Harika Drugs Private Limited

RISK ASSESSMENT REPORT
Chapter 7 of EIA Report

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Risk Assessment

7.0 Introduction

The objective of the risk assessment study is to identify and quantify the major hazards and the risk associated with various operations of the Existing / Proposed project, which may lead to emergency consequences (disasters) affecting the public safety and health. Hazard is anything (e.g. condition, situation, practice, behavior) that has the potential to cause harm, including injury, disease, death, environmental, property and equipment damage.

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 has 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 / explosion and Toxic dispersion. Based on this information, an emergency preparedness plan will be prepared to mitigate the consequences.

7.1 Hazard identification

A classical definition of hazards states that hazard is 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 neighboring community. In principle, both probability and consequences should be considered

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	< 0.5-2.0
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 shall 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) or an article:

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. As per applicable rules, 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. The description of applicable rules is 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 format in SC-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

Applicable Rules	Description
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.	

7.1.3 Storage Facilities of Hazardous Chemicals

The maximum storage capacities, daily consumption, type of storage and physical status of identified hazardous chemical, which are proposed to be used for manufacturing various products are given in **Table 7.2**. The project proponent deals with different materials in their production, some of which are hazardous in nature i.e. flammable, explosive, toxic and corrosive. Chemicals consumed in this plant are in solid and liquid and for the same the Hazard analysis is required. The information on Material safety data sheet (MSDS) for all the identified hazardous chemicals is presented in **Annexure-XLVIII.**

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 Kg	Type of Storage & Maximum	Nature of the Material
1.	IPA	6561.11	25 KL x1	SS tank, Tank Form Area	IB Flammable
2.	Xylene	4533.89	25 KL x1	SS Tank, Tank Form Area	I C Flammable
3.	Acetone	100	160 kg x 2	MS Drums, Drum yard	IB Flammable
4.	Methyl Isobutyl ketone	2893.3	160 kg x 18	MS Drums, Drum yard	Toxic & IB Flammable
5.	Toluene	5357.33	170 kg x 29	MS drums, Drum yard	IB Flammable
6.	IPA HCl	178.04	180 kg x 3	HDPE drums, Drum yard	Flammable & Toxic
7.	Thionyl Chloride	560.22	300 kg x 7	MS/GI Drums, Ware house	Toxic
8.	Sodium Hydroxide	474.67	50 kg x 100	HDPE bags , Ware House	Corrosive & Toxic
9	2-Benzyl Pyridine	221.67	200 kg x 5	HDPE drums, Ware House	Combustible liquid
10	3- Methyl BenzylBromide	17	200 kg x 2	HDPE drums, Ware House	Combustible liquid

S. No	Name of the Material	Daily consumption kg/day	Maximum Storage facility Kg	Type of Storage & Maximum	Nature of the Material
11	Citric acid	166.67	50 kg x 12	HDPE bags, Ware House	Toxic
12	Maleic acid	146.33	50 kg x 10	HDPE bags, Ware House	Toxic
13	p-Toluene Sulfonic acid	333.33	50 kg x 20	HDPE bags, Ware House	Toxic
14	Sodium amide	157.36	250 kg x 2	MS Drums, Ware House	Fire hazard

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 tank form area.
- Solvent / Hazard chemical Storage (drums) in Drum Yard/ ware house.
- Hazard handling and process area
- Coal handling and storage area

7.2 Hazard Analysis

Identification of hazards is an important step in Risk Assessment as it leads to the generation of accidental scenarios. 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 identified hazardous chemicals along with Hazard rate, Flash Ignition Point (FIP), Melting point 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 NFPA classification are presented in **Tables 7.5 and 7.6** respectively. Storage of hazard chemicals mainly solvents in respective tanks in tank form area. Apart

from tank form area the hazard chemicals are also stored in specified drums in drum storage area and others in ware house, details of storage of chemicals are depicted in plant layout **Fig. 7.1**.

Table 7.3: Hazardous materials properties, rating and TLV value - Solvent storage yard

Sl. No.	Raw Material	Physical Status of Chemical	Rating	Melting Point (^oC)	Boiling Point (^oC)	Flash Point (^oC)	IDLH (ppm)	TLV Value (ppm)	LEL (%)	UEL (%)
1	Acetone	Liquid	1	-95.35	56.5	-20	2500	1000	2.15	13
2	IPA	Liquid	1	-89	82.5	11.7	2000	400	2	12.7
3	Xylene	Liquid	3	-25	144	32.2	900	100	0.9	6.7
4	MIBK	Liquid	2	-84.7	117	14	300	50	1.2	8
5	Toluene	Liquid	2	-95	110.6	4.4	500	200	1.1	7.1
6	IPA HCl	Liquid	3	-89.5	82.2	11.67	-	-	6.0	36.5
7	Thionyl Chloride	Liquid	3	-104.5	76	N/A	200	1 as HN_3	N/A	N/ A
8	2-Benzyl Pyridine	Liquid		8-10	276	125	-	-	-	-
9	3- Methyl Benzo Bromide	Liquid	4	-	180	82	-	-	-	-
10	Citric acid	Solid	11	153	Decomposes	100	0.28 kg/m^3	2.29 kg/m^3	-	-
11	Maleic acid	Solid		130	135	-	-	-	-	-
12	p-Toluene Sulfonic acid	Solid	8	100 -108	140	-	-	-	-	-
13	Sodium Hydroxide	Solid	3	318.3	1390	N/A	10 mg/m^3	2 mg/m^3	-	-
14	Sodium amide	Solid	4.3	210	400	29	-	-	-	-

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

Table 7.4: Hazard Maximum Storage and NFPA Rating – Open storages

S. No.	Description	Physical Status of Chemical	Maximum storage (kl)	NFPA Rating			
				Nh-health	Nf-Fire	Nr-Reaction	Material Factor (MF)
1	Acetone	Liquid	0.32	1	3	0	16
2	Isopropyl Alcohol	Liquid	20	1	3	0	16
3	Xylene	Liquid	16	2	3	0	16
4	MIBK	Liquid	3.0	2	3	1	16
5	Toluene	Liquid	5.0	2	3	0	16
6	IPA HCl	Liquid	0.5	2	3	1	16
7	Thionyl Chloride	Liquid	2.0	4	0	2	24
8	Bezyl Pyridine	Liquid	1.0	1	0	0	4
9	3- Methyl Benzo Bromide	Liquid	0.3	-	-	-	-
10	Citric acid	Solid	0.6	2	1	0	4
11	Maleic acid	Solid	0.15	2	1	0	4
12	p-Toluene Sulfonic acid	Solid	1.0	-	-	-	-
13	Sodium Hydroxide	Solid	5.0	3	0	2	24
14	Sodium amide	Solid	0.5	3	3	2	24

