Nichino Chemical India Private Limited

RISK ASSESSMENT REPORT
Chapter 7 of EIA Report

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Chapter 7

Additional Studies:

Risk Assessment

7.0 Introduction

The principal objective of the risk assessment study is to identify and quantify the major hazards and the risk associated with various operations of the proposed project, which may lead to emergency consequences (disasters) affecting the public safety and health.

Risk analysis provides a relative measure of the likelihood and severity of various possible hazardous events by critically examining the plant storages, process and operating units, deal with different materials in their production, some of which are hazardous in nature i.e. flammable, explosive, toxic and corrosive. Fire, explosion, toxic release or combinations of these are the hazards associated with industrial plants using hazardous chemicals. Risk Assessment have now been developed to improve upon the integrity, reliability and safety of the plant.

Scope of study involves - Hazard Identification and analysis, evaluation of risks due to the Maximum Credible Accident (MCA) analysis, consequence analysis and preparation of DMP by evaluation of risks due to fire and explosion, atmospheric release of Toxic dispersion. Based on this information, an emergency preparedness plan will be prepared to mitigate the consequences.

7.1 Hazard Identification

Identification of hazards is of primary significance in the analysis, quantification and cost effective control of accidents involving chemical handling and process thereof. A classical definition of hazard states that hazard is in fact the characteristics of system/ plant/ process that present potential for the accident. Hence, all the components of a system/ plant/process need to be thoroughly examined to assess the potential for initiating or propagating an unplanned events/sequence of events, which can be termed as an accident.

Estimation of probability of unexpected event and its consequences form the basis of quantification of risk in terms of damage to property, environment and personnel. Therefore, the type, quantity, location and condition of release of toxic or flammable substances have to be identified in order to estimate its damaging effects, the area involved, and the possible precautionary measures required to be taken.

Once a hazard is identified, it is necessary to evaluate it in terms of the risk it presents to the employees and the neighbouring community. In principle, both probability and consequences will be considered.

The following two methods for hazards identification have been employed in the study:

- Identification of major hazardous units based on Manufacture, Storage and Imports of Hazardous chemicals Rules, 1989 of Government of India and
- Amended rules 1994 & 2000 and Identification of Fire-Explosion and Toxicity Index (FE&TI)

7.1.1 Identification of Major Hazard Installations based on GoI Rules, 1989 as amended in 1994 & 2000

By studying accidents occurred in Indian industries in over a few decades, a specific legislation covering major hazard activities has been enforced by Government of India in 1989 in conjunction with Environment Protection Act, 1986. This is referred here as GOI rules 1989. For the purpose of identifying major hazard installations the rules employ certain criteria based on toxic, flammable and explosive properties of chemicals.

Indicative Criteria for Identification of Toxic, Flammable & Explosive Chemicals (GOI Rules, 1989) & Amended rules 1994 & 2000

(a) Toxic Chemicals:

Chemicals having the following values of acute toxicity and which owing to their physical and chemical properties are capable of producing major accident hazards:

Sl. No.	Toxicity	Oral toxicity LD50 (mg/kg)	Dermal toxicity LD50 (mg/kg)	Inhalation toxicity LC50 (mg/l)
1.	Extremely toxic	< 5	< 40	< 0.5
2.	Highly toxic	5–50	40-200	0.5-2
3.	Toxic	50-200	200-1000	2-10

(b) Flammable Chemicals:

(i) Flammable gases: Gases which are at 20˚C and at standard pressure of 101.3 KPa are:-

1. Ignitable when in a mixture of 13% or less by volume with air, or

2. Have a flammable range with air of at least 12 % points regardless of the lower flammable limits.

Note: The flammability will be determined by tests or by calculation in accordance with methods adopted by International Standards Organization (ISO)-10156 of 1990 or by Bureau of Indian Standards (1446 of 1985).

(i) **Extremely flammable liquids**: Chemicals which have flash point lower than or equal to 23˚C and boiling point less than 35˚C

(ii) **Very highly flammable liquids**: Chemicals which have a flash point lower than or equal to 23˚C and initial boiling point higher than 35˚C.

(iii) **Highly flammable liquids**: Chemicals which have a flash point lower than or equal to 60˚C but higher than 23˚C.

(iv) **Flammable liquids**: Chemicals which have a flash point higher than 60˚C but lower than 90˚C.

(c) Explosives: Explosive means a solid or liquid or pyrotechnic substance (or a mixture of substances) like:

i. Which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings

ii. Which is designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as the result of non-detonative self-sustaining exothermic chemical reaction

7.1.2 Applicability of Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 & subsequent amendments

A systematic analysis of the chemicals and the quantities of storage of chemicals has been carried out to determine threshold quantities as notified by GOI Rules 1989 and the applicable rules are identified. The results are summarized in **Table 7.1**.

Table 7.1: Description of applicable provisions of GoI rules 1989 as amended in 1994 & 2000

Applicable Rules	Description
4	**Identify Major accident** Take adequate steps to prevent major accidents Provide information to persons working onsite Impart training, provide equipment and antidotes
5	Notification of major accidents to concerned authority If any major accident occurs, occupier to inform Concerned authority as listed in SC-5 and submit report as per the formatinSC-6 (applies after commencing of the activity)
7	Notification of site to competent authority

8	Updating of site notification following changes in threshold quantity
9	Transitional provision for the existing activity
10	Preparation of safety reports for commencement of activity
11	Updating of safety reports based on modification
12	Provision of further information on safety reports to the authority
13	Preparation of on – site emergency plan by the occupier
14	Preparation of off-site emergency plan by the occupier
15	Information to be given to persons liable to be effected by a major Accident
17	Collection, development and dissemination of information on hazardous Chemicals employed by the occupier
Occupier will develop information in the form of safety data sheet as specified in SC-9. Every container of the hazardous chemical will be labeled with name of the manufacturer or importer of the hazardous chemical.	

From the above table it can be inferred that there would be Hazardous chemicals stored at the proposed site, which would attract the GOI rules 4, 5, 7-9 and 13-15, as the quantity likely to be stored at site lies above the stipulated threshold quantities.

7.1.3 Storage Facilities of Hazardous Chemicals

The maximum storage capacities, daily consumption, type of storage and physical status of each hazardous chemical proposed to be used for manufacturing various products are given in **Table 7.2**. The project proponent deals with different raw materials in their production, some of which are hazardous in nature i.e. flammable, explosive, toxic and corrosive. Fire, explosion, toxic release or combinations of these are the hazards associated with industrial plants using hazardous chemicals. Chemicals consumed in this plant are in solid, liquid and gaseous form and observed that some of these chemicals are hazardous in nature. The Hazard analysis is required for these chemicals. The information on Material safety data sheet (MSDS) for all the identified hazardous chemicals is presented in Volume-II of EIA report.

Table 7.2: List of Hazardous chemicals, Daily consumption, Maximum Storage, Type of Storage and Nature of Material

S. No.	Name of the Material	Daily consumption kg/day	Maximum Storage facility	Type of Storage & Maximum	Nature of the Material
1	Acetic anhydride	60.3	200 kgx1	Combustible & corrosive	HDPE drum, W.H
2	Acetone	2178.3	160 kgx18	IB Flammable	MS drum, WH
3	Aceto nitrile	1197.3	160kgx10	Flammable & toxic	MS drum, WH
4	Carbondisulfide	789	10 kl tank	Flammable &Toxic	U/G tank
5	Chloro acetic acid	150.3	25 kgx18	Toxic & corrosive	LDPE bag, WH
6	Chloro acetyl chloride	130	200 kgx2	Toxic	HDPE drum, WH
7	Dimethyl formamide	6823.3	200kgx44	Combustible	HDPE drum, WH
8	Ethylene dichloride	15199.5	10klx2	I B Flammable	SS tank, Tank form
9	Ethyl Acetate	677.68	160 kgx6	I B Flammable	HDPE,WH
10	Formic acid	2800	10 klx1	Toxic	PPFRP, Tank form
11	Hexane	1683.3	200 kgx11	I B Flammable	HDPE drum, WH
12	Hydrogen gas	17.7	7M3x84	Highly Flammable	cylinders
13	Hydrazine hydrate	588.52	200 kgx9	Combustible & toxic	MS drum, WH
14	Hydrogen peroxide (30%)	171.5	200 kgx3	Toxic	HDPE drum, WH
15	Methanol	13715.7	10 klx1	I B Flammable	MS drum, Tank form
16	Methylene Dichloride	4447.23	250 kgx23	Toxic	MS drum
17	MIBK	166.7	160 kgx2	Toxic & I B flammable	MS drum
18	Mixed xylene	665.3	10 klx1	IC flammable	MS tank
19	n- Butanol	167694.5	160 kgx6	IC flammable	MS drum
20	o- Xylene	1730	160 kgx30	IC flammable	HDPE
21	Phosphorous oxy chloride	1473.0	250 kgx18	Toxic	HDPE
22	Pyridine	94.7	200 kgx1	Toxic & flammable	HDPE
23	Sulfuric acid	885.3	45 kgx59	Toxic	HDPE
24	Tetra hydro furan	268.29	180 kgx11	Flammable	HDPE
25	Thionyl chloride	1825.6	300 kgx18	Toxic	GI
26	Toluene	10882.6	10 Klx2	IB Flammable	HDPE

7.1.4 Potential Hazards

The following are the potential areas in an existing / proposed expansion project that can lead to major accidents.

- Solvents/ hazardous chemicals in specific tanks at above/ underground.
- Solvent / Hazard chemical Storage (drums) in ware house.
- Different hazard cylinders at dedicated sites
- Hazard handling and process area
- Coal handling and storage area
- Electric zone

7.2 Hazard Analysis

Identification of hazards is an important step in Risk Assessment as it leads to the generation of accidental scenarios. Hazard identification involves the identification of hazard prone chemicals in each process / operations unit as well as the location of the processes / operations in the plant and its storage. Once a hazard is identified, it is necessary to evaluate it in terms of the risk it presents to the employees and the neighbouring community. In principle, both probability and consequences will be considered.

Nature of the hazard most likely to accompany the hazardous material is its spill or release airborne toxic vapours / mists and fire/ explosion due to large storage or processes in its handling. On release, the hazardous substance can cause damage on a large scale. The extent of the damage is dependent upon the nature of the release, the physical state of the material and the micro-meteorological condition prevailing at the time of accident. As part of Risk Analysis, the damage distances are computed based on probable meteorological conditions.

List of hazardous chemicals along with maximum storage facility, per day consumption Flash Ignition Point (FIP), Boiling Point (BP) along with IDLH, TLV, UEL and LEL values is presented in **Table 7.3**. Further material analysis are made as per NFPA rating along with material factor is presented in **Table 7.4**. Classification of Flammable / Combustible liquids and description of National Fire Protection Agency (NFPA) classification are presented in **Tables 7.5** and **7.6** respectively. Storage of hazard chemicals mainly 10 KL flammable (IB & IC) solvent tanks i.e. Toluene, Carbon disulfide, Ethylene dichloride, Methanol and Xylene. Apart from these tanks other hazard chemicals are stored in respective drums of different capacity and are storing in specified ware house and gas cylinders at dedicated areas, details of storage of chemicals are depicted in plant layout **Fig.7.1.** LD50 values of the proposed products are presented in **Annexure-LIV.**

Table 7.3: Hazardous materials properties, rating and TLV value

Sl. No.	Raw Material	Physical Status of Chemical	Rating	Melting Point (°C)	Boiling Point (°C)	Flash Point (°C)	IDLH (ppm)	TLV Value (ppm)	LEL (%)	UEL (%)
1.	Acetic Anhydride	Liquid	2	-73.1	140	49	200	5	2.7	10.3
2.	Acetone	Liquid	1	-95.35	56.5	-20	2500	1000	2.15	13
3.	Acetonitrile	Liquid	2	-46	81-82	2	500	20	4.4	16
4.	Carbon disulfide	Liquid	3	-111.6	46.3	-30	500	20	1.3	50
5.	Chloro acetic acid	Liquid	3	63	180	120	-	-	LEL	-
6.	Cloro acetyl chloride	Liquid	3	-22	106	N/A	-	02 mg/m^3	N/A	N/A
7.	Dimethyl formamide	Liquid	3	-60.4	150.3	58	500	-	2.2	15.2
8.	Ethylene dichloride	Liquid	2	-35.4	83.4	33	50	10	6.2	16.0
9.	Ethyl Acetate	Liquid	2	-73	78.37	9	2000	400	2.0	11.5
10.	Formic acid	Liquid	3	8.4	100.5	50	30	3	-	-
11.	Hexane	Liquid	3	6.47	69	-23	1100	500	1.2	7.7
12.	Hydrogen	Gas	0	-259.2	-423	N/A	-	--	4	74
13.	Hydrogen hydrate	liquid	3	-51.7	113.5	72	-	-	72	-
14.	Hydrogen peroxide (30%)	liquid	3	-11	131	n/a	75	1	n/a	n/a
15.	Methanol	Liquid	1	-97	65	12	6000	200	6	36
16.	Methylene dichloride	Liquid	2	-96.7	39.6	14	2300	50	12	19
17.	MIBK	Liquid	2	-84.7	117	14	300	50	1.2	8
18.	Mixed xylene	Liquid	3	-25	144	32.2	900	100	0.9	6.7
19.	n- Butanol	Liquid	1	-89.8	117	35	1400	20	1.45	11.2
20.	o- Xylene	Liquid	3	-25	144	32.2	900	100	0.9	6.7
21.	Phosphorous oxy chloride	liquid	8	1.1	105.8	-	0.85	0.1	n/a	n/a
22.	Pyridine	liquid	3	-42	115.3	20	-	5	N.A	N.A
23.	Sulfuric acid	Liquid	3	-35	270	N.A	14 mg/m^3	1 mg/m^3	N.A	N.A
24.	Tetra hydro furan	liquid	2	-108.5	64.8	-14.4	2000	200	1.8	11.8
25.	Thionyl chloride	Liquid	3	-104.5	76	N/A	200	1	N/A	N/A
26.	Toluene	Liquid	2	-95	110.6	4.4	500	25	1.1	7.1

