layout, operating manuals including startup

& shutdown, safety instructions etc., The parameters such as temperature, pressure, flow, level were investigated for deviation and hazard situations are identified.

Some basic definitions of terms frequently used in HAZOP studies are deviation, causes, consequences and guide words etc., Deviations are departures from the design intent which are discovered by systematically applying the guide words. Causes are the reasons why deviations might occur. Consequences are the reasons why deviations should they occur. Guide words are simple words used to understand a particular plant section in operating condition in order to guide and simulate the creative thinking process and so discover deviations. NO, less, more, as well as, part of, reverse, other than are guide words used.

Potential problems as represented by the consequences of the deviation should be evaluated as they arise and a decision reached on whether they merit further consideration or action. Except for major risk areas where a fully quantitative assessment is required this decision is made semi-quantitatively on the consequence (usually scaled as trivial, important or very probable).

7.5.5 Hazard Factors

A study of past accident information provides an understanding of failure modes and mechanisms of process and control equipment and human systems and their likely effects on the overall plant reliability and safety. Some of the major contributing factors for accidents in chemical industries are:

S. No	Contributing Factor	Percent Loss
1	Equipment design faults	41
2	Process design faults	10
3	Operator errors	31
4	Maintenance deficiencies	12
5	Material hazards	6

7.5.6 Common Causes of Accidents

Engineering and Instrumental

Based on the analysis of past accident information, common causes of major chemical plant accidents are identified as:

- Poor house keeping
- Improper use of tools, equipment, facilities
- Unsafe or defective equipment facilities
- Lack of proper procedures
- Improving unsafe procedures
- Failure to follow prescribed procedures
- Jobs not understood
- Lack of awareness of hazards involved
- Lack of proper tools, equipment, facilities
- Lack of guides and safety devices
- Lack of protective equipment and clothing

Failures of Human Systems

An assessment of past chemical accidents reveals human factor to be the cause for over 60% of the accidents while the rest are due to other plant component failures. This percentage will increase if major accidents alone are considered for analysis. Major causes of human failures reported are due to:

- Stress induced by poor equipment design, unfavorable environmental conditions, fatigue, etc.
- Lack of training in safety and loss prevention.
- Indecision in critical situations.
- Inexperienced staff being employed in hazardous situations.

Often, human errors are not analyzed while accident reporting and accident reports only provide information about equipment or component failures. Hence, a great deal of uncertainty surrounds analysis of failure of human systems and consequent damages. The number of persons/materials are potentially exposed to a specific hazard zone is a function of the population density and distribution near the accident location. The failure rate data and ignition sources of major fires are presented in the following **Tables 7.10 and 7.11**.

Table 7.10 Failure Rate Data

S.No	Item	International Data
1.	Process Controllers	2.4×10^{-5} hr^{-5}
2.	Process control valve	2.0×10^{-6} hr^{-1}
3.	Alarm	2.3×10^{-5} hr^{-1}
4.	Leakage at biggest storage tank	5.0×10^{-5} yr^{-1}
5.	Leakage of pipe line	1×10^{-7} m^{-1} yr^{-1}
6.	Human Failure	1×10^{-4} $(demand)^{-1}$

Table 7.11 Ignition Sources of Major Fires

S.No	Ignition Source	Percent
1.	Electrical (wiring of motors)	23%
2.	Smoking	18%
3.	Friction	10%
4.	Over heated material	8%
5.	Burner flames	7%
6.	Combustion sparks	5%
7.	Spontaneous ignition	4%
8.	Cutting & welding	4%
9.	Exposure (fires jumping into new areas)	3%
10.	Mechanical sparks	2%
11.	Molten substances	1%
12.	Chemical actions	1%
13.	Static sparks	1%
14.	Lightening	1%
15.	Miscellaneous	1%

7.6 Maximum Credible Accident and Consequence Analysis (MCACA)

The potential hazards due to flammable and toxic nature of the raw materials, process streams and products can be quantified. However, it is necessary to carry out a hazard analysis study to visualize the consequences of an unexpected release from chemical plant, which consists of a number of process units and tank farm facilities. The present study provides quantified picture of the potential hazards and their consequences.

7.6.1 Methodology

MCACA aims at identifying the unwanted hazardous events, which can cause maximum damage to plant and personnel. At the first instance, all probable accident scenarios are developed. Scenarios are generated based on properties of chemicals, physical conditions under which reactions occur or raw materials stored, as well as material strength of vessels and conduits, in-built valves and safety arrangements, etc. Creating a scenario does not mean that it will occur, only that there is a reasonable probability that it could. A scenario is neither a specific situation nor a specific event, but a description of a typical situation that covers a set of possible events or situations.

The following steps are involved in identifying the maximum credible accident scenarios.

a. A detailed study of the process and plant information including process flow diagrams and piping & instrumentation diagrams.

b. Hazard classification of chemicals, operations and equipment.

c. Identification of representative failure cases of vessels and the resulting release scenarios

d. Establishment of credibility of visualized scenarios based on past accident data.

7.6.2 Identification of Vulnerable Areas

The unit operations in the process and storage areas involve mass and energy transfer operations to effect the necessary physical changes. Nature of chemicals and the operating conditions create special hazardous situations. In the present case the chemicals handled are flammable and toxic in nature. With these factors in mind a thorough examination of the process information is carried out and a list of inventories of the hazardous chemicals is prepared to identify the hazardous situations. Based on the raw material consumptions determined from the pilot scale studies, experience in handling commercial scale processes and logistics in procurement of raw materials, the inventories to be maintained for each of the raw material and its mode of storage is determined. High inventory liquid raw materials like solvents are usually stored in tank farms, while solids and other low inventory liquids are stored in ware house based on compatibility, reactivity, toxicity etc. with appropriate safety and fire fighting facilities to handle any kind of emergencies.

7.6.3 Representative Accident Scenarios

A study of past accidents, which took place in similar process units and the present plant, provides reasons and course of accidents and there by focusing on most critical areas. A thorough examination of engineering details indicated many possible scenarios like gasket leak, pinholes in pipes and vessels apart from rupture of pipelines and vessels and catastrophic failure of vessels resulting in a pool. Heat radiation damage distances for Pool fire was considered.