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

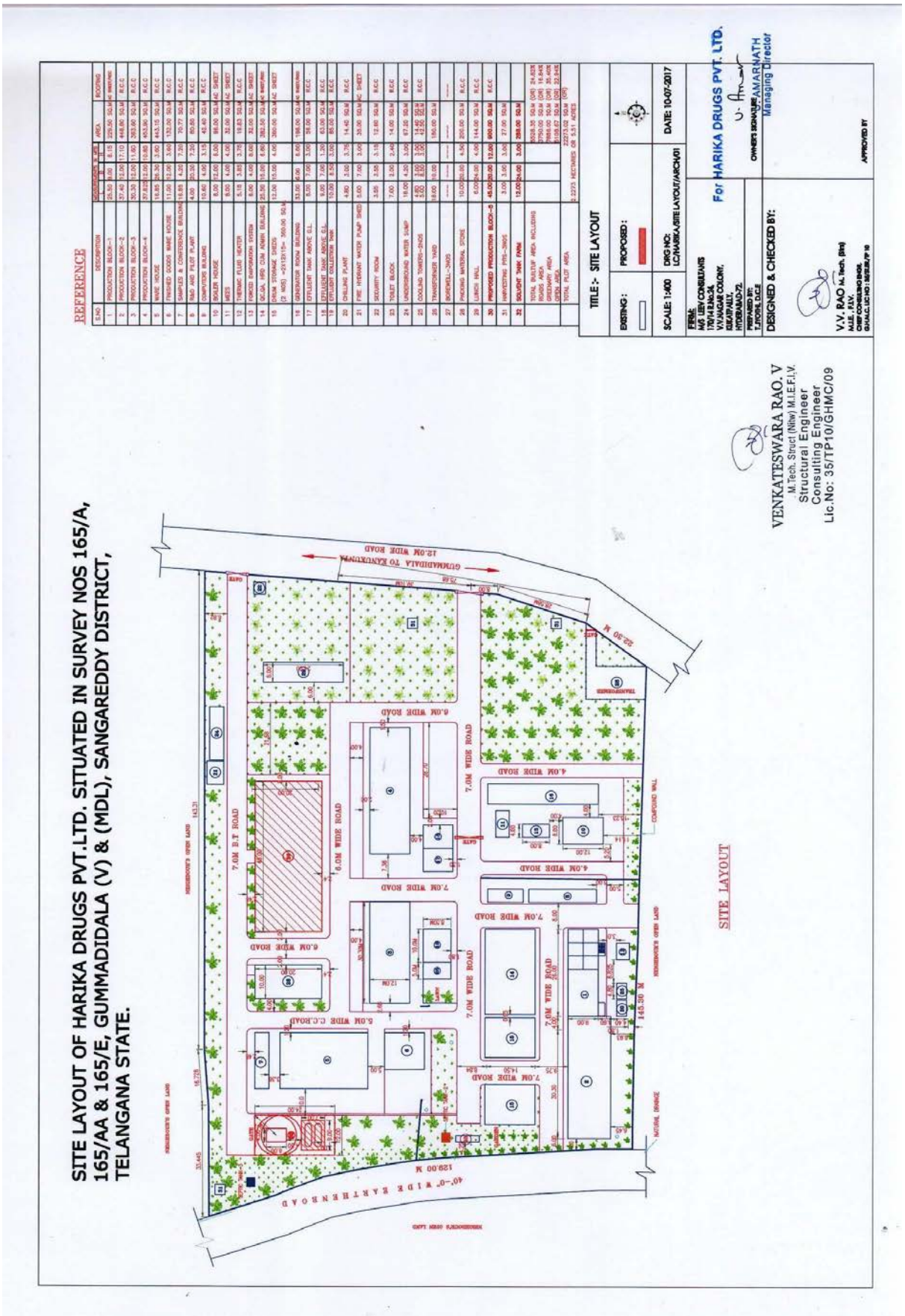

Fig. 7.1: Plant layout

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. It estimates the global risk associated with a process unit and classifies the units according to their general level of risk. 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 and 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 should 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**.