Note: Chemical Listing and Documentation of Revised IDLH Values (as of 3/1/95)

Table 7.4: Hazard Maximum Storage and NFPA Rating

S. No.	Description	Physical Status of Chemical	Maximum storage (Max Kl)	NFPA Rating			
				Nh-health	Nf-Fire	Nr-Reaction	Material Factor (MF)
1	Acetic anhydride	Liquid	200 kgx1	3	2	1	14
2	Acetone	Liquid	160 kgx18	1	3	0	16
3	Aceto nitrile	Liquid	160kgx10	3	3	0	16
4	Carbondisulfide	Liquid	10 kl tank	3	4	0	21
5	Chloro acetic acid	Liquid	25 kgx18	3	0	1	14
6	Cloro acetyl chloride	Liquid	200 kgx2	3	0	1	14
7	Dimethyl formamide	Liquid	200kgx44	2	2	2	24
8	Ethylene dichloride	Liquid	10klx2	3	3	0	16
9	Ethyl Acetate	Liquid	160 kgx6	4	3	0	16
10	Formic acid	Liquid	10 klx2	3	2	0	10
11	Hexane	Liquid	200 kgx11	2	3	0	10
12	Hydrogen gas	Gas	7M3x84	0	4	0	21
13	Hydrogen hydrate	Liquid	200 kgx9	3	2	2	24
14	Hydrogen peroxide (30%)	Liquid	200 kgx3	0	1	14	4
15	Methanol	Liquid	10 klx2	2	0	1	14
16	Methylene Dichloride	Liquid	250 kgx23	3	1	1	4
17	MIBK	Liquid	160 kgx1	2	3	1	16
18	Mixed xylene	liquid	10 klx1	2	3	0	16
19	n- Butanol	Liquid	160 kgx6	1	3	0	16
20	o- Xylene	liquid	160 kgx14	2	3	0	16
21	Phosphorous oxy chloride	Liquid	250 kgx18	4	0	2	24
22	pyridine	liquid	200 kgx1	3	2	2	24
23	Sulfuric acid	liquid	45 kgx59	3	0	1	24
24	Tetra hydro furan	liquid	180x2	2	3	1	16
25	Thionyl chloride	Liquid	300 kgx18	4	0	2	24
26	Toluene	Liquid	10 Klx2	2	3	0	16

Table 7.5: Classification of Flammable/Combustible Liquids

Class IA flammable liquid	Flash Point below 22.78°C and Boiling Point below 37.78°C.
Class IB flammable liquid	Flash Point below 22.78°C and Boiling Point at or above 37.78°C.
Class IC flammable liquid	Flash Point at or above 22.78°C and below 37.78°C.
Class II combustible liquid	Flash Point at or above 37.78°C and below 60°C.
Class IIIA combustible liquid	Flash Point at or above 60°C and below 93.33°C.
Class IIIB combustible liquid	Flash Point at or above 93.33°C.

Table 7.6: Description of National Fire Protection Agency (NFPA) Classification

Rating Nh	Type of possible injury	Rating Nf	Susceptibility of material to burning	Rating Nr	Susceptibility to release of energy
4	Materials which on very short exposure could cause death or major residual injury even though prompt medical treatment is given	4	Materials which will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature or which are readily dispersed in air and which will burn readily	4	Materials which in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressure
3	Material which on short exposure could cause serious temporary or residual injury even though prompt medical treatment is given	3	Liquids and solids that can be ignited under almost all ambient temperature conditions	3	Materials which in themselves are capable of detonation of explosive reaction; but require a strong initiating source or which must be heated under confinement before explosively with water
2	Materials which on intense or continued exposure could cause temporary, incapacity or possible residual injury unless prompt medical treatment is given	2	Materials that must be moderately heated or exposed to relatively high ambient temperature before ignition can occur	2	Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Also materials which may react violently with water to form explosive mixture
1	Materials which on exposure would cause irritation but only minor residual injury even if no treatment is given	1	Materials that must be preheated before ignition can occur	1	Materials which in themselves are normally stable, but which can become unstable at elevated temperatures and pressure or which may react with water
0	Materials which on exposure under fire conditions would offer no hazard beyond 0 that of ordinary combustible material	0	Materials that will not burn	0	Materials which in themselves are normally stable, even under fire exposure conditions and which are not reactive with water

Nh- Health, Nf- Fire, Nr-Reaction

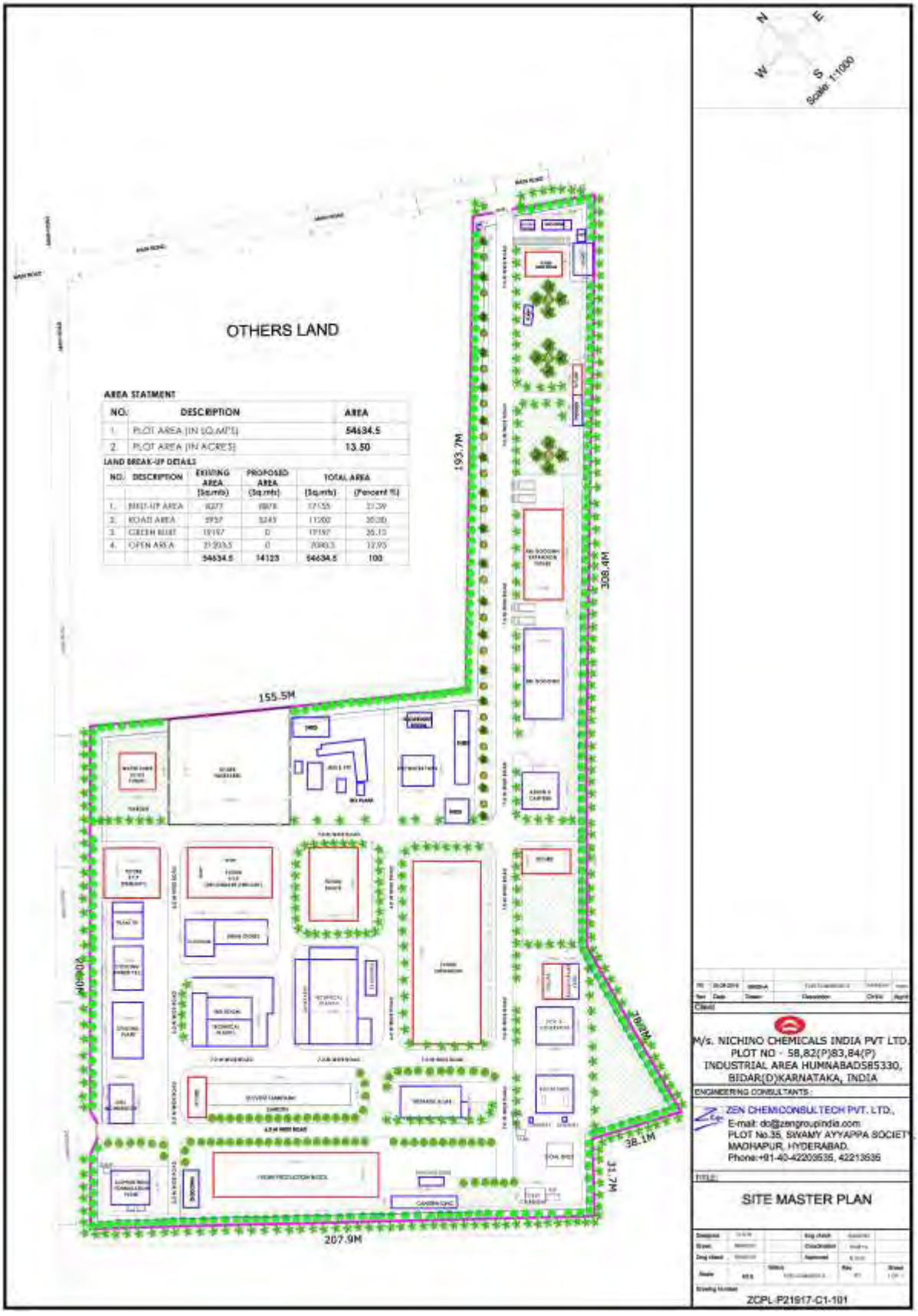


Fig. 7.1: Plant layout

7.2.1 Fire and Explosion Index

Fire and Explosion Index (FEI) is useful in identification of areas in which the potential risk reaches a certain level. FEI covers aspects related to the intrinsic hazard of materials, the quantities handled and operating conditions. This factor gives index value for the area which could be affected by an accident, the damage to property within the area and working days lost due to accidents. The method for evaluation of FEI involves the determination of Unit Hazard Factor and the determination of Material Factor (MF). Fire and explosion index is then calculated as the product of Material Factor (MF) and Unit Hazard Factor.

The Unit Hazard Factor is obtained by multiplication of General Process Hazard (GPH) factor and Special Process Hazard (SPH) factor. GPH factor is computed according to presence of exothermic reactions and loading & unloading operations. The penalties due to each of these reactions / operations are summed up to compute GPH factor. Similarly, SPH factor can be evaluated for the operations close to flammable range or pressures different from atmospheric pressures. Penalties of these operations for both factors can be obtained from Dow's FEI index form.

Material Factor for a given chemical is evaluated from NFPA indices of danger, health, flammability and reactivity data. It can be directly obtained from Dow's Fire and Explosion Index Hazard classification Guide of American Institute of Chemical Engineers, New York. The Material Factor for a given substance in the process unit gives intrinsic potential to release energy in case of fire or an explosion.

FEI Range	Degree of Hazard
0 – 60	Light
61 – 96	Moderate
97 – 127	Intermediate
128 – 158	Heavy
159 and Above	Severe

7.3 MCA Analysis

As part of Environmental Impact Assessment / Environmental Management Plan (EIA/EMP), the risk due to the Maximum Credible Accident (MCA) scenario will be quantitatively assessed. MCA stands for an accident with maximum damage distance, which is believed to be probable. In practice the selection of accident scenarios for MCA analysis is carried out on the basis of engineering judgment and expertise in the field of risk analysis especially in accident analysis.

The MCA analysis involves ordering and ranking of various sections in terms of potential vulnerability. The data requirements for MCA analysis are:

- Operating manual
- Flow diagram and P&I diagrams
- Detailed design parameters
- Physical and chemical properties of all the chemicals
- Detailed plant layout
- Detailed area layout

MCA analysis encompasses defined techniques to identify the hazards and compute the consequent effects in terms of damage distances due to heat radiation, toxic releases, vapour cloud explosion etc. A list of probable or potential accidents of the major units in the arising due to use, storage and handling of the hazardous materials are examined to establish their credibility. Depending upon the effective hazardous attributes and their impact on the event, the maximum effect on the surrounding environment and the respective damage caused can be assessed.

7.3.1 Event Tree Analysis

The accident scenarios of hazard chemicals can be divided into the following categories.

- Flammable gases
- Liquefied gas or boiling liquid release under pressure
- Non boiling liquid release
- Toxic gas release

Different consequences of accidental release of hazard due to undesirable conditions of failure are possible depending on type of event such as continuous or instantaneous releases in gas/ vapour / liquid. Event Tree Analysis for rupture and leak scenarios for continuous/ instantaneous release of gas/ liquid and for delayed or immediate ignition or toxic cloud. Typical flow chart of accidental release of hazardous chemicals is given in **Fig.7.2**.

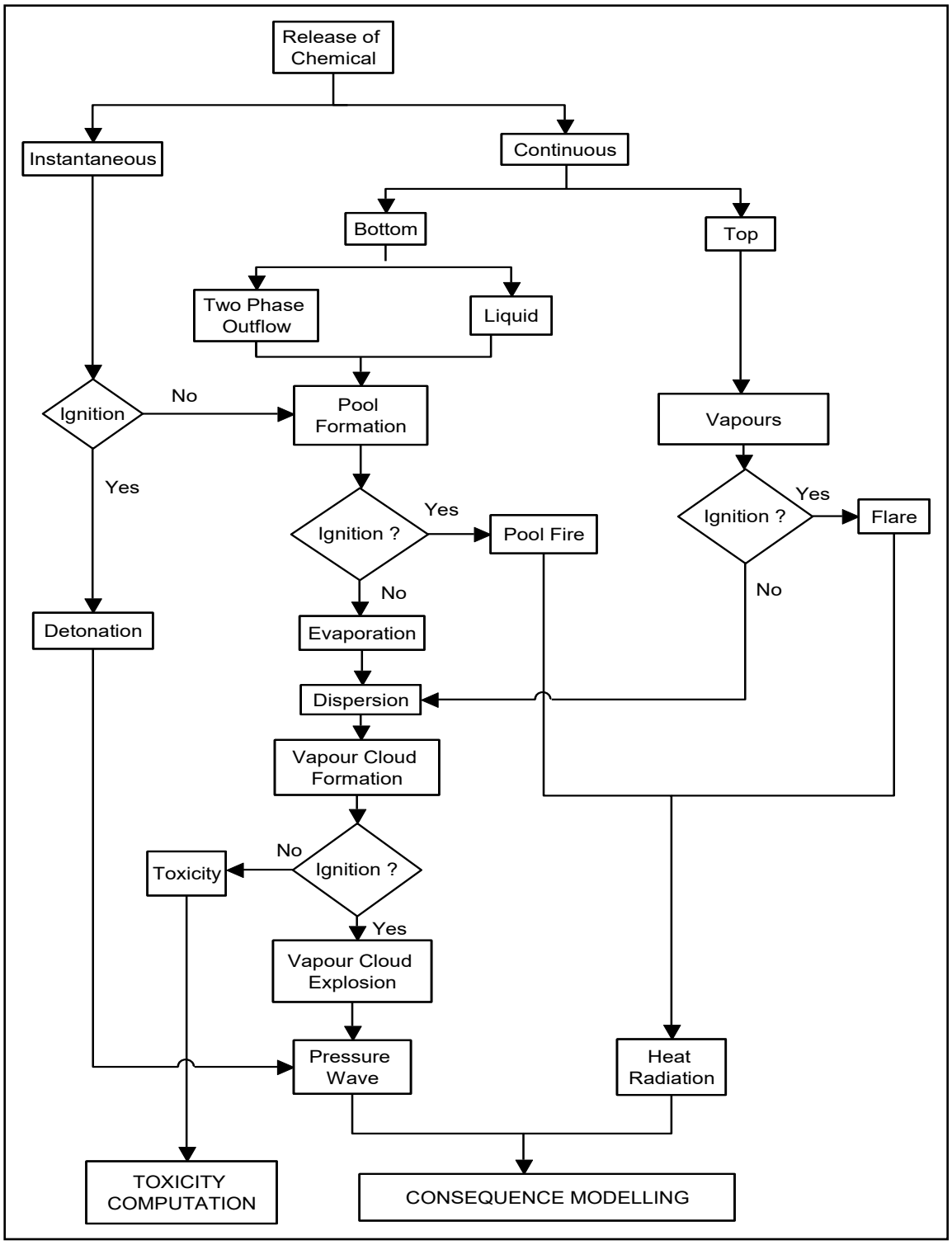


Fig. 7.2: Typical Flow Chart of Accidental Release of Hazardous Chemicals

7.3.2 Methodology of modeling exercise

Source models represent the material release process. They provide useful information for determining the consequences of an accident including the rate of material release, the total quantity released and the physical state of the material. The source models that are used repeatedly are:

- Flow of liquid /vapor through a hole in a tank/ pipes
- Flowing liquids
- Liquid pool evaporation or boiling

The purpose of source model is to determine:

- Form of material released is solid/ liquid/ vapour
- Total quantity of material released
- Rate at which it is released

Dispersion Model: Dispersion model describes the transportation of air borne toxic material away from the accident site and in to the surrounding areas. After the release, the air borne toxic substances are carried away by the wind in a characteristic plume or a puff. The maximum concentration of toxic material occurs at the point of release. The concentration at downwind is less due to turbulent mixing and dispersion of toxic substances with air. A number of parameters that affect the atmospheric dispersion of toxic material are wind speed, atmospheric stability, general conditions such as buildings, water bodies and trees, height of release and initial movement of the material released.