Failure Frequency:

The release scenarios considered above can be broadly divided in to two categories

(i) Catastrophic failures which are of low frequency and

(ii) Ruptures and leaks which are of relatively high frequency

Vapor or liquid release from failure of gasket, seal and rupture in pipe lines and vessels fall in second category whereas catastrophic failure of vessels and full bore rupture of pipe lines etc., fall in to first category. Typical failure frequencies are given in **Table 7.12.**

Table 7.12 General Failure Frequencies

Item	Mode of failure	Failure frequencies
Pressure Vessel	Serious leak	$1.0*10^{-5}$/Year
	Catastrophic	$3.0*10^{-6}$/Year
Pipe lines		
=50 mm dia	Full bore rupture	$8.8*10^{-7}$/m.year
	Significant leak	$8.8*10^{-6}$/m.year
>50 mm =150 mm dia	Full bore rupture	$2.6*10^{-7}$/m.year
	Significant leak	$5.3*10^{-6}$/m.year
>150 mm dia	Full bore rupture	$8.8*10^{-8}$/m.year
	Significant leak	$2.6*10^{-6}$/m.year
hose	Rapture/Failure	$4.0*10^{-5}$/hr
Unloading arm	Rapture/Failure	$3.0*10^{-8}$/hr
Check valve	Failure on demand	$1.0*10^{-4}$/on demand
motor operated valve	Failure on demand	$1.0*10^{-3}$/ on demand
Flange	Leak	$3.0*10^{-4}$/ Year
Pump seal	Leak	$5.0*10^{-3}$/ Year

Gasket failure	Failure	$5.0*10^{-5}$/ Year
Process safety valve(PSV)	Lifts heavily	$4.0*10^{-3}$/ Year
	Blocked	$1.0*10^{-3}$/ Year
	Lifts lightly	$6.0*10^{-2}$/ Year

7.7 Consequence Analysis

The accidental release of hazardous chemicals leads to subsequent events, which actually cause the damage. The damages are of three types.

1) Damage due to heat radiation.

2) Damage due to Over pressure effects subsequent to explosion

3) Damage due to toxic effects

The type of damage and extent of damage depends on nature of chemical, the conditions of release, atmospheric conditions and the subsequent events. The sequence of probable events following the release of a hazardous chemical is schematically shown in **Figure 7.2.** The best way of understanding and quantifying the physical effects of any accidental release of chemicals from their normal containment is by means of mathematical modeling. This is achieved by describing the physical situations by mathematical equations for idealized conditions and by making corrections for deviation of the practical situations from ideal conditions. In the present study ALOHA software from USEPA. These models for various steps are described in the following sub-sections.

7.7.1 Release Models and Source strength

This depends on the nature of failure of the unit and the content of the unit and operating temperature and pressure of the unit. The release may be instantaneous due to total failure of storage unit or continuous due to leakage or rupture of some component of the storage facility. The material discharged may be gas or liquid or the discharge could be manifested through two phase flow. The models that are used to calculate the quantity of liquid/vapor released are:

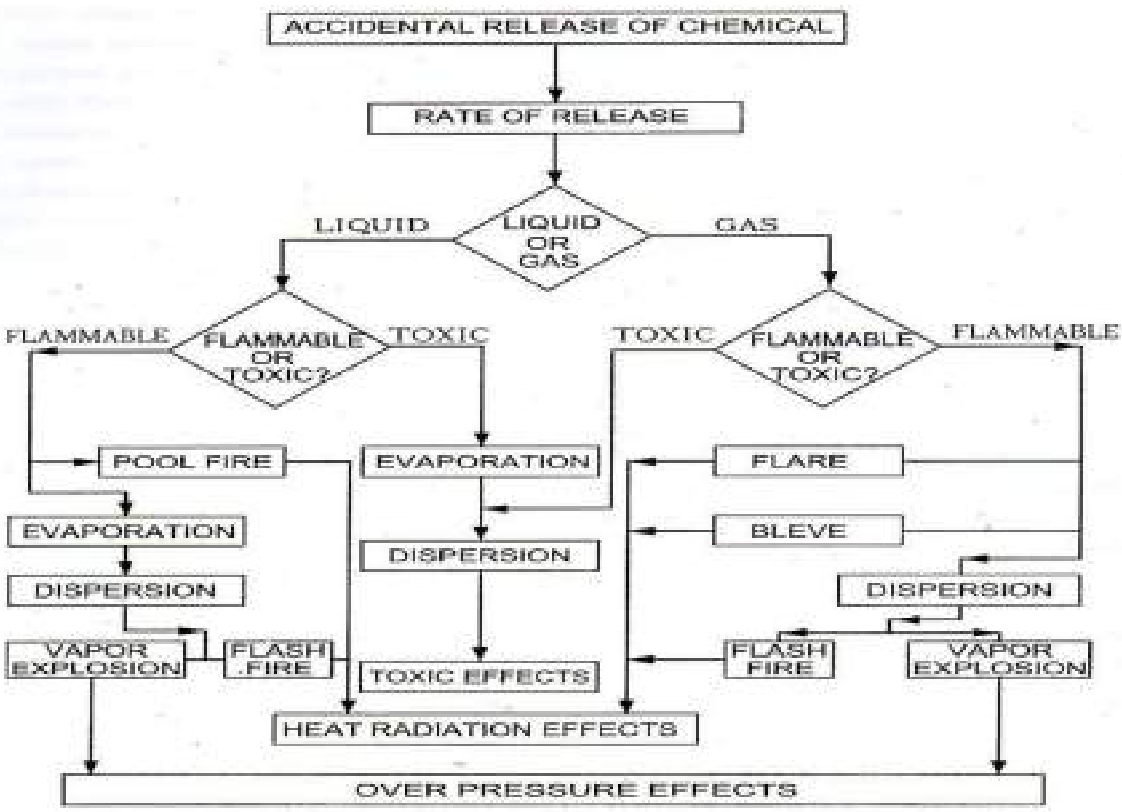

Fig 7.2 Steps in Consequence Calculations

The following criteria tables present heat radiation intensities (**Table 7.13**), radiation exposure and lethality (**Table 7.14**), and damage due to peak over pressure is presented in **Table 7.15.**

Table 7.13 Damage Due to Incident Radiation Intensities

S. No	Incident Radiation (KW/m2)	Type of Damage Intensity	
		Damage to Equipment	**Damage to the People**
1	37.5	Damage to process Equipment	100% lethality in 1 min. 1% lethality in 10 sec.
2	25.0	Minimum energy required to ignite wood at indefinitely long exposure without a flame	50 % lethality in 1min. Significant injury in 10 sec.
3	19.0	Maximum thermal radiation intensity allowed n thermally unprotected adjoining equipment.	---
4	12.5	Minimum energy to ignite with a flame, melts plastic tubing	1% lethality in 1 min.