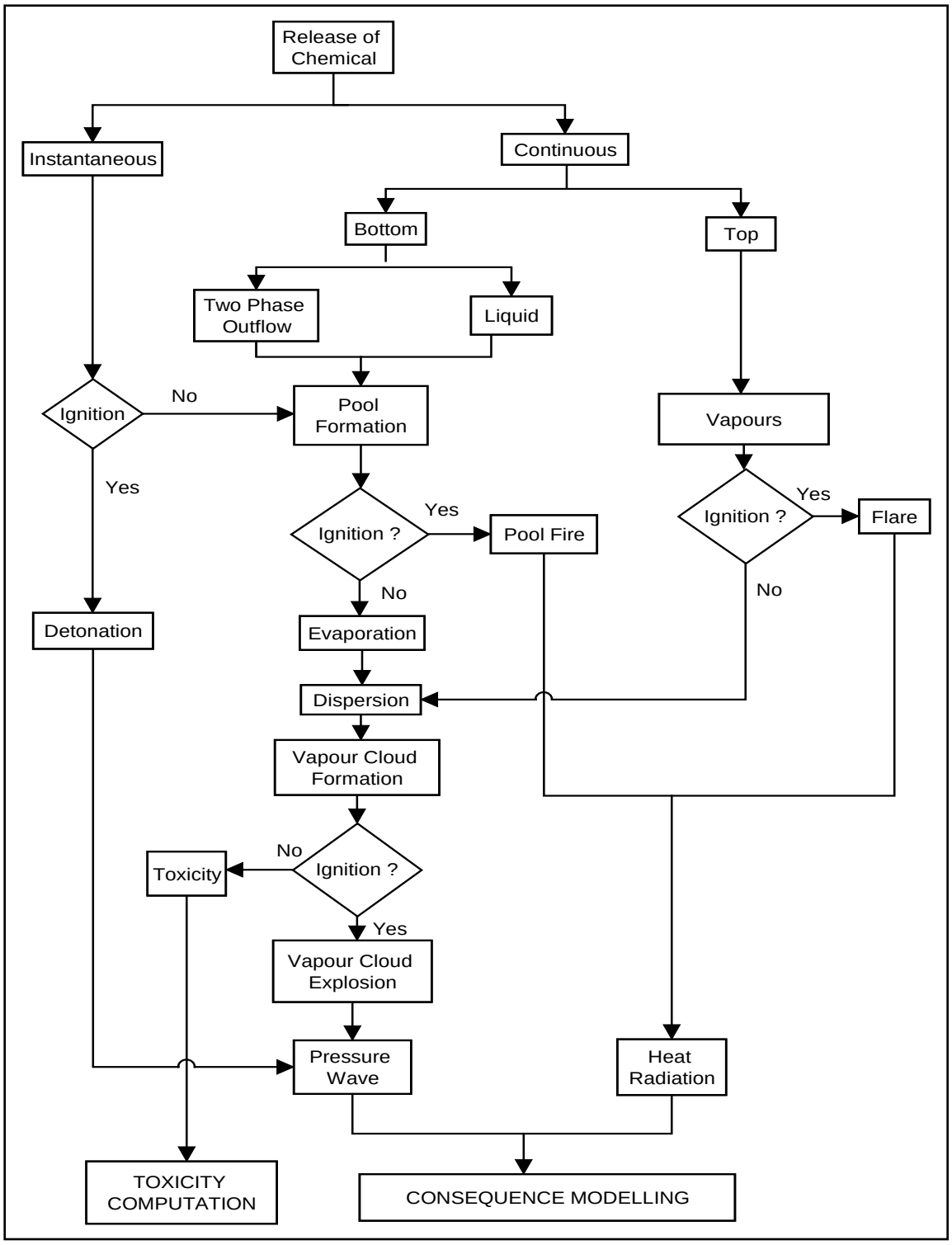

Fig. 7.2: Typical Flow Chart of Accidental Release of Hazardous Chemicals

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

- The form of material released is solid/ liquid/ vapour
- The total quantity of material released
- The 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 (psig)	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

Sl. No.	Press (psig)	Damage
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
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

Unconfined Fire/ Vapour cloud explosion

This scenario was visualized for Flammable liquid storage tanks mainly solvents in tank form area i.e. IPA and Xylene are stored in underground tank form area a capacity of 25 KL each. Other selected solvent are storing in HDPE drums i.e. Acetone, MIBK, Toluene and others. 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 vapour cloud explosion and reported for damage distance due to over pressure 0.3, 0.1 and 0.03 bar.

Table 7.10: Consequences of MCA Analysis – Storages (*distances in meters)*

(Pool Fire/ Fir Ball/ VCE)- Tank form Area

(Pool Fire/ Fir Ball/ VCE)- Tank form Area

Hazard Material	Capacity	Heat Radiation (KW/m^2)- Meters			Over Pressure (bar) - Meters		
		37.5	12.5	4.5	0.3	0.1	0.03
IPA 25 KL x1 Tank form area	Leak of vapor 108g/min Ignited under unconfined vapor	-	-	<10	10	17	35
O-Xylene 25 KL x1 Tank form Area	Leak of vapor 24.7 g/min	-	-	<10	-	-	-

Hazard Material	Capacity	Heat Radiation (KW/m^2)- Meters			Over Pressure (bar) - Meters		
		37.5	**12.5**	**4.5**	**0.3**	**0.1**	**0.03**
Acetone 160 kg	VCE / BLEVE Fire Ball Dia.37 m	29	55	93	28	39	87
MIBK 160 kg	VCE / BLEVE Fire Ball Dia.31 m	38	50	109	33	62	105
Toluene 170 Kg	VCE / BLEVE Fire Ball Dia.32 m	35	65	108	40	54	119

Flammable liquids: Analysis indicate that Confined pool of IB flammable liquid IPA and IC Flammable liquid Xylene is under ground, tanks are stored in underground, if any release of respective pipe lines leak concentration within lower explosive limits within 10 meter radial distance. If ignited in case of IPA over pressure effect is maximum of 0.03 bar 35 m.

In the case of flammable liquids, i.e. Acetone, MIBK and Toluene are in different capacity of drums in Drum yard, due to leak/ rupture of drums with ignition radiation effect 4.5 KW/m^2 covers a distance from 87 to 119 m, whereas damage distance of pressure wave VCE from 93 to 109 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 and over pressure effect due to leak of IPA vapor and Acetone are shown in **Annexure XLIX and L** 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 vapour cloud explosion unlikely occurs.

Toxic Release

The toxic hazard chemicals are going to be used by proponent in their proposed plant and are mainly MIBK and Thionyl chloride and are stored in various capacities of drums. MIBK drums are stored in Drum yard area, where as Thionyl chloride drums in ware house. The same are also selected on basis of IDLH and TLV value for the study. 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 unconfined pool. Consequences results are reported in **Table 7.11**. Consequence analysis indicate that if any leak (continuous) IDLH concentration of Thionyl chloride 14 ppm covers a distances up to 218 m and PEL value of 1 ppm up to 965 m at wind ward side of plant. 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 levels onsite as well as off-site area.

In the case of toxic hazard drums which are stored in ware house, material spread over due to leak/ ruptures forms unconfined area. For the same specific precautionary measures are to be followed as per MSDS guidelines and the same is addressed in next section.

The damage contour of Thionyl chloride is shown in **Annexure-LI**. For Thionyl chloride and MIBK toxic hazard are predicted and distance of exposure of IDLH level as well as for TLV (PEL) are reported in **Table 7.11**.

Table 7.11: Consequence Analysis for Toxic Release Scenario

Scenario Considered	IDLH (ppm)	TLV (ppm)	Leak	Source Strength (kg/sec)	IDLH Distance (m)	TLV (m)
MIBK 160 kg x 18	300	50	Instantaneous	2.67	287	710
			Continuous	0.045	39	103
Thionyl chloride 300 kg x 7	14 (AEGL)	1	Instantaneous	5	1200	3300
			Continuous	0.0833	218	965

Wind velocity 2m/sec and stability B & D

Handling of Hazardous Materials

- **Material hazards:** Coal is the major fuel for existing/ proposed steam boiler/ thermic fluid heaters and High Speed Diesel (HSD) Oil for DG sets for existing/ proposed one.
- **Process hazards** due to loss of containment during handling of hazardous materials or processes resulting in fire, 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 instantaneous release of Thionyl chloride, for the same distance of effect is reported.

In the case of delayed ignition /spark of vapour cloud of the solvent tanks i.e. Acetone, MIBK and Toluene, which causes over pressure effect including effect of radiation may/ may not cross plant boundary, however depends on case by case, effected distance from boundary wall.

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 including personal protection system and also should have a mutual aid with industries located in and around Harika Drugs Pvt. Ltd, Gummadidala (V&M), Sangareddy district along Hyderabad – Narsapur Road. On-site/ Off-site emergency plan with effective fire combat facility should maintain and it has to be upgraded further with suitable mitigation measures.