Fire and Explosion Scenarios: Flammable substances on release may cause Jet fire and less likely unconfined vapour cloud explosion causing possible damage to the surrounding area. The extent of damage depends upon the nature of the release. The release of flammable materials and subsequent ignition result in heat radiation wave or vapour cloud depending upon the flammability and its physical state. Damage distances due to release of hazardous materials depend on atmospheric stability and wind speed. It is important to visualize the consequence of the release of such substances and the damage caused to the surrounding areas.

- First, before the ignition, a cloud of sufficient size must have been formed. Normally ignition delays of few minutes are considered the most probable for generating the vapour cloud explosions
- Second a sufficient amount of the cloud must be within the flammable range of the material to cause extensive overpressure.

- Third, the flame speed determines the blast effects of the vapour cloud explosions, which can vary greatly

Combustible materials within their flammable limits of (UEL and LEL) may ignite and burn if exposed to an ignition source of sufficient energy. On process plants, this normally occurs as a result of a leakage or spillage, which will depends on the physical properties of the material and the operating parameters. The event Classification of fire and explosion scenarios is described in **Table 7.7**.

Table 7.7: 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
Explosion	A release of large amount of energy that form a blast wave
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
Vapor Cloud Explosion	Explosion resulting from vapor clouds formed from flashing liquids or non-flashing liquids and gases

Models for the Calculation of Heat load and Shock Waves: If a flammable gas or liquid is released, damage resulting from heat radiation or explosion may occur on ignition. Models used in this study for the effects in the event of immediate ignition (torch and pool fire) and the ignition of a gas cloud. These models calculate the heat radiation or peak overpressure as a function of the distance from the torch, the ignited pool or gas cloud. The physical significance of the various heat loads is presented in **Table 7.8**.

Table 7.8: Various Physical Effects Due to Heat Radiation

Flux / Intensity (KW/m^2)	Thermal Effects
49	3rd degree burns Severe burns due to fire ball zone
37.5	100% lethality Severe burns, 80% or more leading to 100% fatality
25	50% lethality Severe burns due to explosion of gas, within lower and upper limit leading to 50% fatality
12.5	1% lethality Burns and injuries due to exposure to thermal radiation
4.5	First degree burns Blistering and first degree burns due to exposure to thermal radiation
1.6	No perceptible discomfort

Boiling Liquid Expanding Vapour Explosion (**BLEVE)**: If the liquid is stored under pressure at a temperature above its boiling point, the initial physical explosion that breaks the receptacle produces a sudden decompression giving rise to a massive evaporation of the saturated liquid. This is known as Boiling Liquid Expanding Vapour Explosion (BLEVE). These explosions are of great destructive power due to the high increase in pressure caused by the sudden incorporation of liquid into the gas phase. The ignition of BLEVE produces a mass of gases at high temperature known as 'fireball' with significant thermal effects. Historically, BLEVEs have been produced with some frequency and have almost caused human casualties.

Model for Pressure Wave: A pressure wave can be caused by gas cloud explosion. The following damage criteria are assumed as a result of the peak overpressure of a pressure wave: 0.03 bar over pressure wave is taken as the limit for the occurrence of wounds as a result of flying fragments of glass. Physical significance of various pressure waves is presented in **Table 7.9.** Methodology (Yellow book) and Software applied for the study TNO and also EPA based one).

Table 7.9: Over Pressure Effect of Explosion

Sl. No.	Press (bar)	Damage
1	0.03	Occasional breaking of large glass windows already under strain
2	0.1	Breakage of small windows under strain
3	0.3	" Safe distance " (probability 0.95 no serious damage beyond this value); projectile limit; some damage to house ceiling; 10% window glass broken
4	1.0	Partial demolition of houses, made uninhabitable
5	1-2	Corrugated asbestos shattered; corrugated steel and aluminum panels, fastenings fail followed by buckling wood panels (standard housing) fastening fail, panels blown in
6	1.3	Steel frame of clad building slightly distorted

Sl. No.	Press (bar)	Damage
7	3.0	Heavy machines (3000lb) in industrial building suffered little damage; steel frame building distorted and pulled away from foundations
8	5.0	Wooden utility pollen
9	7.0	Loaded train vapour over turned
10	10.0	Probable

7.4 Consequence of MCA Analysis

Based on the hazard identification and nature of hazard occurrence, MCA scenario is short listed below.

- Pool fire due to rupture / leakage and accumulation
- Fire/ explosion of flammable gas / vapour
- Dispersion of Toxic gas

Pool Fire/ Vapour cloud explosion

This scenario was visualized for Flammable liquid storage tanks mainly solvents in tank form area i.e. Methanol, Ethylene dichloride, Mixed Xylene and Toluene with a capacity of 10 Kl each, whereas carbon disulfide 10 KL tanks at underground. Other selected solvent are storing in HDPE drums i.e. Acetone, Acetonitrile, Methylene Dichloride, Ethyl acetate, n-Butanol, MIBK, Hexane and others including combustible Dimethyl formamide. For the same various radiation of heat levels are analyzed for selected stability class and wind velocity. The damage distances for pool fire due to leak and catastrophic rupture (BLEVE) of storage tank for heat radiation of 37.5, 12.5 and 4.5 Kw/m² are given in **Table 7.10.** Pressure wave's values are also calculated for vapor cloud explosion and reported for damage distance due to over pressure 0.3, 0.1 and 0.03 bar in Table 7.10. Detail analysis is also carried out identified hazard flammable gas Hydrogen (7 m^3 cylinder).

Table 7.10: Consequences of MCA Analysis – Storages

(*Catastrophic Damage distances in meters)*

(Pool Fire/ Fir Ball/ VCE)

Hazard Material		Heat Radiation (KW/m^2)- Meters			Over Pressure (bar) - Meters		
		37.5	**12.5**	**4.5**	**0.3**	**0.1**	**0.03**
Ethylene dichloride 10 KL x 2	Pool fire Dia 3.19 m	-	-	<10	-	-	-
	VCE/BLEVE F.B. Dia 134 m	LOC	120	221	212	248	422
Methanol 10 KL	Pool Fire Mr Dia	-	-	<10	-	-	-
	VCE/ BLEVE FB dia 3.3 m	65	150	259	LOC	192	263
Pyridine 200 kgx1	Pool fire area 4 m2 unconfined	-	-	<10	-	-	-
	VCE/BLEVE F.B dia 34 m	33	42	104	40	52	116
Toluene 10 KL x2	Pool Fire Dia.3.3 m Dia	-	,<10	12	-	-	-
	VCE/ BLEVE F.B dia 119 m	121	227	379	289	346	618
Carbon disulphide 10 KL x 1	Evaporation rate 0.084 kg/second	-	-	<10	-	-	-
Mixed xylene 10 KL x 1	Pool fire 3.3 m dia	-	<10	21	-	-	-
Acetonitrile 160 kgx10	VCE/BLEVE fire ball dia 31 m	36	53	90	61	66	108
Acetone 160 kgx18	VCE/BLEVE fire ball dia 31 m	27	52	88	28	39	87
n-. Butanol 160 kgx6	VCE/BLEVE fire ball dia 31 m	30	57	96	37	47	105
Di methyl formamide 200 l x 44	VCE/BLEVE fire ball dia 33 m	25	51	88	38	50	111
Ethyl Acetate 160kgx6	VCE/BLEVE fire ball dia 30 m	23	45	79	28	38	85
Hexane 200 kgx11	VCE/BLEVE F.B.Dia 29 m	34	62	104	40	50	109
Methylene dichloride 250 kgx23	VCE/BLEVE fire ball dia met	LOC	22	49	<10	17	40
MIBK 160 Kgx2	VCE / BLEVE Fire Ball Dia.31 m	38	50	109	33	62	105
Tetra hydro furan 180 kgx11	VCE/BLEVE fire ball	30	57	96	40	54	120

Hazard Material		Heat Radiation (KW/m^2)- Meters			Over Pressure (bar) - Meters		
		37.5	12.5	4.5	0.3	0.1	0.03
	dia 31 m						
O-Xylene 160 kgx30	VCE/BLEVE, Fire ball dia.31 m	35	64	107	40	53	116
Hydrogen 7 m3 Cylinder x 84	VCE / BLEVE FB dia 31 m	-	-	<10	11	16	33

Flammable liquids: Analysis indicate that Confined pool fire of IB flammable liquids Ethylene dichloride, Methanol, Toluene and Toluene heat radiation effect covers 10 to 21 m from center of pool, where in pool diameter is maximum of 3.3 m and in all the cases heat radiation effect of 37.5 KW/m^2 within the pool only. In the case of catastrophic rupture of storage tank with ignition radiation effect 4.5 KW/m^2 up to maximum distance vary from 221 to 379 m and overpressure effect of 0.03 bar varies 263 to 618 m.

In the case of Flammable liquids (I B & I C), which are stored in ware house mainly Acetone, Acetonitrile, MIBK, n-Butanol, Pyridine, Hexane, Methylene dichloride, o-Xylene and Tetra hydro furan are in 160 to 250 kg drums, due to leak/ rupture of drums with ignition radiation effect 4.5 KW/m^2 covers a distance from 49 to 109 m, whereas damage distance of pressure wave VCE from 40 to 120 m. MCA analysis indicate that all the predicted values of damage distances are within in the plant mainly on-site area including lower and upper explosive limits. It is also indicate that effect of heat radiation is mainly at the site of incident, which is due to instantaneous release of material spread over unconfined area and by spark/ ignition thermal radiation and vapour cloud explosion occurs and causes effect on-site area.

Over pressure in 'psi' (As bar 0.3, 0.1 and 0.03) against damage distance and effect of heat radiation due to BLEVE for Methanol and N-Butanol are shown in **Annexure LV and LVI** along with respective heat radiation and pressure wave isopleths. It occurs only due to ignition/ spark / detonation of vapour cloud, However it is observed that average concentration of upper exposure limit is mainly on-site, hence vapor cloud explosion unlikely occurs.

Flammable gas: Hydrogen is considered as **Class2** flammable gas, there is a proposal to store maximum of 84 cylinders of capacity each 7m^3 and going to store at dedicated area. Analysis indicate that heat radiation effect 4.5 KW/m^2 covers within 10 meter and over pressure effect 0.03 bar up to 33 m in case of leak.

Toxic Release

The toxic hazard chemicals are going to be used by proponent in their proposed plant and are mainly Acetic anhydride, Acetonitrile, Chloro acetyl chloride, Methylene chloride,

Pyridine, sulfuric acid, Phsphorus oxy chloride, and Thionyl chloride and it is stored in various capacity of drums, whereas Ethylene dichloride and formic aid is stored in horizontal tank in Tank form area, where as carbon disulfide in 10 kl underground tank. The same are selected on basis of IDLH and TLV value for the study. Some of the chemicals are flammable as well as toxic. Hence Acetic anhydride, Aceto nitrile, Methyl dichloride and Ethylene dichloride are selected for toxic dispersion. For the purpose of risk assessment study, consequences due to release of these toxic elements are analyzed for estimation of exposure distances due to toxic releases from confined / unconfined pool. Consequences results are reported in **Table 7.11**. Consequence analysis indicate that IDLH concentration of Thionyl chloride 14 ppm covers a distances up to 218 m and (PEL) TLV value of 1 ppm up to 965 m in case of leak at wind ward side of plant, where as in case of leak of Chloro acetyl chloride 1300 and 4300m and in case of Phosphorous oxy chloride 449 m and 1400 m respectively. Analysis indicate that if any incident due to leak forms unconfined area toxic vapors dispersed towards downwind side causes effected area of IDLH levels are mostly onsite area, where as PEL (TLV) levels onsite as well as off-site area.

In other cases, which are stored in tanks in tank form area such as Ethylene dichloride, due to leak/ rupture of tank damage distance of IDLH onsite of incident where as PEL (TLV) up to 77 m, being material spread over in confined area of pool. In the case of toxic hazard drums which are stored in ware house, material spreads over due to leak/ rupture forms unconfined area. For the same predicted for exposure distance of IDLH and TLV (PEL) levels and the same are reported in **Table.7.11**.