5	4.0	--	Causes pain if duration is longer than 20 sec, however blistering is unlikely (First degree burns)
6	1.6	--	Causes no discomfort on Longer exposure

Source: Techniques for Assessing Industrial Hazards by World Bank

Table 7.14 Radiation exposure and lethality

Radiation Intensity (KW/m2)	Exposure Time (seconds)	1% Lethality	Degree Burns
1.6	--	0	No Discomfort even after longer exposure
4.5	20	0	1st
4.5	50	0	1 st
8.0	20	0	1 st
8.0	50	<1	3 rd
8.0	60	<1	3 rd
12.0	20	<1	2 nd
12.0	50	8	3 rd
12.5	--	1	--
25.0	--	50	--
37.5	--	100	--

Table 7.15 Damage Due to Peak Over Pressure

Human Injury		Structural Damage	
Peak Over Pressure (bar)	**Type of Damage**	**Peak over Pressure (bar)**	**Type of Damage**
5 – 8	100% lethality	0.3	Heavy (90%Damage)
3.5 – 5	50% lethality	0.1	Repairable (10%Damage)
2 – 3	Threshold lethality	0.03	Damage of Glass
1.33 – 2	Severe Lung damage	0.01	Crack of Windows
1 – $1^{1/3}$	50% Eardrum rupture	-	-

Source : Marshall, V.C.(1977)' How lethal are explosives and toxic escapes.

7.7.2 Results of Consequence Analysis

The damages due to the accidental release of chemicals are of three types.

a) Damage due to heat radiation

b) Damage due to Over pressure effects subsequent to explosion

c) Damage due to Toxic effects

7.7.2.1 Analysis of Hazardous Scenarios

The hazardous chemicals involved are stored within the threshold limits of storage and hence few representative chemicals mainly solvents were studied.

7.7.2.1.1 Heat radiation effects *(Terms of Reference No. Sp. TOR (13))*

When a non-boiling liquid spills, it spreads into a pool. The size of the pool depends on the availability of the bund and obstacles. The heat load on objects outside a burning pool of liquid is calculated with the heat radiation model. The average heat radiation intensity, the diameter-to-height ratio dependent on the burning liquid, geometric view, distance from the fire, relative humidity of air, horizontal or vertical orientation of the object radiated with respect to fire are factored. All storage tanks in tank-farm area are provided with dykes. For each of the hazardous chemicals involved various scenarios such as pipe line leaks of 5mm or pipeline ruptures or catastrophic vessel ruptures of the inventories as outlined have been considered and damage distances for Lower Flammability Limits (LFL) and heat radiation effects for the three levels of intensity are calculated and presented in **Table 7.16** . Heat radiation damage distances for most of the scenarios are not occurring in the case of release from 25 mm holes at a height of 0.1 m from the bottom of the tank for one hour, in the storage tanks. In case of pipeline leaks, 5 mm leaks are considered for 15 mm and 50 mm pipe sizes. The release rates from 5 mm leaks are observed to be low, and these leaks have low incident hazard. The concentration of the flammable material in the vapor cloud was found to be below the lower flammability limits.

Table 7.16 Heat Radiation Damage Distances – Tank Farm (Pool Fire)

S.No	Name of Raw material	Tank Capacity (KL)	Diameter (m)	Height (m)	Release Rate (Kg/sec)	Heat radiation damage distances in m for KW/m2		
						37.5	12.5	4.0
1	Dichloromethane	30	3.1	4.0	2.07	<10	<10	12
2	Dimethyl Formamide	30	3.1	4.0	0.41	<10	<10	<10
3	Ethanol	30	3.1	4.0	0.38	<10	<10	<10
4	Methanol	30	3.1	4.0	0.38	<10	<10	<10
5	Acetone	30	3.1	4.0	0.38	<10	<10	<10
6	Isopropyl alcohol	30	3.1	4.0	0.38	<10	<10	<10
7	Acetic acid	15	2.3	3.8	0.43	<10	<10	<10

8	Ethyl Acetate	30	3.1	4.0	0.40	<10	<10	<10
9	Toulene	30	3.1	4.0	0.40	<10	<10	11

Table 7.17 Heat Radiation Damage Distance – Hydrogen Cylinders

S. No.	Scenario Description	Release Rate Kg/sec	Storage Tank Details			Heat radiation damage distances in m for KW/m2		
			Height (m)	Diameter (m)	Storage Pressure	37.5	12.5	4.0
1	Hydrogen Gas Cylinder (50Kg)	5.42	0.87	0.27	350 Bar	<10	12	20

7.7.2.1.2 Overpressure effects:

When an unignited gas cloud mixes with air and reaches the flammable range and if the cloud ignites wither a flash fire or flash fire explosion can occur. Since the burning time is shorter, instead of heat radiation from a flash fire, peak overpressure as a function of distance from the centre of the cloud is derived. In case of pipeline leaks, damage distances due to overpressure effects are not observed. The values are found to be similar as there are no pressurized storage tanks in the tank farm, and the over pressure distances are contingent on the tank capacity.