7.5.1.1 Fire Prevention and Protective Equipment

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

1. Water
2. Water Tenders
3. Foam Tenders
4. Fire hydrant and monitor nozzle installation
5. Dry powder extinguisher
6. Water fog and sprinkler system
7. Mobile Fire-fighting equipment
8. DCP fire extinguishers

9. CO_2 Fire extinguishers and High expansion foam generator
10. For large fire Dry chemical, CO_2 and alcohol resistant foam.
11. Fire extinguishers will be tested periodically and will be kept in operational mode.

Apart from above specific preventive/ safety measures to be followed as follows

- First aid appliances
- Critical switches and alarm will be kept in-line
- Shut off valves, isolation will be easily approachable in emergencies. Sign board 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 especially in toxic gas release.
- The 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.
- The 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, 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.

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: At present storage tanks are proposed in underground of tank form area i.e. Solvents such as Isopropyl alcohol and Xylene if any should 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, which are proposed to use in limited quantity are stored in Drum yard i.e., Acetone, MIBK and Toluene, if any material such as HCl / IPA HCl should transferred from respective drums (MS and HDPE) to the day tank situated at the production block with the help of AODD pump through pipe from the drums and from day tank to reaction vessel.

Occupational Health: 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. Toxic solid (hydrous/ anhydrous) material, Halogenated compounds and Acid fumes/ vapor compound acquire aggravated properties. It is only wise to treat every chemical as toxic. Any accidental release of hazard of flammable / toxic, distance of radiation and toxic exposure including over pressure effect is reported in Table 7.10 and Table 7.11. For the same risk mitigation measures (general and specific) followed by DMP discussed in next sections.

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 borohydride, 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.
Spill 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 especially incompatible chemical in same shed, if not keep safe distance. MS/ HDPE drums have to be stored on spill containment pallets. In case of any leakage from the drum it should 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 of drums in a cool, dry, well-ventilated area away from incompatible substances, sufficient buffer space should 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 is to be followed to minimize / avoid release of hazard chemical and to control at source if leak/ spill of gas/ vapor/ liquid.

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 absorbent/ adsorbent.

It is also necessary 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 catridge mask
6. Chemical resistant suit
7. Antistatic gloves
8. PVC gloves

Safety Systems

1. Designated areas with proper indication flammable/ toxic / explosive & safety rings
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 should be based on the hazard and risk ranking and should 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	Failing or rolling objects, points objects. Corrosive or hot liquids.	Safety shoes and boots for protection against moving and failing 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). Onsite 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 especially 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:

- The fire and explosion properties of the material
- The nature of fire and explosion process and
- The procedure to reduce fire and explosion

To avoid or reduce Vapour Cloud Explosion (VCE) to minimise dispersion of flammable vapour 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).

However vapour cloud explosion is unlikely to occur in M/S Harika Drugs Pvt. Ltd, vapour cloud being released in most of the cases is below the LEL as per analysis and also usage of flammable liquids are very few.

Each chemical has specific character and hence all the chemicals will not be stored in one storage shed, being not supposed to mixed, stored together, during storage and handling. It is the nature of chemicals that they should not co-exist. The major incompatibilities for storage and handling of hazard chemicals are presented in **Table 7.14.**

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

Chemical	Incompatible with
Acetone	H_2SO_4, HNO_3, Oxidizing agents, H_2O_2 and Chloroform
2-Benzyl Pyridine	Strong oxidizers, strong acids
Citric acid	Reactive with oxidizing agents, reducing agents, metals, alkalis
IPA	Strong oxidizers, Acetaldehyde, Chlorine, Ethylene oxide, acids and Isocyanate
IPA -HCl	Various substances i.e. Slightly reactive to reactive with metals, alkalis
Maleic acid	Reactive with oxidizing agents, reducing agents, metals, alkalis. Slightly reactive to reactive with moisture.
MIBK	Strong oxidisers
3 Methyl Benzo Bromide	Alcohols, Bases, Amines, Oxidizing agents
P- Toluene Sulfonic acid	Metals, strong oxidizing agents, strong bases
Sodium amide	Highly reactive with oxidizing agents, moisture. The product reacts violently with water to emit flammable but non toxic gases.
Sodium hydroxide	Water; acids; flammable liquids; organic halogens; metals such as aluminum, tin & zinc; nitro methane [Note: Corrosive to metals.]
Thionyl chloride	Alkalies, Oxidising agents, other chemicals
Toluene	Strong acids, combustible and flammable substances, oxidizing agents
Xylene	Strong oxidising agents and strong acids

Precautionary measures to be taken for accidental release of hazard chemicals is as follows

7.5.2.1 Combustible materials

Industry proposed to store combustible liquids/ solids, In case of small fire due to spark/ ignition-water and for large fire dry chemical, alcohol foam, water spray and keep away source of ignition.

7.5.2.2 Flammable – Pool Fire/ Vapour cloud Explosions / BLEVE

In case of leak of respective vapor from underground storage tanks in tank form area and drums in drum yard and as well as in ware house, total material taken as source strength for possible emanation of vapor and leak of respective vapor and unconfined pool in case of drums and simultaneously leakage control with safe precautionary measures. If 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 fire-fighting 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 drums by external heat or any other means. Result causes over pressure and heat radiation effect on on-site area and crosses plant boundary (off-site) area closed by plant. The risk mitigation measures is as follows

- All solvent tanks having condenser cooling with Flame arrestor provided if any.
- 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 / vapour appropriate fire-fighting system may be deployed accordingly on basis of Risk level.

7.5.2.3 Toxic Releases

Industry is proposed to handle proposed Thionyl chloride and MIBK and others.

Thionyl chloride:

Industry has a facility to store Thionyl chloride in drums of capacity 300 kg each and is being handled using Drum pump, being it is in liquid form once accidental leak or complete discharge of chemical, spill over in unconfined area of pool and evaporates and move towards wind ward direction causes severe health effect, being AEGL (Acute Exposure Guideline Level) value is 14 ppm and once exposed get medical aid immediately. If reacted 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.

Sodium Hydroxide:

Industry consuming 474.67 kg per day, for this there is a provision to store 100 bags of each 50 kg. It is very hazard in case of skin and eye contact (irritant, corrosive), of ingestion, of inhalation. The amount of tissue damage depends on length of contact. Eye contact can result in corneal damage or blindness. Skin contact can produce inflammation and blistering. Inhalation of dust will produce irritation to gastro-intestinal or respiratory tract, characterized by burning, sneezing and coughing.