Sulfuric acid: There is a proposal to store Sulphuric acid in 45 kg carboys of 59 in number. Due to leak/rupture of Sulfuric acid, fumes (IDLH -15mg/m^3) towards windward side and covers a distance of 83 m, whereas respective PEL values 1 mg/m^3 and covers a distance of 324 m respectively. For the same specific precautionary measures are to be followed as per MSDS guidelines and the same are addressed in next chapter.

The damage contour of **Carbon disulfide** and **Thionyl dichloride** are shown in **Annexure LVII** and **Annexure LVIII** respectively. For all the toxic hazard are predicted and distance of exposure of IDLH level as well as for TLV (PEL) are reported in **Table 7.11**. Prediction made for Wind velocity 2m/sec and stability B & D.

Table 7.11: Consequence Analysis for Toxic Release Scenario

Scenario Considered	IDLH (ppm)	TLV (ppm)	Leak Size (mm)	Source Strength (kg/sec)	IDLH Distance (m)	TLV (m)
Acetic anhydride 200 kgx1	200	5	Leak	0.015	28	160
			Instantaneous	0.895	207	1000
Aceto nitrile 160 kgx10	500	40	Leak	0.043	61	236
			Instantaneous	2.59	415	1300
Chloro acetyl chloride 200kgx2	2 mg/m^3	0.2mg/m^3	Leak	0.078	1300	4300
			Instantaneous	4.69	4000	8600
Carbondisulfide 10 KL tank	500	20	Evaporation/ Rate	0.084	68	365
Ethylene dichloride 10 KLx2	50	10	Confined Pool 8 Sq.m	0.0034	34	77
Formic acid 10 KLx1	30	3	Confined Pool 8 Sq.m	0.0057	42	136
Pyridine 200 kgx1	1000	5	Leak Unconfined Pool	0.0556	26	570
Sulphuric Acid 45 kg x25	15 mg/m^3	1 mg/m^3	Unconfined Pool	0.0125	83	324
Methylene Chloride 250 kgx23	2300	50	Leak	0.0915	20	204
			Instantaneous	5.49	158	946
Phosphorous oxy chloride 250 kgx18	0.85 mg/m^3 PAC1	0.1 mg/m^3 PAC-3	Leak	0.023	449	1400
			Instantaneous	1.39	2200	4600
Thionyl chloride 300kgx18	14	1.0	Leak	0.083	218	965
			Instantaneous	5.0	1200	3300

Handling of Hazardous Materials

- **Material hazards:** Coal is the major fuel for existing/ proposed steam boiler and High Speed Diesel (HSD) Oil for DG sets and Furnace oil for steam boilers.
- **Process hazards** due to loss of containment during handling of hazardous materials or processes resulting in fire, toxic dispersion and explosion, etc.
- **Mechanical hazards** due to "mechanical" operations such as welding, maintenance, falling objects etc. - basically those NOT connected to hazardous materials.
- **Electrical hazards:** electrocution, high voltage levels, short circuiting, etc.

Out of these, the material and process hazards are the one with a much wider damage potential as compared to the mechanical and electrical hazards, which are by and large limited to only very small local pockets.

7.5 Risk mitigation measures

Consequences analysis indicate that the damage distances for fire and explosion situations and IDLH distances due to toxic release of hazardous chemicals fall well within the plant site as well as outside the boundary specially in the case of leak/ instantaneous release of Chloro acetyl chloride and Phosphorus oxy chloride and Thionyl chloride. Apart from these other toxic chemicals are Acetic anhydride, Aceto nitrile, Pyridine and Methylene chloride vapours, for the same distance of effect is reported.

In the case of flammable liquid, effect of pool fire distance is onsite and its effected area up to maximum of 18 ms from confined pool edge. Delayed ignition / spark of vapour cloud of the solvent tank causes over pressure effect crossing plant boundary includes effect of radiation.

For the above incorporating certain mitigation measures at source of release, the consequences to the members of public in and outside the plant will be further reduced.

Since the scope of the risk assessment studies cover the risk mitigation measures based on Maximum Credible Accident (MCA) Analysis, certain general and specific recommendations are suggested and listed in this chapter. In this regard, the recommended mitigation measures for natural disasters are also included.

7.5.1 General

The industry has to provide appropriate independent fire combat facility and personal protection system and also will have a mutual aid with industries located in and around M/s. Nichino Chemical India Pvt. Limited. On-site/ Off-site emergency plan with effective fire combat facility has been established. However, further suitable mitigation measures with fire protective equipment is to be upgraded.

- Surrounding population needs to be aware of the safety precautions to be followed in case of any toxic release from proposed plant.
- Proposed buildings possibly made to withstand external blast waves and windows will be made of blast resistant glass with strong frame.
- Fire protection system will be in place in accordance with the requirements of NFPA standards. Design requirements and Safe Engineering practices will have full capability for early detection and suppression of fire

Fire prevention and code enforcement is one of the major areas of responsibility for the fire service. The details of the fire-fighting systems and capabilities may be worked out with fire & safety personnel.

7.5.1.1 Fire Prevention and Protective Equipment

Existing fire-fighting facility to be upgraded for proposed plant to utilise the same as and when required. The following fire fighting facility is to be checked, if not procured and maintain the same as in case of basic fire preventive measures.

- Water
- Water Tenders
- Foam Tenders
- Fire hydrant and monitor nozzle installation
- Dry powder extinguisher
- Water fog and sprinkler system
- Mobile Fire-fighting equipment
- DCP fire extinguishers
- CO_2 Fire extinguishers
- High expansion foam generator
- For large fire Dry chemical, CO_2 and alcohol resistant foam.
- First aid appliances
- Fire extinguishers will be tested periodically and will be kept in operational mode
- Critical switches and alarm will be kept in-line
- Shut off / valves isolation will be easily approachable in emergencies
- Signboard for toxic or flammable hazard and no smoking signs and type of risk will be provided at various locations
- A wind direction pointer will also be provided at storage site, tanks and location of drums storage. So that in emergency the wind direction can be directly seen accordingly downwind population cautioned specially in toxic gas release.
- Sufficient/adequate space in the storage areas such that to escape from fire and at the same time it will allow emergency procedures to be mobilized.
- Dykes are provided for most of the solvent storage tanks for existing / proposed one if any. However for all the storage tanks of existing chemicals/ solvents wherever necessary, it may be provided and keep safe distance between tanks to avoid domino effect in case of fire.
- Fire proofing materials will have adequate adhesion, strength and durability in the area.
- Seal all the waste in vapour tight plastic bags for eventual disposal or incineration.
- Use face shield, PVC gloves, and safety boots while handling and contaminated clothing has to be removed immediately.
- In case of accidental release, shut-off leaks without risk. Prevent spillage from

entering drains or water sources.

- For small spills, take up with sand or other non-combustible material and placed into closed containers for later disposal.
- For large liquid spills, build dyke far ahead of the spill to contain the spilled material for reclamation or disposal as per environmental safety guidelines and decontaminant the area.
- Cool containers/ drums with flooding quantity of water until well after fire is quit.
- Periodical mock drills will be conducted so as to check the alertness and efficiency of the DMP.
- In any case of large fire occurs**,** cool the tanks/ drums with flooding quantity of water until fire is quit.

7.5.1.2 Solvent Storage Tanks / Drums Handling Precautions

Storage tanks : There are few independent storage tanks/ drums mentioned above if any, will be transferred to the day tank situated at the production block with the help of mechanical seal pump through pipe lines from the tank, from day tank to reaction vessel unloading by gravity.

Drums: Most of the hazard Chemicals/ solvents are storing in ware house, if any material will be transferred from respective drums (MS and HDPE) to the day tank situated at the production block with the help of AOD pump through pipe from the drums and from day tank to reaction vessel.

The storage and handling of hazardous chemicals in a chemical industry is inevitable, and they carry inherent characteristic risk to the employees due to the properties of chemicals such as toxicity & flammability. Accident due to fire and explosion by flammable substances are possible in process industry. The disastrous effect of fire, explosion and release of toxic fumes in storage and production area, occurs due to inappropriate design, improper storage, improper handling, poor maintenance or deficiencies in the operation of the plant. Chemical in any form can be stored, handled and used if their physical, chemical and hazardous properties are thoroughly understood and necessary precautions are taken. Chemicals are handled in standard containers like MS / HDPE drums, Carbuoys, etc. All the chemicals are to be arranged and stored in accordance with their compatibility, dry, well ventilated, with flame proof electrical equipments and lighting. All the chemicals are to be provided with identification labels.

Each chemical has its specific character. Hence, chemicals do not co-exist. They need their independent space, while storing. When two chemicals come in contact may generate heat, and gases by-product. Ambient temperature and moisture can trigger the reaction.

Halogenated compounds acquire aggravated properties. It is only wise to treat every chemical as toxic.

Chemicals are potential enough to destroy the flesh and the skin is ultrasensitive to chemicals. Chemicals on contact, the affected parts of the body will be washed thoroughly with plenty of water for at least 15 minutes, to dilute the aggressive nature of the chemical, as water is the only universal solvent and the best diluent. Then only further treatment is to be followed.

Eye wash/drench shower is to be provided at a strategic location for emergency purpose. Chemical safety data sheets and handling procedure, First aid measures are to be prepared and displayed for information and safety of the working personnel. The common safety data of the raw materials and solvents are given in **Table 7.12.**

Table 7.12: Safety data which are common to all raw materials and solvents

1. Fire Fighting Measures	
Extinguisher media	Water spray, dry chemical and carbon dioxide or foam as appropriate for surrounding fire and materials. In case of fire of water/air reactant chemicals like sodium boro hydride, water/foam shall not be used. Dry sand, dry chemical/lime may be used.
Special firefighting procedure	As with all fires, evacuate personnel to safe area. Fire fighters should use self-contained breathing apparatus and protective clothing.
Unusual fire and explosion hazard	This material is assumed to be combustible. As with all dry powders it is advisable to earth the mechanical equipment in contact with dry material to dissipate the potent buildup of static electricity.
Firefighting Procedures	As with all fires, evacuate personnel to a safe area. Fire fighters should use self-contained breathing apparatus and protective clothing.
2. Physical Hazards	
Hazardous Decomposition Products	When heated to decomposition, materials emit toxic fumes under fire conditions.
Hazardous Polymerization	Will not occur
3. Health Hazard Information	
Adverse Effects	Adverse effects may include dizziness, fainting, headache, and diarrhea, and nausea, loss of taste, dry cough, rash fever, joint pain, and unusual tiredness. Possible allergic reaction occurs to material if inhaled, ingested or in contact with skin.
Acute	Possible eye, skin, gastro-intestinal and/or respiratory tract irritation.
Chronic	Possible hyper sensitization
Inhalation	May cause irritation. Remove to fresh air.
Eyes	May cause irritation. Flush out with copious quantity of water by keep opening both eyelids of the affected eye/s. Obtain medical attention immediately.
Skin	May cause irritation. Flush out with copious quantity of water.
Ingestion	May cause irritation. Flush out mouth with required quantity of water by gargling. Obtain medical attention immediately.
4. First Aid Measures	

Precautions to consider	Persons developing hypersensitive (anaphylactic) reactions must receive immediate attention; material may be irritating to mucous membranes and respiratory tract. When handling, avoid all contact and inhalation of dust, fumes, mists, and/or vapors associated with the material. Keep container tightly closed and use with adequate ventilation. Wash thoroughly after handling. Individuals working with chemicals should consider all chemicals to be potentially hazardous even if their individual nature may be uncharacterized or unknown.
Emergency and first aid procedures	Remove from exposure. Remove contaminated clothing. Person developing serious hypersensitive reactions must receive immediate medical attention. If a person is not breathing, give artificial respiration. If breathing is difficult, give oxygen. Obtain medical attention immediately.
5. Exposure Controls / Personal Protection	
Respiratory protection	Use the NIOSH approved respirator, if it is determined to be necessary by an industrial hygienic survey involving air monitoring. In the event of a respirator is not required, an approved dust mask will be used.
Ventilation	Recommended
Protective gloves	Rubber
Eye protection	Safety goggles/face shield
Other protective clothing	Appropriate laboratory apparels/Apron. Protect exposed skin.
6. Handling / Spill / Disposal Measures	
Handling	As a general rule, when handling the materials, avoid all contact and inhalation of dust, mists, and/or vapors associated with the material. Wash thoroughly with soap water after handling.
Storage	Store in airtight containers. This material should be handled and stored as per label instructions to ensure product integrity.
Gspill response	Wear approved respiratory protection, chemically compatible gloves and protective clothing. Wipe up spillage or collect spillage using a high efficiency vacuum cleaner. Avoid breathing dust. Place spillage in an appropriately labeled container for disposal. Wash out the spilled site thoroughly.

Measures to Avoid Evaporation

Keep chemical holding tank/ containers/ drums tightly closed. Keep away from sparks, flame and sources of ignition. Avoid utilizing common shed for different hazard chemicals specially in compactable chemical in same shed, if not keep safe distance.

At present most of the Chemicals will be received in HDPE and MS drums /carbuoys are stored in a ware house. The ware house floors have to be made of impervious and the room is well ventilated. MS drums are to be stored on spill containment pallets. In case of any leakage from the drum it will collect in the tub space provided in the pallet itself as containment.

Drums are transferred from ware house to manufacturing area along with spill pallets. It is necessary to store drums in a cool, dry, well-ventilated area away from incompatible substances sufficient buffer space will be provided between containers/ drums, so that it can

be isolated during leak/spill and respective remedial measures can be undertaken to minimize the effect on-site area. If any chemical to be dispensed for part quantities, the dispensing operation will be done in the dispensing room with local exhaust ventilation system connected to scrubber.

Following contaminant procedure and safety systems to be followed to minimise/ avoid release of hazard chemical and to control at source if leak/ spill of gas/ vapor/ liquid.