7.7.3 Observations:

From the previous incident records published in literature and hydrocarbon release data bases, it has been observed that pinhole leaks contribute highest percentage where as the second cause is small sized leaks of 25 mm diameter in tank farm. Accordingly the consequence analysis was carried out for 25 mm sized leaks in the tank farm.

7.7.4 Recommendations:

The following are the recommendations to minimize the hazards and improve the safety of the proposed plants. Plants of this nature, which handle a variety of chemicals, face problems of fire and vapor cloud explosions. It has been observed that the damage distances are more or less confined to the plant area only. Taking precautionary safety measures as outlined below can further minimize these effects.

- In view of hazardous nature of operations, it is recommended to adopt best practices with respect to design, operation and maintenance.
- It is recommended that all flammable areas and process area be maintained free of ignition sources. Ensure that sources of ignition, such as pilot lights, electrical ignition devices etc., at strategic locations like solvent storage areas are avoided.
- All electrical fittings involved in and around the pipeline and operation system should conform to flame/explosion proof regulations.
- Strict hot work control and display of danger signs should be ensured.
- It is recommended to provide one fire hydrant point in the tank-farm area to take care of any emergency. Installation of fire water hydrant net work is suggested.
- It is suggested to provide fire extinguishers in process plant at solvent storage area and the vents of solvent tanks to be provided with PESO approved flame arrestors.
- Fire protection equipment should be well maintained so that it is available when required. They should be located for quick accessibility. Provide carbon dioxide fire extinguishers and DCP extinguishers for Electrical fires.
- It is suggested to have a periodical review of safety awareness and safety training requirements of plant employees with respect to hazards present in the plant.
- In general, all pipelines carrying flammable liquids/vapor are periodically checked for their integrity. Spillages have to be avoided and disposal should be done quickly.

7.7.5 Toxic Management Plan *(Terms of Reference No. Sp. TOR (14))*

The list of chemicals identified to have toxic or carcinogenic nature is presented in **Table 7.18.**

Table 7.18 List of Toxic/Carcinogenic Chemicals and Mode of Storage/Transport

S.No	Name of Raw Material	Maximum storage (Kgs)	Physical Form	Type of Hazard	Mode of Storage
1	2,3-di-o-acetyl-5-deoxy-5-fluorocytidine	3222	Liquid	Carcinogenic	Drums
2	3-chloro-4-(3-cyclopropylureido)phenol	58	Liquid	Toxic	Drums

3	3-Chloro-4-fluoro aniline	1514	Powder	Toxic	
4	4-Dimethylamino pyridine	10	Crystalline	Toxic	HDPE Bags
5	4-Chloro-7-methoxy-6-quinolinecarboxamide	61	Solid	Carcinogenic	Bags
6	Acetone cyanohydrin	118	Liquid	Toxic	Drums
7	Ammonium hydroxide	396	Liquid	Toxic	Drums
8	Chloroform	5250	Liquid	Carcinogenic	Drums
9	1,8-Diazabicyclo[5.4.0]undec-7-ene	56	Liquid	Toxic	Drums
10	Dichloromethane	30000	Liquid	Carcinogenic	Storage Tanks
11	Diisopropyl azodicarboxylate	60	Liquid	Carcinogenic	Drums
12	Dimethylacetamide	1225	Liquid	Carcinogenic	Drums
13	Ethylene dichloride	70	Liquid	Toxic	Drums
14	Ethynylbenzenamine	364	Liquid	Toxic	Drums
15	Methane sulfonyl chloride	45	Liquid	Toxic	Drums
16	Methyl ((S)-2-(2-chloroacetamido)-4-phenylbutanoyl)-L-leucyl-L-phenylalaninate	236	Powder	toxic	Bags
17	N- Methyl pyrrolidine	700	Liquid	Carcinogenic	Drums
18	Oxalyl chloride	68	Liquid	Toxic	Drums
19	Pd(dppf)cl2 in DCM	11	Solid	Carcinogenic	
20	Phosphorylchloride	1830	Liquid	Toxic	Drums
21	Sodium Triazole	78	Powder	Carcinogenic	HDPE Bags
22	Thionyl chloride	469	Liquid	Toxic	Drums
23	Thiophosgene	114	Liquid	Toxic	Drums

Handling: Storage & handling in compliance with MSDS. The transfer of solvents shall be mainly by closed pipeline systems, while solvents are transferred from drums by using air operated diaphragm pumps in closed hoods. Solid phase raw materials are charged by using closed hoppers to avoid dust emissions and hazard of static electricity. SOP's for better operational control.

Engineering Control Measures: All the operations filtration and drying is conducted in closed conditions. Forced dry ventilation system to hoods. Vent condensers in series to reactors, distillation columns, driers and centrifuge to mitigate atmospheric emissions of toxics. Solvents with low boiling point will be stored in double limpet coil storage tanks with coolant circulation.

Vents of secondary condensers connected to vacuum pumps followed by tertiary condenser. Common headers connecting all the process vents and the same are connected to scrubbers. Low boiling solvents tanks are connected with reflux condensers to minimise the loss. The transfer pumps shall be provided with mechanical seals.

Personnel Protective Equipment: Personal protective equipment shall be provided to all employees including contract employees. All the employees shall be provided with gumshoe, helmet, masks, goggles. The other equipment like ear muffs, gloves, respirators, aprons etc., will be provided to employees depending on the work area allocated to them. The PPE selection shall strictly follow the prescribed guidelines of MSDS.

Health Monitoring of Employees: The pre employment screening and periodic medical examination shall follow the guidelines of factories act. The pre employment screening shall obtain medical history, occupational history followed by physical examination and baseline monitoring for specific exposures.

Frequency of Health Monitoring

Occupation	Type of evaluation		Frequency
Process area	Physical Observation	Height Weight	Once a year for regular employees. Half yearly for contract employees
	Eyes	Color vision	
	Detailed Test	Hearing Ability; Physical Status General Condition; Previous Accidents Skin Infections; Any Physical Handicap	
	Clinical Observation	Lungs; Heart; Hydrocele; Central Nervous System; Liver functioning; Diabetes; Any operations undergone; Symptoms of communicable and other contagious disease and Medical fitness	
Noise Area	Audiometry		Annually

7.7.6 Transportation *(Terms of Reference No. 7(iii))*

All the raw materials and finished products are transported by road. Dedicated parking facility will be provided for transport vehicles. The plant is located near national highway, and there will not be any unauthorized shop or settlements along the road connecting the plant site. There will be 20-25 truck trips per day to the factory. Safety signage is placed at various locations in the battery limit. The drivers of the vehicles will be provided with TREM cards and will be explained the measure to be adopted during various emergencies.