Small Spill: Use appropriate tools to put the spilled solid in a convenient waste disposal container. If necessary neutralize the residue with a dilute solution of acetic acid.

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

Personal Protection in Case of a Large Spill: Splash goggles. Wear full suit, Vapor and dust respirator and also boots and gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist before handling this product. It is a Corrosive solid - stop leak if without risk. Do not get water inside container. Do not touch spilled material. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas. Neutralize the residue with a dilute solution of acetic acid. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

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.

Sodium amide: It has a provision to store 25 bags of each 10 kg in 250 kg MS drums. Explosion Hazards in presence of various substances**,** extremely hazardous in case of skin contact (irritant) and eye contact (irritant). Very hazardous in case of inhalation (lung irritant) and slightly hazardous in case of ingestion. The amount of tissue damage depends on length of contact. Eye contact can result in corneal damage or blindness. Skin contact can produce inflammation and blistering. Severe over-exposure can produce lung damage, choking, unconsciousness or death. Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering. Slightly explosive to explosive in presence of moisture.

Flammable solid. SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray or fog.

Small Spill: Use appropriate tools to put the spilled solid in a convenient waste disposal container.

Large Spill:

Corrosive solid, flammable solid when in contact with water emits flammable gases. Stop leak if without risk. Do not get water inside container. Do not touch spilled material. Cover with dry earth, sand or other non-combustible material. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Eliminate all ignition sources. Call for assistance on disposal

Personal Protection in Case of a Large Spill: Splash goggles. Full suit. Dust respirator. Boots, Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist before handle this product

Benzyl pyridine:

It has a provision to store 1 ton of chemical in 200 kg bags of 5 in nos., and has potential health effects. May cause eye and skin irritation. May cause gastrointestinal irritation with nausea, vomiting and diarrhoea.

Spills/Leaks - Avoid runoff into storm sewers and ditches which lead to waterways. Clean up spills immediately, observing precautions in the Protective Equipment section. Sweep up or absorb material, then place into a suitable clean, dry, closed container for disposal. Remove all sources of ignition. Provide ventilation.

As in any fire, wear a self-contained breathing apparatus in pressure-demand. During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion. Use water spray to keep fire-exposed containers cool. Containers may explode in the heat of a fire. Vapors may be heavier than air. They can spread along the ground and collect in low or confined areas.

Extinguishing media - Use agent most appropriate to extinguish fire. Cool containers with flooding quantities of water until well after fire is out. Use water spray, dry chemical, carbon dioxide, or appropriate foam.

3-Methylbenzyl bromide:

It has a provision of two 200 kg HDPE drums in ware house and it is imported chemical. If any spillage during handling, contain spillage and then collect with an electrically protected vacuum cleaner or by wet-brushing and place in container for disposal according to local regulations. Keep in suitable, closed containers for disposal. Prevent further leakage or spillage if safe to do so. Do not let product enter into water body.

If material not on fire and not involved in fire: Keep sparks, flames, and other sources of ignition away. Keep material out of water sources and sewers. Use water spray to knock-down vapors.

Fire Fighting Measures: This combustible material may be burned in a chemical incinerator equipped with an afterburner and scrubber. Offer surplus and non-recyclable solutions to a licensed disposal company. Wear self-contained breathing apparatus for fire-fighting if necessary.

For small fires, use media such as "alcohol" foam, dry chemical, or carbon dioxide.

For large fires, apply water from as far as possible. Use very large quantities (flooding) of water applied as a mist or spray; solid streams of water may be ineffective. Cool all affected containers with flooding quantities of water.

Personnel protection: Wear positive pressure self-contained breathing apparatus when fighting fires involving this material. Use personal protective equipment. Avoid breathing vapors, mist or gas. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas. Beware of vapors accumulating to form explosive concentrations. Vapors can accumulate in low areas.

Citric acid :

It has a provision of storage 12 bags with a capacity of 50 kg each and considered as Potential Acute Health Effects. Hazardous in case of eye contact (irritant) & on inhalation (lung irritant) and slightly hazardous in case of skin contact and also ingestion. The amount of tissue damage depends on length of contact. Eye contact can result in corneal damage or blindness. Skin contact can produce inflammation and blistering. Severe over-exposure can produce lung damage, choking, unconsciousness or death.

In case of SMALL FIRE Use DRY chemical powder and for LARGE FIRE: Use water spray, fog or foam.

In case of spillover, for Small Spill - Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of container according to local and regional authority requirements.

Large Spill: Stop leak if without risk. Do not get water inside container. Do not touch spilled material. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Eliminate all ignition sources. Call for assistance on disposal. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system and do not use water jet.

Personal Protection in Case of a Large Spill**:** Wear Splash goggles. full suit, dust respirator. Boots and gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist before handling this product.

Exposure Limits: The exposure limits given below are for particulates not otherwise classified: ACGIH: 10 mg/m^3 TWA (Total Inhalable fraction); 3 mg/m^3 TWA (Respirable fraction) OSHA: 15 mg/m^3 TWA (Total dust); 5 mg/m^3 TWA (Respirable Fraction)

Maleic Acid:

Daily consumption of material 146.33 kg/day and has a provision to store 10 HDPE bags of each 50 kg capacity and it may be combustible at high temperature, very hazardous in case of eye contact (irritant) and ingestion. It is hazardous in case of skin contact (irritant) and in case of inhalation (lung irritant). The amount of tissue damage depends on length of contact. Eye contact can result in corneal damage or blindness. Skin contact can produce inflammation and blistering. Severe over-exposure can produce lung damage, choking, unconsciousness or death. Inflammation of the eye is characterized by redness, watering, and itching.

SMALL FIRE: Use DRY chemical powder.

LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Small Spill: Use appropriate tools to put the spilled solid in a convenient waste disposal container.

Large Spill: Stop leak if without risk. Do not get water inside container. Do not touch spilled material. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Eliminate all ignition sources. Call for assistance on disposal.

P- Toluene sulfonic Acid:

Industry consuming 333.33 kg/day and has a provision to store 20 HDPE bags of each 50 kg capacity. It causes eye irritation and redness and pain, if contact with skin causes skin irritation and redness and pain. It may be harmful if absorbed through the skin.

Ingestion- May cause gastrointestinal irritation with nausea, vomiting and diarrhea. May be harmful if swallowed.

Inhalation- Causes respiratory tract irritation and it may be harmful if inhaled. Inhalation of vapors will cause coughing or breathing difficulty as in any fire, wear a self-contained

breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent),and full protective gear.