CHEMICALS / NEUTRALISING	ACID (CORROSIVE)	WATER EACTIVE	CAUSTICS	OXIDIZER	REDUCER	POISON	AIR REACTIVE	FLAMMABLE	ALKALI METALS
ABSORBING AGENT	Polypropyl-ene pad, Brooms & Sand	Polypropyle-ne pad & Broom	Polyprop-ylene pad, Broom & sand	Polyprop-ylene pad & Brooms	Polypropyle-ne pad & Brooms	Polyprop-ylene pad & Brooms	Polypropyl-ene pad & Brooms	Polypropylene pad, Brooms & sand	Dry sand / Mineral oil
NEUTALIZER	Sodium Bi Carbonate (or) Soda Ash	Sodium Bi Carbonate (or) Soda Ash & Special Dry Powder (TEC)	Weak Acid (5% Hydrochl oric acid)	5% sodium thiosulph-ate solution & Powder	5% sodium hypo chlorite solution	5% sodium hypo chlorite solution	Sodium Bi Carbonate (or) Soda Ash & Mineral oil	Activate Charcoal	Nil
DECONTAMINA TER	Water and to be checked by pH paper	Water	Water and to be checked by pH paper	Water	Water	Solvent for water reactive and then with water	Water	Water	Mineral oil and then with water

Spill containment procedure:

1. In case of minor spill isolate the chemical/ material
2. Neutralize the spill with the chemical
3. Sweep the area
4. Decontaminate the area with suitable decontaminer as mentioned in the above table

It is also necessary that every chemical industry to be maintained spill control kit with minimum of these items is to be followed and updated in regular interval.

1. Sorbent rolls
2. Sorbent brooms
3. Sorbent pads
4. Air tight goggles
5. Half face cartridge mask
6. Chemical resistant suit

7. Antistatic gloves
8. PVC gloves

Safety Systems

1. Designated areas with proper indication flammable/ toxic / explosive & safety signs
2. Double earthing systems
3. Flame arrestor to the vent
4. Flame proof transferring pumps
5. Handling precautions/sop protocol
6. Pressure Gauges
7. Level indicators
8. Flame proof lighting to storage yard

Personal Protective Equipment (PPE)

Personal Protective Equipment (PPE) provides additional protection to workers exposed to workplace hazards in conjunction with other facility controls and safety systems. Selection of PPE will be based on the hazard and risk ranking and will be according to the criteria on performance and testing established. The generally recommended measures for use of PPEs in the work place are given in **Table 7.13**

Table 7.13: Recommended Personal Protective Equipment's

Objective	Workplace Hazards	Suggested PPEs
Eye and face protection	Flying particles, molten metal, liquid chemicals, gases or vapors, light radiation.	Safety glasses with side-shields, Chemical splash glasses protective shades, Fiber glass resistant to most chemicals etc.
Head protection	Falling objects, inadequate height clearance, and overhead power cords.	Plastic helmets with top and side impact protection.
Hearing protection	Noise, ultra-sound.	Hearing protectors (ear plugs or ear muffs)
Foot protection	Falling or rolling objects, points objects. Corrosive or hot liquids.	Safety shoes and boots for protection against moving and falling objects, liquids and chemicals.
Hand protection	Hazardous materials, cuts, vibrations, extreme temperatures.	Gloves made of rubber, PVC coated gloves or synthetic material (Neoprene), leather, steel, insulation materials, etc.
Respiratory protection	Dust, fogs, fumes, mists, gases, smokes, vapors	Facemasks with appropriate filters for dust removal and air purification (chemical, mists, vapors and gases). Canisters for toxic gas single or multi-gas personal monitors, if available.
	Oxygen deficiency	Portable or supplied air (fixed lines). On-site rescue equipment.

Body / leg protection	Extreme temperatures, hazardous materials.	Fire Entry Suit; Insulating clothing, body suits, aprons etc. of appropriate materials Stud safety shoes, PVC knee boots

7.5.2 Specific Recommendations

Specific attention to be made during storage, transport and handling mode specially for combustible, flammable/ explosive and toxic material.

The major hazard situations in the unit are: The pool fire occurs due to:

- Possible rupture/ leak of storage tanks / drums
- Dispersion of liquid to confined or unconfined area
- Ignition of releasing liquid/ vapour

To prevent accident due to fire and explosion, it is necessary to know:

- Fire and explosion properties of the material
- Nature of fire and explosion process and
- Procedure to reduce fire and explosion

To avoid or reduce Vapor Cloud Explosion (VCE) to minimise dispersion of flammable vapor by operating water/ foam tenders and to avoid further dispersion by maintaining water/ foam curtain.

- Sudden release of large quantity of flammable vapour, typically this phenomenon occurs when a storage tank containing suspended and pressurized liquid ruptures
- Dispersion of vapour in nearby areas while mixing with air
- Ignition of the released vapour cloud

Vapor clouds are normally ignited at the edge as they drift and stop further spreading of the cloud in that direction causes Unconfined Vapour Cloud Explosion (UVCE).

Boiling Liquid Expanding Vapour Explosion (BLEVE) is caused by sudden failure of the container due to any cause. The primary cause is usually an external flame impinging on the shell of a vessel above the liquid level weakening' the container and leading to a sudden shell rupture. A pressure relief valve does not protect against this mode of failure. BLEVE can occur due to any mechanism that results in the sudden failure of the container allowing a superheated liquid to flash typically increasing its volume over 200 times. This is sufficient to generate a pressure wave and fragments. If the released liquid is flammable a fireball may

result. However, vapour cloud explosion unlikely occur in M/s Nichino Chemical India Pvt. Limited being released vapour cloud in most of the cases below the LEL as per analysis.

The major incompatibilities is a guide to the storage and handling of chemicals and which combinations to eliminate accidents, if any. Each chemical has specific character and hence all the chemicals will not be stored in one storage shed, being not supposed to get mixed, stored together, during storage and handling. It is the nature of chemicals that they do not co-exist. The major incompatibilities for storage and handling of hazard chemicals are given **Table 7.14**.

Table 7.14: Major incompatibilities for storage & handling of hazardous chemicals

Chemical	Incompatible with
Acetic acid	Solvents, oxidizing agents, water, other chemicals
Aceto nitrile	Strong oxidisers
Acetone	H_2SO_4, HNO_3, Oxidizing agents, H_2O_2 and Chloroform
Aceto nitrile	Strong oxidisers
Carbon disulfide	Not available
Chloro acetic acid	Incompatibility with various substances
Cloro acetyl chloride	Reacts with oxidizing agents and alkalies
Dimethyl formamide	Highly flammable liquid, and polymerisable, may violently with broad range of chemicals, alkaline metals, acid hydride, bromine, chlorine and carbon tetra chloride.
Ethylene dichloride	Strong oxidizers, caustic, chemically reactive metals Al, Na, K and liquid ammonia.
Ethyl acetate	Nitrates; strong oxidizers, alkalis & acids
Formic acid	Sulfuric acid, strong caustics, furfuryl alcohol, hydrogen peroxide, strong oxidizers and bases. Reacts explosively with oxidizing agents.
Hydrogen gas	May react violently with oxidants
Hydrogen hydrate	Extremely reactive or incompatible with oxidizing agents, metals, acids. Reactive with moisture.
Hydrogen peroxide (30%)	Heat, reducing agents, organic materials, dirt, alkalies, rust and many metals. Spontaneous combustion may occur on standing in contact with flammable materials.
Methanol	Other chemicals
Methylene Dichloride	Strong oxidizers, caustic, chemically active metals Al, Na, K and conc. Nitric acid
MIBK	Strong oxidizers
Mixed xylene	Strong oxidizers, Mineral acids, Alkali metals and Halogens
Sulphuric acid	Organic materials, chlorates, carbides, water powdered metals
n-Butanol	Strong oxidizers, Mineral acids, Alkali metals and Halogens
o- Xylene	Strong oxidizing agents and strong acids
Phosphorus oxy chloride	Water combustible materials, carbon disulfide, Dimethyl formamide, metals
Pyridine	Heat, flame, Maleic anhydride, perchromates, strong oxidizers. Will attack some forms of plastics, rubber and coatings.
Sulphuric acid	Organic materials, chlorates, carbides, water powdered metals
Tetra hydro furan	Strong oxidizers, lithium and aluminium alloys.
Thionyl chloride	Alkalis, oxidizing agents, other chemicals.
Toluene	Strong acids, combustible and flammable substances, oxidizing agents

Specific precautionary measures are to be taken by M/s Nichino chemicals India Pvt. Limited on case by case for following accidental release of hazard chemicals.

7.5.2.1 Combustible materials

Industry proposing to store acetic acid in 10 KL capacity tank and Dimethyl formamide in 200 kg drums of 50 no. MCA analysis of indicate that effect of heat radiation is close to edge of pool. In case of acetic acid, for small fire-water and for large fire dry chemical, alcohol foam, water spray and keep source of ignition neutralize with dilute sodium carbonate.

7.5.2.2 Flammable – Pool Fire/ vapour cloud Explosions / BLEVE

There is a flammable liquid Methanol, Mixed Xylene, Ethylene dichloride and Toluene storing in horizontal tank, whereas Acetone, Ethyl Acetate, MIBK, n-Butanol, pyridine, o-Xylene and other flammable one in drums. In case of leak or catastrophic rupture of storage tank and other solvent in drums, total material taken as a source strength and forms a pool in respective dyke and unconfined pool in case of drums. If ignition takes causes pool fire.

In the case of leak, pit tank is to be provided in tank area to collect, leaked solvent as precautionary measure to collect and disposed accordingly and simultaneously leakage control with safe precautionary measures. If pool fire occurs start using the fire hydrant points, water sprinklers, water monitor and foam gun kept near the tank farm area. In case of unconfined pool of flammable liquid in ware house, spill containment procedure to be followed and if ignited firefighting measures and take follow up action.

- Evacuate all the personnel in the tank farm area.
- Stop all activities/loading unloading in the tank farm area
- Cordon off the area and do not allow any person inside tank farm.
- Follow emergency procedure for fire protection measures in solvent storage tank form area.

If ignition takes after vapour cloud formation or BLEVE takes due to exposure of storage tank by external heat or any other means. Result causes over pressure and heat radiation effect on-site area and crosses plant boundary (off-site), area closed by plant boundary. The risk mitigation measures is as follows

- All solvent tanks having condenser cooling with Flame arrestor provided.
- Appropriate fire-fighting system is to be applied in case of accidental release of other flammable liquids.
- Lightening arrestors provided to near tank

- Breather valves facility with Nitrogen blanketing provided to all
- MCP provided inside the solvent tank farm area

In the above case use alcohol form, water spray or fog, cool containing water jet to prevent pressure buildup or auto ignition or explosion In case of small fire due to leak of flammable liquid / vapor appropriate firefighting system may be deployed accordingly on basis of Risk level.

Hydrogen cylinders (7 m^3): There is a facility to store 84 cylinders at dedicated area, which is going to be used within the plant in production unit.
Procedure for controlling leakage and fire of Hydrogen gases

- Immediately stop all the hot work activities in the surrounding areas
- If possible close the cylinder without endangering the life
- If fire has taken place cool the hydrogen generating unit with water
- Evacuate the materials in the surrounding area of the affected location.
- Use DCP / CO_2 to extinguish the fire.

7.5.2.3 Toxic Release

Industry is proposed to handle toxic chemical (gases/ liquids) which are stored / proposed, Carbon disulfide in 10 KL underground tanks, Acetic anhydride, Acetonitrile, Chloro acetyl chloride, Phosphorus oxy chloride, Thionyl chloride and Pyridine in drums in ware houses, whereas toxic sulfuric acid drums at specific area.

Hydrogen peroxide: Industry has a provision to store 200 kg of HDPE drums 3 no, however material storing 30% conc.one.

- It is considered as in compatible with oxidisable material – Iron, Copper, Brass, Chromium, Zinc, Pb, Silver and Manganese. It is not to near combustible material and store in closed container with adequate ventilation, it is less corrosive and toxic when compare with 50% one, being 30% concentration one using.
- Spill control – Carefully throw poly propylene booms/ pillows around as the spill to prevent the spread of spill. Absorb the spill with polypropylene pads and squeeze the pads in to disposable containers. Wash the contaminated area with about 5% sodium thio sulphate solution. Flush the contaminated area with water and drain to ETP.

Methyl Dichloride: There are 25kg drums of 40 in no. in ware house. Due to leak for continuous release of methyl dichloride gas travels towards downwind direction, causes health effect onsite only up to 204 m being people exposed to 50 ppm level (PEL). Do not approach area without self-contained breathing apparatus and protective clothing. Reduce vapors with fog or fine water spray.

Thionyl chloride: Industry has a facility to store Thionyl chloride maximum of 300 kg of 18 drums, being it is in liquid form once accidental leak or complete discharge of chemical, it spill over in unconfined area and evaporates and move towards wind ward direction causes severe health effect, being IDLH value is 14 ppm and once exposed get medical aid immediately. It reacts with water may release flammable and toxic gases and vapors may be heavier and moves along the ground level towards down wind. Ask the people to vacate the area and to move for fresh air towards crosswind side. For spill/ fire dry chemical may be used, If water is only media flooding of water necessary as in any fire and wear breathing apparatus during operation.

Phosphorus oxy chloride: There is a provision for storage of 250 kgx18 drums. If leak/ spill, collect leaking and spilled liquid in sealable dry containers as far as possible. Absorb remaining liquid in dry sand or inert absorbent and remove to safe place. Personal protection: chemical protection suit including self-contained breathing apparatus Keep in a well-ventilated room.

In case of fire in the surroundings: use appropriate extinguishing methods. Never pour water into this substance; when dissolving or diluting always add it slowly to the water

Ethylene Dichloride: It has a provision to store in two SS tank of 10 KL capacity. It is Toxic by ingestion. Exposure in an enclosed area may be very harmful. Ethylene Dichloride is storing in 10 KL tank. It is Potentially In compatible Absorbents and strong oxidiser, chemically active metals such as Na, K, Al, Mg, being it is halogenated organic compound. During handling

SPILL / LEAK -Take up with sand, earth or other non-combustible absorbent material, whereas for Large Spill - Prevent entry into waterways, sewers, basements or confined areas. Use personal protection equipment, ensure adequate ventilation and all source of ignition.