Transportation of raw materials may result in accidents due to high speed collision, low speed collision, overturning and non-accident-initiated release. The initiating and contributing causes are presented in **Table 7.19**

Table 7.19 Truck Incidents – Initiating and Contributing Causes

Human Errors	**Equipment Failures**	**System or Procedural Failures**	**External Events**
Driver Impairment Speeding Driver Overtired Contamination Overfilling	Non-dedicated trailer RR crossing guard Failure Leaking Valve Leaking Fitting	Driver incentives Driver training Carrier selection Container Specification Route selection	Vandalism/ Sabotage Rain Fog Wing Flood/washout
Other Vehicle's Driver Taking Tight	Brake Failure Insulation/Thermal Protection Failure	Emergency response training Speed Enforcement	Fire at rest areas/parking areas Earthquake
Unsecured Load	Relief device failure Tire failure Soft shoulder Overpressure Material defect Steering failure Sloshing High center of gravity Corrosion; Bad Weld; Excessive Grade Poor Intersection design Suspension system	Driver rest periods Maintenance Inspection Time of day Restrictions	Existing accident

The scenarios presented for storages are calculated for transport related incidents/accidents and presented in **Table 7.20.**

Table 7.20 Transportation Specific Concerns

Concern	Road
Spill on Water	Over or near a body of water
Unconfined Pools	In an undisturbed flat area
BELVE-Induced catastrophic vessel failure	Possible if sufficient quantity in car with small leak to feed fire or if double tank trailer or burning fuel leak
Toxic products of combustion or reaction	Dependent on material and whether ignition occurs

7.7.7 Control Measures for Accidental Spillage of Chemicals

Name of the Chemical Stored	Storage Details		Hazard Rating Systems			Type of Hazards Involved	Persons Effected	Control Measures
	Quantity (KL)	Pressure/ Temp	TLV (PPM)	STEL (PPM)	FP (^{O}C)			
Acetone	30	NTP	1000	500	-20	Highly flammable liquid and vapor. Causes serious eye irritation. May cause drowsiness or dizziness.	Operators Maintenance Technicians	Keep away from heat/sparks/open flames/hot surfaces. - No smoking. Avoid breathing dust/ fume/ gas/ mist/ vapors/ spray. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Safety board's displayed on the tank. Effective ventilation must be provided. For accidental contact if you feel unwell, seek medical advice immediately. Handling of Acetone with Safety gloves and protective clothing
Dimethyl Formamide	30	NTP	10		58	Flammable liquid and vapor Harmful in contact with skin Causes serious eye irritation Harmful if inhaled	Operators Maintenance Technicians	Avoid exposure - obtain special instructions before use. Avoid contact with skin and eyes. Avoid inhalation of vapor or mist. Keep away from sources of ignition - No smoking. Take measures to prevent the buildup of electrostatic charge. Wear respiratory protection. Avoid breathing vapors', mist or gas. Ensure adequate ventilation.
Methanol	20	NTP	1000	1000	14	Highly flammable liquid and vapor.	Operators Maintenance Technicians	Keep away from heat/sparks/open flames/hot surfaces. Use personal protective

								equipment. Avoid breathing vapors, mist or gas. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas.
Dichloromethane	20	NTP	50		13	Limited evidence of a carcinogenic effect.	Operators Maintenance Technicians	Do not breathe gas/fumes/vapour/spray. Avoid contact with skin and eyes Wear suitable protective clothing and gloves. Store in cool place. Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage
Toluene	20	NTP	200		4	Highly flammable liquid and vapor. May be fatal if swallowed and enters airways. Causes skin irritation May cause drowsiness or dizziness. May cause damage to organs through prolonged or repeated exposure	Operators Maintenance Technicians	Keep away from heat/sparks/open flames/hot surfaces. - No smoking. Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray. Use personal protective equipment as required. IF SWALLOWED: Immediately call a POISON CENTER or doctor/ physician. Do NOT induce vomiting. Use personal protective equipment. Avoid breathing vapors, mist or gas. Ensure adequate ventilation

7.8 Disaster Management Plan *(Terms of Reference No. 7(xiii)*

7.8.1 Introduction

A disaster is a catastrophic situation in which suddenly, people are plunged into helplessness and suffering and, as a result, need protection, clothing, shelter, medical and social care and other necessities of life.

Disasters can be divided into two main groups. In the first, are disasters resulting from natural phenomena like earthquakes, volcanic eruptions, storm surges, cyclones, tropical storms, floods, avalanches, landslides, and forest fires. The second group includes disastrous events occasioned by man, or by man's impact upon the environment. Examples are armed conflict, industrial accidents, radiation accidents, factory fires, explosions and escape of toxic gases or chemical substances, river pollution, mining or other structural collapses, air, sea, rail and road transport accidents and can reach catastrophic dimensions in terms of human loss.

There can be no set criteria for assessing the gravity of a disaster in the abstract since this depends to a large extent on the physical, economic and social environment in which it occurs. However, all disasters bring in their wake similar consequences that call for immediate action, whether at the local, national or international level, for the rescue and relief of the victims. This includes the search for the dead and injured, medical and social care, removal of the debris, the provision of temporary shelter for the homeless, food, clothing and medical supplies, and the rapid re- establishment of essential services.

An emergency may be said to begin when operator at the plant or in charge of storage of hazardous chemicals cannot cope up with a potentially hazardous incident, which may turn into an emergency. The emergencies could be a major fire or explosion or release of toxic gas or a combination of them.

The proposed plant will store fuels, which are flammable in nature, and the storage will be as per the Controller of Explosives and OISD norms. The hierarchy of the employees is yet to be determined and the project is still in the initial stages of designing. Hence a tentative disaster management plan is prepared to be suitably modified before commissioning of the plant.