Extinguishing Media: Use water spray, dry chemical, carbon dioxide, or chemical

Spills/Leaks: Vacuum or sweep up material and place into a suitable disposal container.

Following general remedial should be applied for spillover of hazard material as discussed below.

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 present 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 arise have adverse impact on internal/ external environment of the industrial unit, 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 react with spilled material.

- Recovery and cleanup should be done by 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 approved, portable and suitable containers 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, send 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 be sent for treatment and land filling

However in all the case of above and other chemicals are used by M/s Harika follow MSDS/ NIOSH data sheet guide lines for First aid, accidental release measures, fire fighting if any.

7.6 Hazard Control Measures

1. Procedures and actions will be well defined and known to all operating 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 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 should 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 lay out.
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 in 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 local seasonal heavy rains. There is no possibility of water logging being area is slightly undulated terrain. 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 onsite warning and instructional system as necessary.
- Follow unit shut down 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 Harika Drugs Pvt. Ltd., Gummadidala (V&M), Sangareddy (District) is slightly at elevated area when compared with surrounding area of plant (close to Hyderabad) and is not in flood prone area, being located of site is around 645 (m) 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 with stand 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, however area considered as least effective during cyclonic weather.

(C) Earthquake

The factory premises is situated in Gummadidala (V&M), Sangareddy (District) which falls under Zone II under Seismic zone**,** classification and accordingly the probability and impact will be least to moderate. However steps should 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.
- Stay inside until the shaking stops after that it is safe to go outside
- Do not attempt to move to a different location inside the building or try to leave.
- DO NOT use the elevators

7.8 Disaster Management Plan

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 should be prepared to mitigate the impact in order to avoid or mitigate the effect of such situations. 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 onsite and offsite area of M/s Harika Drugs Pvt. Ltd.,
- 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.

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 pipe line. 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.

Offsite emergency requires additional planning over and above those considered under onsite plans, which should 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 manger, 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 onsite crisis lies solely with the concerned organization, whereas the organization structure for offsite 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 onsite plan
- Mobilize the financial resources for expenditure in case of emergency
- Depute nodal officer with the district or state authority for offsite crisis
- Transfer the information collected from the advisory group to EAG
- Laises 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
- Laises 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
- Laises 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 Harika Drugs Pvt. Ltd., MCA analysis indicates that the following places required Emergency preparedness plan.

Storage of flammable liquid in underground tanks in tank form area - vapour cloud explosion / fire ball.

Location of drums (HDPE and MS) storages are in drum storage area and in ware house – fire/ explosion due to instantaneous release and delayed ignition of vapour cloud / toxic release in the case of dispersion of toxic gas/ vapour an it may cross over plant boundary, need off- site emergency preparedness plan.

Most of the flammable liquid is stored in tanks/ drums of different capacity,

emergency level depends on extent of material release and vapour cloud formation. Delayed ignition or spark, explosion causes thermal radiation and over pressure effect mainly within plant boundary. In case of spillage/ instantaneous release of toxic chemicals released to atmosphere, as gas/ vapor form dispersed towards downwind direction covers off-site area, if delayed in control at source mainly IB flammable liquid and toxic Thionyl chloride is being considered.

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 should be available as shown in following **Fig. 7.3.**

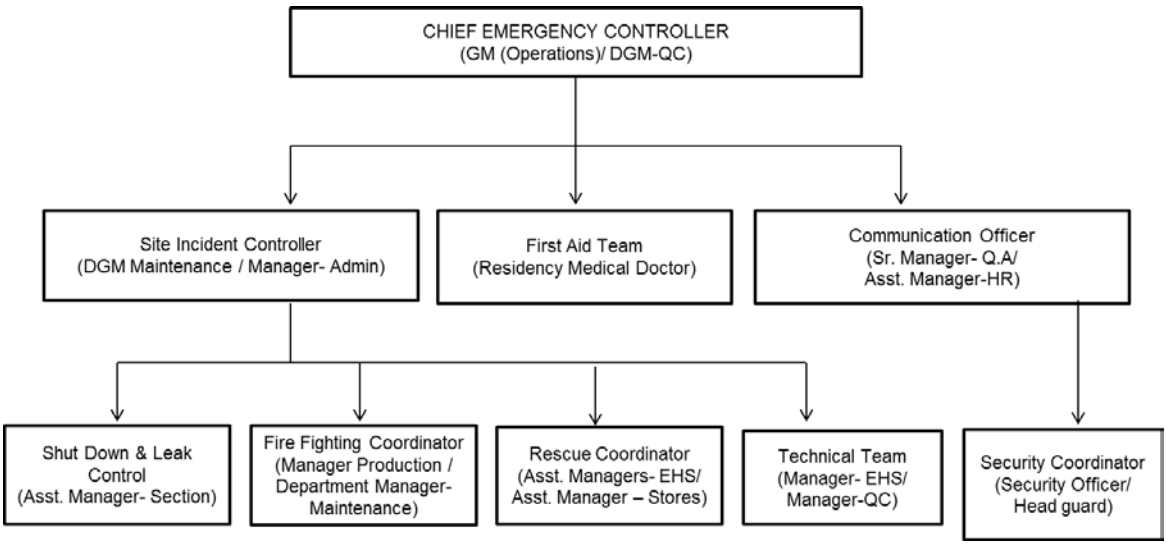

Fig. 7.3: Factory Management Organization chart

7.8.1.2 Accident Prevention Procedures / 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 on a plant. Personnel should understand their duties and responsibilities and be attentive to conditions that might lead to fire. The following precautions are recommended:

- There should be provision for safe handling and storage of dirty rags, trash and waste oil flammable liquids and chemicals spilled on platform should be immediately cleaned

- Containers of paints and hydrocarbon samples, gas cylinders for welding and cutting should be stored properly.
- Cutting and welding operations should be conducted in accordance with safe procedures. Smoking should be restricted to designated platform areas and "no smoking" areas should be clearly identified by warning signs
- Particular attention should 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

The 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, should be noted in plot plan.