SMALL FIRE: Dry chemical, CO_2 or water spray. In case of LARGE FIRE: Dry chemical, CO_2, alcohol-resistant foam or water spray. Move containers from fire area if you can do it without risk. Dike fire-control water for later disposal; do not scatter the material.
Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Flooding of water is to be applied to containers until well after fire is out.

Carbon disulfide: At present plant has one underground CS_2 tank with a capacity of 10 kl and CS_2 tank is always stored in water sump. Water sump capacity is 20 KL and the CS_2 pipelines are water jacketed and also existing standard (SOP) for all important operations. During operation if any small fire use dry chemical and for large fire Alcohol/ water spray to be applied. It is in compatibility with strong oxidants and chemically active – active metals,

chlorine, NOx, azides and organic amine.

For accidental release/fire - dry chemical, foam or CO_2, being flammable liquid/ vapor. Any leak or spill over, through poly propylene booms/pillows around and on the spill to prevent the source of spill, absorb the spill by polypropylene pads, squeez the pad in disposable container. Pour the dry sand on spillover material and collect the material in disposable container and finally incinerated.

Pyridine: The plant has a provision to store in one HDPE drum with a capacity of 200 kg during operation if any spill over occurs

Carefully throw polypropylene booms / pillows around and on the spill to prevent the spread of the spill. Absorb the spill with polypropylene pads and squeeze the pads into disposable container. Pour dry sand on the spill and collect into disposable container. Send the disposal container containing solvent & Booms & Pads to Incinerator and disposal container containing contaminated sand to ETP Sludge drying beds for proper disposal Ventilate area of leak or spill. Remove all sources of ignition. Wear appropriate personal protective equipment.

If exposed, immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

Other chemicals: Most of the hazard chemicals are storing in ware houses in specified drums in liquid and solid form, these chemicals flammable, toxic as well as corrosive in nature, and storing in ware house.

Apart from above **commercial pesticide** products are also considered as hazardous especially during handling and during usage mainly such as – Acephate , BITU, Carbomate, Ethion and Nicosulfuran etc.,.

ACEPHATE:

It is a Organo phosphorus Insecticide, White crystalline material with rotten cabbage odor. Cholinesterase inhibitor, harmful if swallowed. It cause moderate eye irritation during handling and avoid breathing dust or spray mist, contact eyes, skin or clothing.

Fire-fighting measures- Material will not burn or explode under normal conditions. Dusts sufficient concentrations could form explosive mixtures with air

Accidental release measures:- In case of spill or leak, control the spill at its space , contain the spill to prevent it from spreading contaminating soil and any water body.

Ethion Technical:

Water- white to amber-colored liquid with a mercaptan or sulfur-like odor.

- Slightly combustible. May support combustion at elevated temperatures.
- Ethion may decompose rapidly and violently at temperatures above 150°C (302°F).
- Thermal decomposition and burning may form toxic by-products.
- For large exposures or fire, wear personal protective equipment.
- Highly toxic to fish and aquatic organisms. Keep out of drains and water courses.
- Highly toxic if swallowed and its PEL value 4 mg/m3 .Moderately toxic if inhaled or absorbed through the skin.

Environmental Precautions: Prevent contamination of soil, drains and surface water.

Method of cleaning: Absorb the material in the sand, soil or suitable absorbent. Place in suitable material and remove to safe place or dispose of in an incinerator approved for chemicals

FIRE-FIGHTING MEASURE:

Suitable Extinguishing Media: Dry chemical, CO_2, Water spray, standard foam.

For larger fire, use water spray, fog or standard foam.

Exposure Hazards : During a fire, irritating and possibly toxic gases like carbon dioxide; carbon monoxide; nitrogen oxides; sulfur dioxide; hydrogen chloride; may be generated by thermal decomposition or combustion.

BITU: N-T-Butyl-N'-Isopropylthiourea $C_8H_{18}N_2S$
Health hazard: Irritation to eyes and skin.
Environmental Harm: Harmful to environment.
IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing
Disposal: Dispose of containers / containers in accordance with local / regional / national / international regulations

Skin contact Immediately remove contaminated clothing and shoes.

Rinse with soap and plenty of water.

Eye contact Rinse thoroughly with plenty of water for at least 15 minutes.

Ingestion Gargle with water. Vomiting and immediate medical treatment.

Inhaled Remove the patient to fresh air

Environmental protection To ensure the safety of the premise, to take measures to measures: prevent further leakage or overflow.

Methods for containment Collect as hazardous waste. Store in a closed container.and cleaning up.

Carbomate

Hazardous Ingredients (4,6-Dimethoxy-2- phenoxycarbonyl) aminopyrimidine

Eye Contact: Check for and remove any contact lenses. Immediately flush eyes with clean, running water for at least 15 minutes while keeping eyes open. Cool water may be used. Seek medical attention.

Skin Contact: After contact with skin, wash with generous quantities of running water. Gently and thoroughly wash affected area with running water and nonabrasive soap. Cool water may be used. Cover the affected area with emollient. Seek medical attention. Wash any contaminated clothing prior to reusing.

Inhalation: Remove the victim from the source of exposure to fresh, uncontaminated air. If victim's breathing is difficult, administer oxygen. Seek medical attention.

Ingestion: Do NOT induce vomiting. Give water to victim to drink. Seek medical attention.

Extinguishing media: Carbon dioxide, dry chemical powder, alcohol or polymer foam.

Special firefighting procedures: Wear self-contained breathing apparatus and protective clothing to prevent contact with skin and eyes.

Unusual fire and explosion hazards/decomposition of product: Emits toxic fumes under fire conditions

Accidental Release Measures

Steps to be taken if material is spilled or otherwise released into the environment - Wear Appropriate respirator, impervious boots and heavy rubber (or otherwise impervious) gloves. Scoop up solid material or absorb liquid material and place into appropriate container. Ventilate area and wash affected spill area after pickup is complete. Wash skin immediately with plenty of water. Place solid or absorbed material into containers and close for disposal.

Nicosulfuron Identified uses : Laboratory chemicals, Manufacture of substances.
If inhaled: If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.
In case of skin contact Wash off with soap and plenty of water. Consult a physician.
In case of eye contact Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician Very toxic to aquatic life with long lasting effects. Very toxic to aquatic life with long lasting effects.

Suitable extinguishing media

Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Special hazards arising from the substance or mixture Carbon oxides, Nitrogen oxides (NOx), Sulphur oxides

Advice for firefighters Wear self-contained breathing apparatus for firefighting if necessary

Personal precautions, protective equipment and emergency procedures- Use personal protective equipment. Avoid dust formation. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Avoid breathing dust.

Environmental precautions

Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

Methods and materials for containment and cleaning up

Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal. Similarly other pesticide including intermediate **specific MSDS** guidelines to be followed

SPILLAGE if any hazardous chemicals

Small spillage: Any hazardous chemical spill that does not involve highly toxic, highly reactive, or explosive chemicals in a situation that is not life threatening. This type of spill in a manageable physical or health hazard to personnel who, when wearing proper Personal Protective Equipment (PPE), will not be exposed to any chemical at a level that exceeds any level or permissible exposure

Smaller Spillage Response & Cleanup Procedure:

If the spillage is of smaller quantity, cleanup the spilled material with suitable absorbent as per MSDS and collecting suitable portable container and send it to Effluent Treatment Plant (ETP) where it be treated / incinerated

Large spillages: Any hazardous chemical spill involves highly toxic, highly reactive, explosive or life threatening chemicals. **(OR)**

Any spill situation that presents significant fire, explosion, or other physical or health hazard risks, particularly if a person may be or has been significantly exposed, contaminated or injured to such an extent that medical or other assistance is required. Situation that may adverse impact the external environment whether or not the spill occurred internal or external to a building.

Large Spillage Response & Cleanup Procedure:

- The area should be immediately evacuated particularly downwind area and Restrict access to the area until completion of recovery and cleanup.
- Eliminate all ignition sources and provide adequate ventilation depending upon the chemical.
- Stop or reduce leak if safe to do so.
- Contain the material with earth sand or absorbent material which does not Reactive with spilled material.
- Recovery and cleanup should be done the trained personnel only. The person cleaning the material should wear required Personal Protective Equipment (PPE) such as respiratory cartridge mask, safety goggles, gumboots, PVC Suit and rubber hand gloves etc…
- Do not touch the spilled material and avoid prolonged and repeat exposure to Toxic
- Prevent spilled material entering waterways, sewers or drainages.
- Ground the containers if the spilled materials generate the static electricity.
- Vacuum / sweep up the spilled material in an approved, portable and suitable container as mentioned the MSDS.
- Place the containers with covers, labels and in suitable locations.
- After recovering the material, cleanup the area with suitable absorbent Material as mentioned in the MSDS.
- Flush the area with water if it is required.

Disposal of Larger Spillages Materials:

- After recovering the material, sent it to Effluent Treatment Plant (ETP).
- Depending on the nature (physical & chemical properties) of material either the material is to be neutralized or incinerated or it shall send for treatment and land filling

However in all the case of above and other chemicals are used by M/s Nichino chemicals India follow MSDS/ NIOSH data sheet guide lines for First aid, accidental release measures, firefighting if any such as pill over of pesticide product.

7.6 Hazard Control Measures

1. Procedures and actions will be well defined and known to all operating personnel's for safe shut down of plant in case of failure of any power, instrumentation, cooling water, air, etc.

2. All the storage tanks will be provided with temperature indicator, pressure gauge and safety valves as depending upon the process and operating parameters.
3. Plant specific HAZOP studies will be carried out using P&IDs for identification of hazards during operation considering deviation of operational parameters, their possible cause of material loss and consequence and safe guards.
4. Interlocks and DCS control will be provided during reaction process.
5. All the motors and other rotating equipment machines will be provided with suitable safety guards.
6. Existing Fire extinguishers fixed / movable will be upgraded in the plant area.
7. Movable fire tenders may be arranged, being it need of hour during emergency.
8. Flame arrestors will be provided at all vent lines for proposed solvent tanks.
9. Suitable first aid fire extinguishers, such as, DCP, CO_2 & foam type will be kept in every plant area at easily approachable spots. Fire hydrant points with sufficient length of hose reel will be provided at major emergency spots.
10. Bound walls, bonded wire fencing, detached storage area will be kept away from probable ignition sources; Dykes will be provided by giving sufficient space provision between all liquid storage tanks.
11. Safety shower and eye washer will be installed at storages/ handling of hazard, process/ operation units.
12. Sufficient space will be provided for free movement in the plant area. Avoid transfer of hazard material from storage to process units by manually, if any.
13. Safe distances have been considered between storages and process operation units and utilities in designing of plant layout.
14. Regarding all components of the plant proper certificate will be taken. Testing and inspection will not be compromised before deliveries.
15. Certificate of structure stability will be taken from competent person.
16. Insulation of piping will be provided as per requirement.
17. All elevated structures will be provided with lightening arrestors.
18. All exposed parts of moving machineries will be provided with suitable guards for personnel safety.
19. All piping and equipment will be provided with earthing connection and it will be tested regularly.
20. Safety valves & rupture disc will be provided to prevent over Pressure I n tanks/ vessels and reactors.
21. SOP will be available of safe shut-down of plant during any emergency.

7.7 Mitigation Measures for Natural Disasters

(A) Flood

Mitigative measures can be structural or non-structural. Structural measures use technological solutions, like flood levels that is only possible during local seasonal heavy rains. There is no possibility of water logging being area is slightly sloppy (undulated elevated terrain). As such there is the least possibility of flooding since the area is located in Deccan plateau and moreover, the average rainfall is 60/70 cm. However, the following procedure is followed in case of flooding.

- Focus resources on minimizing the spread of water into other areas of the plant
- Stop all operations immediately. Close all valves of solvent storage tank.
- Switch off power supply to avoid electrocution due to short circuit.
- Protect property and records by removing items from floors and/or covering with water resistant coverings.
- Evaluated information will be disseminated to personnel.
- Shift the water reactive material to elevated places like racks / building. Attempt to move items of value to “higher ground” if possible
- Activate the on-site warning and instructional system as necessary.
- Follow unit shutdown procedures and shutdown Electrical power.
- Control water flow by dike arrangement using sandbags, and or pumping.
- Start up after checking and clearing water from each and every unit.

(B) Cyclones and Severe Storms

Location of M/s Nichino Chemical India Pvt. Limited is at undulated plain area when compared with and is not in flood prone area; location of site is around 496 MSL. However, during storm and if any flood water enters from outside plant area, land use management will provide protection from wind and storm surge.

- Engineering of structures would withstand wind forces and building will be constructed with wind-resistant capacity.
- Securing elements such as metal sheeting, roofing, and fences will be done to avoid severe damages.

Cyclone and severe weather warning systems will be installed and awareness regarding cyclone risk and evacuation plan will be addressed.

(C) Earthquake

The factory premises is situated close to village Gadwanti, KIADB, Bidar district (Near to Hyderabad) which falls under Zone II under Seismic zone**,** classification and

accordingly the probability and impact will be least to moderate. However, steps will be taken for Personal structural mitigation in earthquake prone areas includes seismic retrofits of property.

Precautionary measure such as

- Securing of items inside a building to enhance household seismic safety.
- Stay away from glass, windows, outside doors and walls, and anything that could fall Lighting fixtures or furniture

Emergency action plan

a. When first tremors are sensed during an earthquake, all personnel will evacuate buildings and assemble at safe place away from structures, walls and falling objects. Emergency shutdown will be declared.
b. Emergency services will be contacted for assistance.
c. After the status is restored, personnel will inspect all the facilities for rescue, first aid and damage control activities, damage assessment, cleanup, restoration and recovery.

(D) Emergency Action Plan for Bomb Threat

When bomb threat call is received, the following measures are to be taken.