7.8.2 Objectives of Emergency Management Plan (ON-SITE)

(Terms of Reference No. 7(xiii)

A quick and effective response during emergency can have tremendous significance on whether the situation is controlled with little loss or it turns into a major emergency Therefore, the objectives of this Onsite Emergency Plan (ONSEP);

During Emergency: Is to provide basic guidance to the personnel for effectively combating such situations to minimize loss of life, damage to property and loss of property.

- To localize the emergency and if possible eliminate it;
- To minimize the consequences of an emergency;
- To prevent spreading of the damage in other areas;
- To give necessary warning to plant personnel and neighborhood;
- To maximize resource utilization and combined efforts towards the emergency operations;
- To mobilize internal resources and utilize them in the most effective way;
- To arrange rescue of persons, transport and treatment of causalities;
- To seek necessary help from industries in neighborhood or local authorities;
- To provide information to government agencies and to provide information to public.

During Normal Time:

- To keep the required emergency equipment in stock at right places and ensure their working condition;
- To keep the concerned personnel fully trained in the use of emergency equipment;
- Preserving records, evidence of situation for subsequent emergency etc.

7.8.3 Scope of ONSEP

This ONSEP is prepared for industrial emergencies like fires, explosions, toxic releases, asphyxia and does not cover natural calamities and societal disturbances related emergencies (like strikes, bomb threats, civil Commissions etc). Also, the scope of this ONSEP is limited to onsite emergencies and does not include measures for off site Emergency Management. Necessary information with regards to Off Site Emergency Management will be furnished to district authorities.

7.8.4 Methodology of Developing ONSEP

The consideration in preparing this Emergency Plan includes the following steps:

- Identification and assessment of hazards and risks;
- Identifying, appointment of personnel & Assignment of Responsibilities;
- Identification and equipping Emergency Control Center;
- Identification of Assembly, Rescue points, Medical Facilities;
- Formulation of plan and of emergency sources;
- Training, Rehearsal & Evaluation;
- Action on Site.

Earlier, a detailed Hazard Analysis and Risk Assessment were carried out for the plant facilities and the hazards are quantified. The likely locations of hazards and consequences are evaluated, duly following the standard procedure.

7.8.5 Elements of Onsite Emergency Plan

Important elements considered in this plan are:

- Identification of emergencies
- Emergency organization
- Emergency facilities
- Emergency procedures
- Communications during emergency
- Rescue, Transport and Rehabilitation

- Roles and responsibilities of key personnel and essential employees
- Mutual aid.

7.8.5.1 Emergencies Identified

Spillage, pool fire, are the possible emergencies in the pipelines, fire near storage, DG set, and Transformers are the other possible emergencies.

The other emergencies are asphyxiation of persons, apart from risks due to cyclonic conditions, earth quake, lightning, floods (natural calamities), sabotage, bombing (social and other reasons) etc. which are not under the management control.

Priority of protection in the event of an emergency is; Life and safety of personnel, preservation of property, restoration of normalcy.

7.8.5.2 Emergency Organization

The project employs a total of 300 people in 3 shifts. The general shift will be for the administrative employees, while the three shifts of 8 hours each are for technical employees. Key personnel and essential employees are identified and are assigned emergency responsibilities.

Security personnel, all operators, fitters, electricians etc. in the shifts are designated essential employees. During emergencies, their services are drafted for essential operations.

7.8.5.3 Emergency Facilities

a) Emergency Control Center (ECC)

It is a location where all key personnel like Chief Coordinator, Emergency controller, maintenance coordinator can assemble and monitor aspects related to emergency and take decisions related to emergency. The office room is designated as ECC. In case if this area is affected, zone security room is designated as alternative ECC.

The following information and facilities would be maintained at the ECC in Plant Control room:

Latest copy of Onsite Emergency Plan and Offsite Emergency Plan (as provided by District Emergency Authority)

- Intercom Telephone;
- P& T Telephone;
- Telephone directories (internal and P&T);
- Factory Layout, site plan;
- P&I diagrams, electrical connections plans indicating locations of hazardous inventories, sources of safety equipment, hydrant layout, location of pump house, road plan, assembly points, vulnerable zones, escape routes;
- Hazard chart;
- Emergency shutdown procedures for generators and fuel supply system;
- Nominal roll of employees;
- List and addresses of key personnel;
- List and addresses of emergency coordinators;
- List and addresses of first aid providers;
- List and addresses of employees trained in fire fighting;
- List and addresses of qualified trained persons;
- Material safety data sheets of raw materials;
- Duties of key personnel;
- Important addresses and telephone numbers including those of fuel supplying company, government agencies, neighboring industries and other sources of help, outs side experts;

The following emergency equipment is made available at alternate ECC (Security point):

- Fire proximity suit/Gloves/Helmets;
- Hand tools suitable for pipe lines (non sparking type);
- Gaskets;

- Teflon tape;
- Gas Explosimeter;
- Flame proof torches/batteries;
- 1/2 crow bar;
- Spade;
- Manila rope;
- Spark arrestor;
- Spare fan belt for truck;
- First aid box;
- Special fire fighting information related to Hydrocarbon fuels;
- Public address megaphone, hand bell, Emergency torch.

b) Assembly points

Office room is identified as Assembly point and is in a low intensity fire affected zone. Additionally the following places in plan are designated as safe assembly points: Time office, and green belt area near the main road. The locations of assembly points would be reviewed later.

c) Fire fighting Facilities

The fire fighting facilities which shall be provided are presented in **Table 7.21.**

Table 7.21 List of Fire Extinguishers

S.No	Description of Item	Quantity
1.	DCP 10 kg	80 Nos.
2.	Foam 50 ltrs	50 Nos.
3.	CO_2 22.5 kg	30 Nos.
4.	CO_2 6.8 kg	25 Nos.
5.	ABC Soda Acid 5 kg	40 Nos.
6.	ABC Soda Acid 1 kg	40 Nos.
7.	Fire Buckets with stand	50 Nos.

d) Location of First aid Boxes

The first aid boxes will be located at the following places: preparation areas, administrative office, time office, and will be under the charge of security coordinator.

e) Emergency siren

Emergency siren will be provided with 0.5 km range of audibility and the location will be time office. The siren will operate on regular supply and also on emergency electrical supply. Shift electrical engineer of plant on receipt of information from shift incharge, is authorized to operate the siren.

f) Emergency escapes

Emergency escapes in the plant area and floor wise emergency escapes will be conspicuously marked.

g) Wind sock

Wind socks to observe the wind directions will be installed on the top of Turbine Plant house.