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

There should be a regular mock fire drill periodically; record of such drills shall be maintained. Every employee or authorized person working in the plant shall be familiarized with the fire alarm signal and shall 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 should 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 should depose environmental friendly not to contaminate water and soil. And toxic flooded with water also controlled and neutralised 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.**

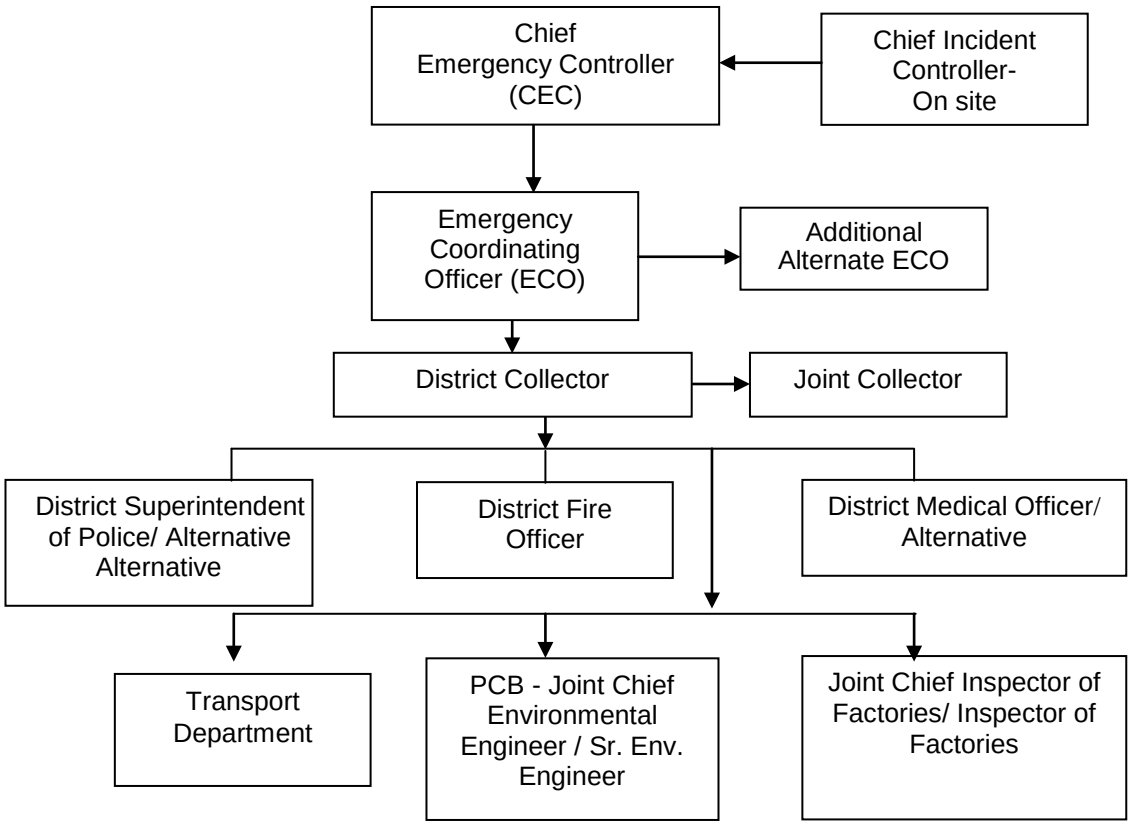

Fig. 7.4: Organization Chart - Off - Site Emergency Preparedness Plan

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 should be circulated to educate the people in vicinity and provide information about hazardous installation, who are potentially affected in the event of an accident, should be 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) should motivate their constituents and others, to be involved in risk reduction and accident prevention efforts and should 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 should establish emergency planning activities/ program's for accidents. In this respect public health authorities, including experts from research organisation should be involved in relevant aspects of offsite emergency planning

Emergency warning alert system should be in place to warn the potentially affected public, and about an imminent threat of an accident. The system chosen should 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 shall be formed under the chairmanship of area head the group includes officers from local units, police, fire, medical, engineering, social welfare, publicity, transport and requisite departments shall be incorporated as members. Some experts will also be included for guidance.

The functions of committee should 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 shall 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 shall be maintained till the disaster is controlled

Traffic Control, Law and Order: Functions and duties of this committee should 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 shall 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 should 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 shall 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**.** Securing assistance of medical and paramedical personnel from nearby hospitals/ medical institutions

Media

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

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

Members of the media should 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 Harika Drugs Pvt. Ltd., being IB flammable IPA and IC Flammable Xylene has a provision of storage of 25 KL capacity in underground tanks and considered as flammable and are stored in tank form area.
2. Being stored in tank form area, leak and release of respective vapour if spark or ignited, heat radiation effect onsite only, need of on-site emergency plan.

3. M/s Harika Drugs Pvt. Ltd., is proposed to store other flammable liquids in different capacity of drums in drum yard, where in MIBK is considered as flammable as well as toxic and has a provision to store 18 drums, hence specific precautionary measures suggested.
4. M/s Harika Drugs Pvt. Ltd., is also planning to be stored flammable Acetone and Toluene drums in drum yard. In case of leak or rupture of drums forms unconfined pool, if ignited of vapour cloud causes severe heat radiation and explosion effect on site area
5. 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.
6. 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.
7. Spill contaminant pallets/ adsorbent to be used effectively to minimise the spill over material and control leak effectively and contaminated material disposed environmental friendly.
8. M/s Harika Drugs Pvt. Ltd., is going to used toxic liquid i.e. Thionyl chloride, MIBK and others. MCA analysis indicates that there is a possibility of IDLH level exposure within and outside the plant area at downwind direction.
9. In the case of instantaneous/ continuous release toxic dispersion covers on/ off site area and for the same need of off-site emergency plan including evacuation plan.
10. 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.
11. Steps should be taken to control at source to minimise spill of solid/ liquid hazard chemical and spread of unconfined area by bordering inert material adsorbent and collect and dispose environmental friendly, control the leak if possible. In case of uncontrolled situation delineate emergency plan including evacuation.
12. Presence of other hazard storages and handling as per on-site plan necessary, except in few occasions of total discharge of material, however time to time emergency plan may be upgrade as when needed as per regulations.

Safety (MSDS) data for Acetone

General :

Synonyms: dimethyl ketone, methyl ketone, 2-propanone, acetone, dimethylketal, pyroacetic acid
Molecular formula: $(CH_3)_2CO$
CAS No: 67-64-1 EC No: 200-662-2

Physical data :

Appearance: colourless liquid with a fragrant, sweet odour
Melting point: -95 C
Boiling point: 56 C
Vapour density: 2.0
Vapour pressure: 181 mm Hg at 20 C
Specific gravity: 0.79
Flash point: -18 C
Explosion limits: 2.6% - 13.0%
Autoignition temperature: 538 C

Stability :

Stable. Incompatible with halogen acids and halogen compounds, strong bases, strong oxidizing agents, caustics, amines and ammonia, chlorine and chlorine compounds, strong acids, nitrosyl compounds. **Highly flammable. Readily forms explosive mixtures with air.**

Toxicology

Harmful by inhalation, ingestion or skin absorption. Irritant. Liquid may cause permanent eye damage (corneal clouding). Contact with skin may cause defatting, leading to irritation. Long-term exposure may cause liver damage. Typical TLV 750 ppm.