- ❖ Inform the message to the highest local police authority and seek their assistance for patrolling and security need.
- ❖ Inform Controller of Explosives the details and nature of the anonymous message and read operations.
- ❖ Request the Local Fire Brigade to position at least one fire tender at the Location immediately.
- ❖ Keep the Concerned Dept. at the Regional Level informed with the developments at regular intervals.
- ❖ Alert the Local Govt/Pvt. Hospitals and seek their help for providing Ambulances, if necessary

7.8 Disaster Management Plan

7.8.1 Introduction

A major emergency is one, which has the potential to cause serious injury or loss of life. It may cause extensive damage to property and serious disruption, both inside and outside a plant. Sometimes, it requires the assistance of outside emergency services to handle it effectively. Emergency may be caused by a number of factors, e.g. plant failure, human error, natural calamities, crash or sabotage, if any other means. Several Government

agencies, both at the Central and State levels, are entrusted with the responsibility of ensuring safety and management of hazardous chemicals under Acts and Rules made for the purpose. Despite these measures, the possibility of accidents cannot be ruled out. In order to be ready to face risk of accidents during processing, a disaster management plan will be prepared to mitigate the impact.

The purpose of this DMP is to give an approach to detail organizational responsibilities, actions, reporting requirements and support resources available to ensure effective and timely management of emergencies associated to production operations in the site. The overall objectives of DMP are to:

- Minimize the occurrence of Leak/ Catastrophic events leading to human, property and material damage/losses by a suitable policy initiative.
- Prevent injury, loss of life or damages by a timely and appropriate response of emergency preparedness plan for on-site and off-site area of M/s Nichino Chemicals India Pvt. Limited, obtain early warning of emergency conditions so as to prevent impact on personnel, assets and environment
- Activate and ensure involvement of all personnel and agencies in emergency response planning and community preparedness.
- Immediate response to emergency scene with effective communication network and organized procedures.
- Involve citizens and other emergency response team members in design, testing and implementation of the DMP

The results of MCA analysis of the Risk Assessment (RA) study is to be used in the preparation of this DMP. To safeguard personnel to prevent injuries or loss of life by protecting personnel from the hazard and evacuating personnel from an installation when necessary, provide guidance to help stakeholders take appropriate action to prevent accidents involving hazardous substances and to mitigate adverse effects of accidents that do nevertheless occur and to minimize the impact of the event on the installation and the environment by:

- Minimizing the hazard as far as possible
- Minimizing the potential for escalation
- Containing any release

This is achieved by describing procedures to deal with emergencies affecting personnel, equipment, third party contractors, local communities or the environment.

Key Elements of DMP

Following are the key elements of Disaster Management Plan:

- Basis of the plan
- Accident/ emergency response planning procedures
- On-site Emergency Preparedness Plan
- Off-site Emergency Preparedness Plan

Basis of the Plan

Identification and assessment of hazards is crucial for on-site emergency planning and it is therefore necessary to identify what emergencies could arise in production of various products and their storages including hazard transfer pipeline. Hazard analysis or consequence analysis gives fire, explosive and toxic scenarios due to accidental release of flammable/ toxic chemicals from storage (tanks / drums) and any other means.

Accident/ Emergency Response Planning Procedures: There are four emergency levels of incident management and response to industrial accidents that the public be aware of.

Level I*:* An incident has occurred and can be controlled by facility personnel. The situation is under control.

Level II*:* An incident has occurred; the situation is not under control but is confined. The incident is confined to a small area or to a fixed-site and does not pose a threat of spreading to a larger area or off-site.

Level III*:* An incident has occurred the situation is not under control and protective action may be necessary for the surrounding or off-site area.
Level IV: An incident has occurred and the situation is not under control. Actions by more than first responders or facility personnel are necessary. Incident involving a severe hazard or an area which poses an extreme threat to life and property and will probably require an evacuation.

Emergency rarely occurs therefore activities during emergencies require coordination of higher order than for planned activities and will be carried out according to fixed time schedule or on a routine day-to-day basis. To effectively coordinate emergency response activities, an organizational approach to planning is required. The important areas of emergency planning are Organization and Responsibilities, Procedures, Communication, Transport, Resource requirements and Control centre.

Off-site emergency requires additional planning over and above those considered under on-site plans, which will be properly integrated to ensure better coordination. An emergency core group (ECG) is constituted to pool and analyze the necessary information for effective decision making.

Emergency core group (ECG) consists of different task of specific coordinators i.e. Plant General Manager, Plant Manager of Process and Maintenance, Engineering group, Safety officer and Fire officer, who in turn mobilise and formulate requisite number of action teams who will provide necessary emergency response.

An emergency action groups (EAG) will be constituted as a part of first response team. Thus the first response team for the plan includes all the members of both ECG and EAG. The constituents have been assigned specific responsibilities for the plan. The responsibility of managing on-site crisis lies solely with the concerned organization, whereas the organization structure for off-site emergency includes both Local/ State government agencies. The functions of the ECG are:

- Formulation and implementation of emergency plan.
- Provide guidance / making basic policy decisions.
- Convening the emergency core group meeting after receipt of emergency call.
- Review of operational preparedness of emergency machinery
- Hold periodic mock/ training to ensure optimum preparedness at operational levels
- Develop and update various hazard scenarios, and cascading effect based on the on-site plan
- Mobilize the financial resources for expenditure in case of emergency
- Depute nodal officer with the district or state authority for off-site crisis
- Transfer the information collected from the advisory group to EAG
- Liaises with external and mutual aid agencies and identify cases where material aid is needed
- Provide information on the incident to district, state / level authorities and if needed call for assistance from competent bodies
- Liaises with press / media, to report the emergency
- Declare rehabilitation centers in case of evacuation of people.
- Takes care of emergency situation like continual health care, re-establishment and creation of social compatibility
- Declare all clear, once everything is normal

Emergency action group (EAG) is the front line team which responds based on the instructions given by ECG. It coordinates among itself for various activities. The functions of EAG are:

- Rushes to the emergency area
- Make systematic assessment of hazard
- Liaises with emergency control centre
- Warns the personnel of an impending danger

- Cordon off the people and control the traffic
- Render first aid medical service
- Seek rehabilitation centers

7.8.1 On-site Emergency Preparedness Plan

An on-site emergency is caused by an accident that takes place in the plant itself and the effects are confined to the factory premises involving only the people working in the factory. On-site emergency plan to deal with such event and it is responsibility of the occupier and also mandatory.

The preparation of an on-site emergency plan and furnishing relevant information to the District Emergency Authority for the preparation of the off-site emergency plan are statutory responsibilities of the occupier of every industry and other units handling hazardous substances. An on-site emergency plan will contain the following key elements:

- Basis of the plan
- Hazard analysis
- Accident prevention procedure/ measures
- Accident/ emergency response procedure /measures and
- Recovery procedure.

7.8.1.1 Purpose

- To protect persons and property of process/ operation equipments in case of all kinds of accidents/ emergencies
- To inform people and surroundings about emergency, if it is likely to adversely affect them
- To inform authorities including helping agencies (doctors, hospitals, fire, police transport etc.) in advance, and also at the time of actual happening
- To identify, assess, foresee and work out various kinds of possible hazards their places, potential and damaging capacity and area
- In case of M/s. Nichino chemical India Pvt. Limited, MCA analysis indicates that the following places required Emergency preparedness plan.

Storage tank of flammable liquid in tank form area and specified tank - pool fire/ vapour cloud explosion / fire ball.

Pool fire (confined) radiation effect (4.5 KW/m^2) in case of flammable liquids i.e. Methanol, Ethylene chloride and toluene vary from 7 to 18 m from edge of pool. Radiation effect of fatality is within pool except m-xylene case 2 to 3 m from edge of pool. In case of delayed

ignition/ spark of vapour cloud due to leak / release of flammable liquid causes damage inside and outside plant, however, it is unlikely occurs, being material holding in confined pool and possibility of average LEL value within limits. Catastrophic rupture under BLEVE also unlikely occurs, only it is due to exposure of storage tanks by external heat or sabotage.

Location of drums (HDPE, MS/SS) and container storages are in ware house - fire/ explosion/ toxic release:

There are hazard flammable/ toxic and corrosive liquids are storing in drums i.e. Acetic anhydride, Acetonitrile, Acetone, n-Butanol, Hexane, Methylene chloride, MIBK, Thionyl chloride, Phosphorus oxychloride, Sulfuric acid and others. In case of leak or rupture it will spread of liquid over un confined area and forms vapour cloud and under spark/ ignition people exposed to heat radiation effect, whereas in the case of dispersion of toxic gas/ vapour even it may cross over plant boundary, need off- site emergency preparedness plan.

Most of the flammable liquid are storing in drums of different capacity, emergency level depends on extent of material release and vapour cloud formation. Delayed ignition or spark explosion causes thermal radian and over pressure effect mainly within boundary and outside plant some extent depends on site event. In case of spillage of toxic chemicals material released to atmosphere as gas/ vapor form dispersed towards downwind direction covers off-site area, if delayed in control at source mainly in case of Chloro Acetyl chloride, Acetic anhydride, Acetonitrile, Thionyl chloride, Pyridine including Sulfuric acid and phosphorous oxychloride, being considered as toxic acid fumes

Location of gas cylinder storage – In the proposed unit highly flammable gas cylinders Hydrogen (7 m^3) at dedicated areas - which depends on type of leak and duration, radiation and over pressure effect mainly on site disaster. However various precautionary measures are suggested to avoid the possible leak and to minimise duration of leak by control at source.

Location of material transfer points (process/ operation unit) – fire/ explosion/ toxic release – however depends on material and extent of material leaked/ releases.

In order to handle disaster / emergency situations, an organizational chart entrusting responsibility to various personnel of industrial unit will be available as shown in **Fig. 7.3.**

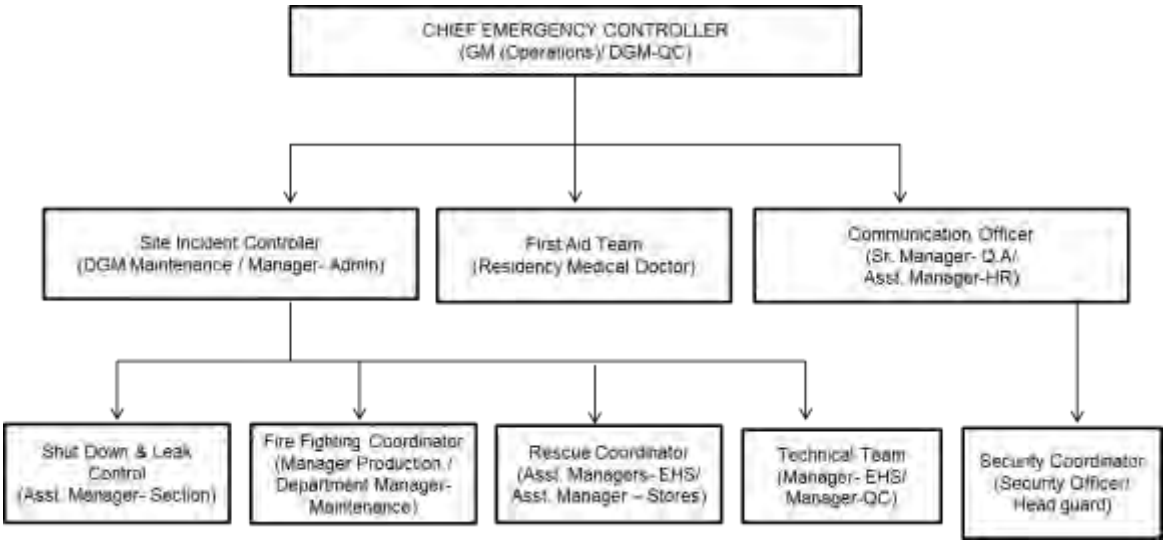


Fig. 7.3: Factory Management Organization chart

7.8.1.2 Accident Prevention Procedures / Measures

A separate plan is provided to deal with the situations, which necessitate emergency action. The emergency response plan includes details of the organizational response to emergencies and the safety precautions to be observed in preventing loss of life and damage to property. Risk mitigation measures based on consequence analysis are recommended above based on the consequences analysis:

Fire Prevention Planning and Measures

Fire is one of the major hazard apart from toxic gas in this unit, Fire prevention and code enforcement is the area of responsibility of the fire service. Safe operating practices reduce the probability of an accidental fire in a plant. Personnel will understand their duties and responsibilities and be attentive to conditions that might lead to fire. The following precautions are recommended:

- There will be provision for safe handling and storage of dirty rags, trash and waste oil flammable liquids and chemicals spilled on platform will be immediately cleaned.
- Containers of paints and hydrocarbon samples, gas cylinders for welding and cutting will be stored properly.
- Cutting and welding operations will be conducted in accordance with safe procedures. Smoking will be restricted to designated platform areas and “no smoking” areas will be clearly identified by warning signs.
- Particular attention will be given to oil pumps, seals; diesel and gas engines which could be potential source of ignition in the event of a failure.

Basic Actions

Basic actions required to handle any emergency are as follows:

- Operation of emergency shut-down systems
- Maintenance of communication ECG/ EAG groups as long as possible
- Persons to be nominated to prepare for evacuation
- Liaison with fire-fighting agencies local government/ private agencies required.
- Effective internal communication by public address system and walkie-talkie sets

Communication Link

A multi-user wireless paging system with selective call facility is useful for promptly locating key operating personnel in the plant, both during normal conditions and during emergencies. A public address (PA) system with loud speaker installed at vital installations can be extremely useful during emergencies. Adequacy and efficiency of fire-fighting and fire detection equipments, personal, detective measures and medical aids will be ensured through proper communication link.

There are various facilities available in the site for communication

i. Intercom facility
ii. Public addressing system
iii. Walki Talkies, Mega phone,
iv. Mobile phone facility at security

7.8.1.3 Before Emergency

Prepare a plan for installations of storage and process/ operation equipments clearly indicating probable areas of various hazards like fire, explosion, toxic releases etc. Locations of assembly points, fire station, telephone room, first aid or ambulance room, emergency control room, main gate, emergency gates, will be noted in plot plan.

The fire protection equipment will always be kept in good operating condition and fire-fighting system will be periodically tested. The training regarding fire-fighting techniques will be provided to all officers/ employees.

There will be a regular mock fire drill periodically; record of such drills will be maintained. Every employee or authorized person working in the plant will be familiarized with the fire alarm signal and will know the location of closed by fire alarm point; Assign key personnel and alternate responsible for site safety. In case of toxic liquid/ gas suitable adsorbent and inert material (sand, earth) and water to arrange at site of storage and process/ operation units including absorbents.