7.8.5.4 Emergency Procedures

a) Procedure for Raising Emergency alarm

Whenever and whoever notices an emergency or a situation with a potential emergency should forthwith raise alarm by calling on the available communication network or shouting or approaching the shift incharge, furnishing details. Anybody noticing fire should inform the plant control room immediately. The shift electrical engineer at control room informs the site controller.

b) Control Room staff

If an emergency is reported then plant control room staff must, request for the location, nature and severity of emergency and obtain the caller's name, telephone number, and inform the shift incharge or site controller who ever are available in the shift.

c) Emergency communication

The following communications will be used during emergencies; P&T Telephones, intercom, walkie-talkies, hand bell and siren. If any of the equipment is not working, runners would be engaged to send the communication.

d) Warning/Alarm Communication of emergency

Emergency siren would be operated to alert all other employees on the orders of manager (electrical). The emergency is communicated by the Emergency siren mode of wailing for 3 minutes. When the emergency has been brought under control, the Emergency controller will direct plant control staff giving an 'all clear signal', by way of normal siren (continuously for 3 minutes).

7.8.5.5 Rescue and Rehabilitation

Emergency vehicle will be made available round the clock under the charge of manager (electrical) who is emergency coordinator. Security personnel are trained in rescue operations. Persons rescued would be taken to First aid centre for further medical attention or Safe Assembly Points as per the condition of the rescued person.

a) Transport Vehicles and Material Trucks

The transport vehicles and vehicles with materials would immediately withdraw to outside the factory. Security guard of the shift is responsible for this. Transport vehicles would wait at the security at the main entrance to provide emergency transport. This is ensured by security coordinator.

b) Mock drill

Occasional mock drill is essential to evaluate that the ONSEP is meeting the objectives. Adequate training is given to all staff members before conducting the mock drill. Mock drills will be initiated with table top exercise, followed by pre-informed mock drills, and few uninformed mock drills in the first phase. Functional exercises (communication, Emergency shut down, fire fighting at different locations, rescue etc.) are carried out in the second phase.

Mock drills will familiarize the employees with the concept and procedures and help in evaluating their performance. These scheduled and unscheduled mock drills are conducted during shift change, public holidays, in night shift once in 6 months.

Response time, strict adherence to discharge of responsibilities, difficulties and inconsistencies experienced are recorded and evaluated. Fire officer will assists Emergency coordinator in designing and extending such mock drills and in evaluating the response.

c) Review

The Emergency plan is reviewed periodically to evaluate the effectiveness, and during change in organizational structure, isolation of equipment for longer duration, and during increase in inventory of fuel and other chemicals. Manger Electrical and Emergency coordinator initiates and authorizes such review as and when required, and the changes if any will be duly informed to all the employees concerned.

7.8.5.6 Emergency Responsibilities

I. Chief Coordinator

The chief coordinator shall be General manger and Alternate is Manager Electrical.

- He is overall incharge of emergency operations.
- He reaches emergency control center as soon as he receives emergency information.
- He coordinates with emergency controller, maintenance coordinator.
- He provides necessary resources required at the emergency site.
- He will inform the inspector of factories, and other statutory authorities.
- Prepares accident report/investigation.
- Arranges for keeping records of chronological events and orders an investigation report and preserves evidence.
- Gives a public statement if necessary.

II. Emergency controller - Shift in charge

On receiving the message about emergency;

- He will assume charge as chief coordinator till general manger arrives at scene and takes charge as a chief coordinator.

- Takes actions to minimize the consequences and directs emergency management and fire control/other causes with available personnel to put off or to reduce the consequences.
- On the arrival of chief coordinator, he will hand over the charge of Chief coordinator and assists him.
- He will identify the need of evacuating any personnel in the vicinity of the affected zone.
- Exercises operational control of the installation and outside the affected area and directs emergency operations.
- Declares emergency and orders plant control room for operation of emergency siren.
- Continuously reviews and assesses possible development to determine most probable courses of events.
- Initiates suspension of all work permits during the period of major emergency for safe guarding the plant and other personnel.

III. Incident Controller

The **Supervisor** assumes the role of incident controller in the following instances of emergencies.

- Protects himself and proceeds to site quickly.
- Assess the magnitude of the incident.
- Initiates the emergency procedure to secure the safety of the workers and minimise damage to installation and property.
- He will undertake all possible steps for safe isolation of plant systems, first aid and fire fighting.
- He keeps in touch with plant control room till emergency controller arrives at the scene of emergency,
- Organizes essential employees present in the shift.

- Ensures that adequate personal protective equipment is available foe essential employees.
- Arranges for search of causalities.
- Arranges evacuation of non-essential workers to assemble at designated assembly points.
- During the fire fighting operations seeks help from electrical/mechanical maintenance personnel for isolation of machine/section involved in fire as the need arises.
- Once the situation is under control, guides different persons for salvage and cleanup operations.
- Assists in assessing the loss, preparation of accident report with the assistance of security officer and senior officials of respective departments present during the accident, investigates the fire with a view to find out causative factors ad action needed to prevent recurrence.

IV. Communicator – production supervisor

- The Control Room Shift Electrical Engineer assumes the role of Communicator and passes the information related to emergency to Incident Controller and Chief Coordinator.
- Other vulnerable installation in the plant is alerted about the emergency.
- On the Instructions from chief coordinator, neighboring installations are alerted about the emergency.
- On the instructions from Chief Coordinator, mutual assistance is called from neighboring industries.
- On the instructions from Chief Coordinator, seeks help form fire brigade.
- Provides emergency Telephone rosters are provided in Plant control room and Fire Station.