7.8.1.4 During Emergency

In the event of fire from accidental release of flammable gas or liquid, a person seeing the incident will follow the laid down procedure in the plant and report as follows:

- Will dial the nearest telephone
- Will state his name and exact location of emergency
- Will contact affected officers on duty and will remain at the location of site to guide crew
- Perform no other duties that may interfere with their primary responsibilities

Notify the attendant if they experience any warning signs or symptoms of exposures or dangerous condition and exit the permit space when instructed by attendant.

In case of fire emergency, person will activate the nearest available push button type instrument which will automatically sound an alarm in fire control room indicating the location of fire.

In case of toxic liquid drum leak/ rupture, immediately isolate and control not to spread and border the liquid with inert material (earth, sand if any non-reactive). Control leak if possible. However, it depends on material to material as per MSDS sheet.

Adsorbed material will depose environmental friendly not to contaminate water and soil. And toxic flooded with water also controlled and neutralized, if necessary.

7.8.1.5 After Emergency

Report injuries or blood/ body fluid exposures to the appropriate supervisor, immediately wash wounds and skin sites by soap and water.

Provide information to the relevant public authority and community including other closely located facilities regarding the nature of hazard and emergency procedure in event of major accident. Record and discuss the lessons learned and the analysis of major accident.

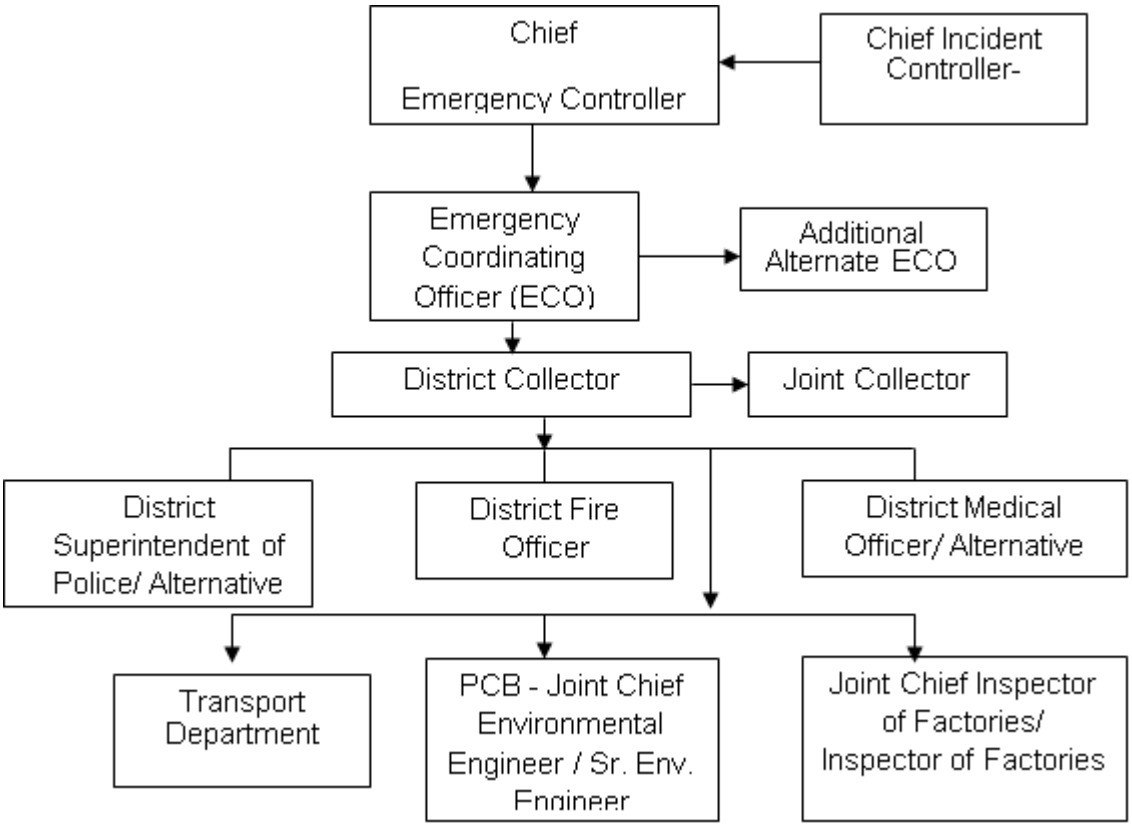
7.8.2 Off-site Emergency Preparedness Program

Emergency is a sudden unexpected event, which can cause serious damage to personnel life, property and environment as a whole, which necessitate delineating off-site Emergency Plan to combat any such eventuality. In off-site disaster management plan, many agencies like Revenue, Public Health, Fire Services, Police, Civil Defence, Home Guards, Medical Services and other Voluntary organization are involved. Thus, handling of such emergencies requires an organized multidisciplinary approach.

Evacuation of people, if required, can be done in orderly way. The different agencies involved in evacuation of people are civil administration, non-Govt. organizations, factory Inspectorate including mutual aid partners of industrial unit and Police authorities.

In the present case off-site emergency mainly occurs for fire explosion, fire ball and toxic dispersion causing people in and outside of plant exposed to heat radiation, shock waves and toxic vapour/ gas. Organisation chart of typical off-site emergency plan is shown in **Fig. 7.4.**

Fig. 7.4: Organization Chart: Off - Site Emergency Preparedness Plan



Fire: Effects of fire on population will be mainly due to thermal radiation. In such cases, houses situated to the proximity of disaster need to be evacuated, although a severe smoke hazard due to fire is to be reviewed periodically.

Explosion: An explosion will give a very little time to warn population and areas affected may be much longer than that in case of fire. The effects of explosion on population will be mainly due to shock waves, flying splinters, collapse of structures and simultaneously exposure to thermal radiation.

Toxic: Toxic dispersion will affect at down distance of industrial unit, for the same people will be evacuated within 15-30 minutes, being people may expose to IDLH level of identified toxic gases, by giving necessary warnings and move towards crosswind side. For the same evacuation is needed.

7.8.2.1 Purpose of Plan

- To save lives and injuries and to prevent or reduce property losses and to provide for quick resumption of normal situation or operation
- To make explicit inter related set of actions to be undertaken, being event of an industrial accident posing hazards to the community
- To inform people surrounding about type of emergency and disaster and it is likely to adversely affect and to guide the people in proper way.
- To rescue and recuperation of injuries and plan for relief and rehabilitation
- To plan for prevention of harms, total loss and recurrence of disaster and it will be ensured that absolute safety and security is achieved within the shortest time

7.8.2.2 Before Emergency

Safety procedure followed before during an emergency through posters, talks and mass media in different languages including local language. Leaflets containing do's/ don'ts before and during emergency will be circulated to educate the people in vicinity and provide information about hazardous installation, who are potentially affected in the event of an accident, will aware of the risks of accidents. Explain concerning the installation, and understand what to do in the event of an accident. Non-governmental Organizations (NGO's) (Such as environmental, humanitarian and consumer group) will motivate their constituents and others, to be involved in risk reduction and accident prevention efforts and will provide technical assistance to help the public analyze and understand information that is made available.

Public authorities (at all levels) and management of hazardous installation will establish emergency planning activities/ program's for accidents. In this respect public health authorities, including experts from research organisation will be involved in relevant aspects of offsite emergency planning.

Emergency warning alert system will be in place to warn the potentially affected public, and about an imminent threat of an accident. The system chosen will be effective and provide timely warning. Suitable warning system could include e.g.: sirens, automatic telephone message, and mobile public address system.

7.8.2.3 During Emergency

As the off-site plan is to be prepared by industrial unit by involving the government and other agencies of control committee will be formed under the chairmanship of area head the group include officers from local units, police, fire, medical, engineering, social welfare, publicity, transport and requisite departments will be incorporated as members. Some experts will also be included for guidance.

The functions of committee will be:

- To work as main co-coordinating body constituted of necessary district heads and other authorities with overall command, coordination, guidance, supervision, policy and doing all necessary things to control disaster in shortest times
- To take advice and assistance from experts in fields to make plan more successful
- To prepare, review, to keep it document with all details
- The incident control committee, traffic control committee and press publicity committee will first be informed

Hospital Committee consisted of doctors for medical help to the injured persons because of disaster. Injuries may be of many types. As such doctors are rarely available we have to mobilize and utilize all available doctors in the area.

Functions and duties of the committee include:

- On receiving information to rush to spot, he will immediately inform his team and will proceed with all necessary equipments to give medical help to all injured as early as possible;
- First aid and possible treatment will be provided at the spot or at some convenient place and patients may be requested to shift to hospitals for further treatment
- Continuity of the treatment will be maintained till the disaster is controlled

Traffic Control, Law and Order: Functions and duties of this committee will be:

- To control traffic towards and near disaster to maintain law and order
- To evacuate the places badly affected or likely to be affected
- To shift the evacuated people to safe assembly points and rehabilitate them after disaster is over.

However, necessary vehicles, wireless sets and instruments for quick communications will be maintained and used as per need.

7.8.2.4 After emergency

Functions and duties of emergency (ECG/EAG) committee are:

- To find out persons in need of human help owing to disastrous effect. They may give first aid if medical team is not available
- They will serve the evacuated people kept at assembly points. They will arrange for their food, water, shelter, clothing, sanitation and guidelines to reach any needful places

- They will look for removal and disposal of dead bodies if any and for help of sick, weak, children and needy persons for their essential requirements
- The team will also work for restoration of detached people, lost articles, essential commodities etc.
- The team will also look after the restoration of government articles
- The team will also ensure that the original activities, services and systems are resumed again as they were functioning before the disaster

Police Department

- The police will assist in controlling of the accident site, organizing evacuation and removing of any seriously injured people to hospitals.
- Co-ordination with the transport authorities, civil defence and home guards
- Arrange for post mortem of dead bodies
- Establish communication centre.

Fire officer / District or Divisional fire officer

The team will organize to put out fires and provide assistance as required.

Hospitals and Doctors

Hospitals and doctors must be ready to treat any injuries, Co-ordinate the activities of Primary Health Centres and Municipal Dispensaries to ensure required quantities of drugs and equipments**.** Secure assistance of medical and paramedical personnel from nearby hospitals/ medical institutions.

Media

The media will have ready and continuous access to designated officials with relevant information, as well as to other sources in order to provide essential and accurate information to public throughout the emergency and to help avoid confusion

Efforts will be made to check the clarity and reliability of information as it becomes available, and before it is communicated to public.

Public health authorities will be consulted when issuing statements to the media concerning health aspects of chemical accidents.

Members of the media will facilitate response efforts by providing means for informing the public with credible information about accidents involving hazardous substances.

Non-governmental organizations (NGO)

NGOs could provide a valuable source of expertise and information to support emergency response efforts. Members of NGOs could assist response personnel by performing specified tasks, as planned in the emergency planning process. Such tasks could include providing humanitarian, psychological and social assistance to members of community and response person.

Duties of NGO are listed below:

- Evacuation of personnel from the affected area
- Arrangements at rallying posts and parking yards
- Rehabilitation of evacuated persons
- Co-ordination with other agencies such as police, medical, agriculture, electricity board, fire services, home guards and civil defence.
- Establishing shelters for rescue, medical, fire-fighting personnel.

7.9 Conclusion & Recommendations

1. Fire/ Explosion considered as considerable accident scenario in M/s Nichino Chemical India (p) Ltd. being several IB flammable solvents (Ethylene dichloride, Methanol, m- Xylene and Toluene) has a provision of 10 KL capacity tanks in tank form area and also existing one underground Carbon disulfide 10 KL tank in specified area and are considered as highly flammable.
2. Being stored in tank form area with respective dykes, leak and release of material causes pool fire if spark or ignited. it indicates heat radiation effect few meters from edge of pool, need of on-site emergency plan.
3. In case of Fire/ explosion due to delayed ignition/ spark after vapour cloud formation causes effect of heat radiation and pressure wave crosses the industry boundary need of Off- site emergency preparedness plan and the plan also required in case of BLEVE causes fire ball. In case of Carbon disulfide leak evaporated respective vapour due to ignition/ spark radiation effect onsite only and even PEL within plant boundary.
4. Specific measures to be taken to avoid or minimise accident, at storage yard fixed and movable fire fighting system should be provided to control vapour cloud formation in case of leak/ discharge as well as to minimise exposes to external heat by storage tanks.
5. M/s Nichino chemicals India (p) ltd is also planning to be stored several flammable liquid in drums in ware houses. In case of leak or rupture of drums forms unconfined

pool, if ignited of vapour cloud causes severe heat radiation and explosion effect on respective ware house area causes damage to property and material.

6. Spill contaminants pallets/ adsorbent to be used effectively to minimise the spill over of material and control leak effectively and contaminated material disposed environmental friendly.
7. M/s Nichino Chemical Iindia (p) ltd is going to be used several toxic liquids i.e. Acetic anhydride, Acetonitrile, Chloro acetyl chloride, Thionyl chloride, Phosphorous oxy chloride, Acetic acid and Sulfuric acid. MCA analysis indicates that there is a possibility of IDLH level exposure within and outside the plant area at downwind direction.
8. Specific remedial measures to be adopted to minimise the leak and control at source and simultaneously off- site emergency plan may be initiated including evacuation plan followed by medical aid with need of hour.
9. In the case of leak and direct release of liquid corresponding gases/ vapours dispersed towards down side of plant area even more than 1.0 km. crossing plant boundary and exposed to IDLH level.
10. Steps should be taken to control at source to minimise spread of unconfined area by bordering inert material adsorbent, control the leak if possible. In case of uncontrolled situation delineated emergency plan including evacuation of possible exposures.
11. Ms Nichino Chemicals India (p) ltd is also proposed to use Highly flammable Hydrogen gas cylinders, however It is proposed to store separately. Specific measures suggested may be taken specially during handling.
12. Presence of other hazard storages and handling as per on -site plan necessary, expect in few occasions of total discharge of material, however time to time emergency plan may be upgrade as when needed as per regulations.