V. Maintenance Coordinator

Dy. Manager Mechanical shall assume the role of maintenance coordinator. His responsibilities include;

- Protecting him self.
- Reaching the emergency spot.
- Arranging all resources for assisting Emergency controller to mitigate the Emergency scene, with respect to maintenance requirements.
- Assisting Emergency controller in arranging the needed containment measures.
- Undertaking post emergency maintenance work upon termination of emergency.
- Ensuring availability of adequate quantities of protective equipment and other emergency materials, spare parts etc at Emergency control center.
- Ensuring upkeep of fire systems, emergency lighting in order.

VI. Resource Coordinator

Shift in charge shall assume the responsibility of resource coordinator.

- Arranges first aid, rescue acts, ambulance, attendance roster checking and security.
- Interacts with chief coordinator for all emergency operations.
- Assists chief coordinator with necessary data and coordinates the emergency activities.
- Maintains liaison with civil administration and mutual aid agencies - neighboring industrial management.
- Ensures availability of humanitarian needs and maintenance of rehabilitation center.
- Ensures emergency transport facility.
- Mobilizes extra medical help from outside if necessary.
- Maintains first aid and medical emergency requirements.

- Keeps list of qualified first aid providers and seeks their assistance.
- Ensures availability of necessary cash for rescue/rehabilitation and emergency expenditure.
- Coordinates mutual aid.
- Participates in reviewing Emergency plan and arranges revision if required.

VII. Security Coordinator.

The production supervisor will assume the responsibilities of security coordinator, and his responsibilities are;

- On receipt of fire call from plant control he prepares for fire fighting and collects necessary equipment.
- Organizes rescue of persons trapped in work areas.
- Assists administration coordinator in organizing Mock drills, evaluation and debriefing.
- During normal situations keeps the fire fighting capabilities in fully ready condition by maintaining equipment.
- Organizes fire drills on periodic basis and evaluates the same.
- Arranges to clear off unconnected persons and trucks from the vicinity and off the main gate.
- Instructs security guards posted on duty in the nearby industries to cordon off the affected section and to control the crowd at the scene of fire.
- Arranges to control law and order till local authorities for Law and order till police arrive at site.
- Post security guard at the scene of fire to check for possible re-ignition, after the emergency is over.
- Assists Resource coordinator in organizing Mock Drills, evaluation and debriefing.
-

VIII. Person Noticing Fire

Any employee on noticing fire will take the following steps;

- Takes protection
- Raises alarm – shouts fire! Fire!! Fire!!! Or other emergency.
- Informs Shift Incharge, or at the control room over telephone giving clear message about the exact location of fire and names of equipment/machinery involved in fire.
- If Telephone is not working, quickly goes to either Plant Control Room and informs.

IX. Trained Fire Fighting Person

The employees trained in fire fighting will take the following steps in the event of fire apart from following the instructions of security coordinator apart from;

- Protects self
- Raises alarm
- Attempts to put out the fire using fire extinguishers.
- If necessary, operates fixed fire fighting equipment.
- Stands by in safety for further instructions.

7.8.6 Remedial Action

The cause of emergency is identified and action is taken from operation point of view such as isolating or shutdown etc.

I. **Failure of pipelines:** feeding into the pipeline is stopped. Isolate the leaking pipeline by closing the relevant valves. Transfer the material present to other pipelines. Shutdown the pump. Close the suction and discharge valves of the pump

II. **Personal Protection:** The people, who are assigned to the rescue operations, must wear suitable personnel protective equipment such as self-contained breathing apparatus and fire suit. They should remain in the incident area as long as he can safely stay there. In spite of the wearing safety protective equipment if he is unable to stay in the contaminated area, he should leave immediately.

7.8.7 BASIC ACTION IN EMERGENCIES

Immediate action is the most important factor in emergency control because the first few seconds count, as fires develop and spread very quickly unless prompt and efficient action is taken.

- Take immediate steps to stop leakage/fire and raise alarm simultaneously.
- Initiate action as per fire organization plan or disaster management plan, based on gravity of the emergency.
- Stop all operations and ensure closure and isolation valves.
- All effort must be made to contain leakage/fire.
- Saving of human life shall get priority in comparison to stocks/assets.
- Plant personnel with specific duties should assemble at the nominated place.
- All vehicles except those required for emergency use should be moved away from the operating area, in an orderly manner by the predetermined route.
- Electrical system except for control supplies, utilities, lighting and fire fighting system should be isolated.
- If the feed to the fire cannot be cut off, the fire must be controlled and not extinguished.
- Start water spray system at areas involved or exposed to fire risks to avoid domino effects.
- In case of leakage of chemicals without fire and inability to stop the flow, take all precautions to avoid source of ignition.
- Block all roads in the adjacent area and enlist police support for the purpose if warranted.

7.8.8 FIRE FIGHTING OPERATIONS

Enlist support of local fire brigade and neighboring industries.

- Fire fighting personnel working in or close to unignited vapor clouds or close to fire must wear protective clothing and equipment including safety harness and manned lifeline. They must be protected continuously by water sprays. Water protection for fire fighters should never be shut off even though the flames appear to have been extinguished until all personnel are safely out of the danger area.

- Exercise care to ensure that static charge is not generated in vapor cloud. For this purpose solid jet of water must be avoided, instead fog nozzles must be used.
- Fire fighters should advance towards a fire in down wind direction.
- If the only valve that can be used to stop the leakage is surrounded by fire, it may be possible to close it manually. The attempt should be directed by trained persons only. The person attempting closure should be continuously protected by means of water spraying (thorough fog nozzles), fire entry suit, water jet blanket or any other approved equipment. The person must be equipped with a safety harness and manned lifeline.
- Any rapid increase in pressure or noise level of should be treated as a warning of over pressurization. In such case all personnel should be evacuated immediately.
- In case of any emergency situation, it is of paramount importance to avoid endangering human life in the event of fire, involving or seriously exposing plant equipment.