Ecological information

Biological degradability: good. Aquatic toxicity: low. Bioaccumulation potential: low. Fish toxicity LC50 (*L. macrochirus*) 8300 mg/l/96h.

Personal protection

Safety glasses. Effective ventilation. Remove sources of ignition from the working area. Nitrile gloves.

Safety (MSDS) data for 2-propanol

General

Synonyms: 2-hydroxypropane, isopropanol, isopropyl alcohol, iso-propanol, iso-propyl alcohol, IPA, sec-propanol, sec-propyl alcohol, dimethylcarbinol, propan-2-ol, avantin, avantine, combi-schutz, rubbing alcohol, spectrar, sterisol, takineocol, virahol
Molecular formula: $CH_3CHOHCH_3$
CAS No: 67-63-0
EC No: 200-661-7
Annex I Index No: 603-117-00-0

Physical data

Appearance: colourless liquid with slight alcohol odour
Melting point: -89 C
Boiling point: 82 C
Vapour density: 2.1
Vapour pressure: 33 mm at 20 C
Specific gravity: 0.79
Flash point: 12 C
Explosion limits: 2.0 % - 12 %
Autoignition temperature: 425 C

Stability

Stable. Incompatible with strong acids, strong oxidizing agents, halogens, aluminium, active halogen compounds. Regulated in UK under Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972. Highly flammable. Vapour-air mixtures may be explosive.

Toxicology

May be harmful by inhalation, ingestion or skin absorption. May act as an irritant. UK OES Long-term 980 mg/m3.

Transport information

(The meaning of any UN hazard codes which appear in this section is given here.)
UN No 1219. Hazard class 3. Packing group II.

Personal protection

Safety glasses. Effective ventilation.

Safety data for o-Xylene

General

Synonyms: ortho-xylene, o-xylol, 1,2-dimethylbenzene
Use: solvent, synthetic agent
Molecular formula: C_8H_{10}
CAS No: 95-47-6
EC No: 202-422-2
Annex I Index no: 601-022-00-9

Physical data

Appearance: colourless liquid
Melting point: -24 C
Boiling point: 144 C
Vapour density: 3.7
Vapour pressure: 7 mm Hg at 20 C
Specific gravity: 0.87
Flash point: 32 C (closed cup)
Explosion limits: 1.1 % - 7 %
Autoignition temperature: 463 C
Water solubility: insoluble

Stability

Stable. Incompatible with oxidizing agents. Flammable. Hygroscopic.

Toxicology

Harmful if inhaled or absorbed through the skin. Narcotic. May cause lung irritation, chest pain or fatal oedema. May impair fertility. Skin irritant. Typical STEL 150 ppm.

Transport information

(The meaning of any UN hazard codes which appear in this section is given here.)
UN No 1307. Hazard class 3. Packing group II.

Personal protection

Safety glasses, adequate ventilation.

Safety phrases

(The meaning of any safety phrases which appear in this section is given here.)
S25.

Safety (MSDS) data for Methyl Isobutyl Ketone

General

Synonyms: 4-methyl-2-pentanone, 4-methylpentan-2-one, hexone, isopropylacetone, MIK, isobutylmethyl ketone, MIBK, isohexanone
Use: artificial flavouring
Molecular formula: $CH_3COCH_2CH(CH_3)_2$
CAS No:108-10-1
EC No:

Physical data

Appearance: colourless liquid with a pleasant odour
Melting point: -85 C
Boiling point: 116 C
Vapour density: 3.5 (air = 1)
Vapour pressure: 15 mm Hg at 20 C
Density (g cm^{-3}): 0.79
Flash point: 16 C (closed cup)
Explosion limits: 1.1 - 7.5 %
Autoignition temperature:
Water solubility:

Stability

Stable. Flammable - note low flash point. Incompatible with strong oxidizing agents.

Toxicology

Harmful if inhaled. Eye, skin and respiratory irritant. Long-term or repeated skin contact may cause dermatitis. Chronic high-level exposure may lead to liver damage. Typical TLV/TWA 50 ppm. Typical STEL 75 ppm.

Toxicity data

(The meaning of any toxicological abbreviations which appear in this section is given Annexure)
ORL-RAT LD50 2080 mg kg^{-1}
IHL-MUS LC50 23000 mg m^{-3}
IPR-MUS LD50 268 mg kg^{-1}

Risk phrases

(The meaning of any risk phrases which appear in this section is given Annexure .)
R11 R20.

Personal protection

Safety glasses, adequate ventilation.

Safety phrases

(The meaning of any safety phrases which appear in this section is given Annexure .)
S2 S9 S16 S23 S33.

Safety (MSDS) data for Toluene

General

Synonyms: methylbenzene, phenylmethane, toluol, antisal 1A, CP 25, methacide, methylbenzol, NCI-C07272, RCRA waste number U220, tolu-sol
Uses: Solvent
Molecular formula: C_7H_8
CAS No: 108-88-3
EC No: 203-625-9
Annex I Index No: 601-021-00-3

Physical data

Appearance: Colourless liquid with a benzene-like odour (odour threshold 0.17 ppm)
Melting point: -93 C
Boiling point: 110.6 C
Specific gravity: 0.865
Vapour pressure: 22 mm Hg at 20 C (vapour density 3.2)
Flash point: 4 C
Explosion limits: 1% - 7%
Autoignition temperature: 536 C

Stability

Stable. Substances to be avoided: oxidising agents, oxygen, moisture. Highly flammable. Hygroscopic.

Toxicology

Toxic by inhalation, ingestion or by absorption through skin. Serious irritant. Experimental teratogen.

Toxicity data

(The meaning of any abbreviations which appear in this section is given ANNEXURE- **)**
ORL-RAT LD50 636 mg kg^{-1}
IPR-RAT LD50 1332 mg kg^{-1}
ORL-HMN LDLO 50 mg kg^{-1}
IPR-MUS LD50 59 mg kg^{-1}
IHL-MAM LC50 30 g m^{-3}

Irritation data

(The meaning of any abbreviations which appear in this section is given ANNEXURE- **)**
EYE-HMN 300 ppm.
SKN-RBT 435 mg mild.

Risk phrases

(The meaning of any risk phrases which appear in this section is given ANNEXURE-) **R11 R20**

Personal protection

Safety glasses. Good ventilation.

Safety phrases

(The meaning of any safety phrases which appear in this section is given ANNEXURE-)
S16 S25 S29 S33.

Safety (MSDS) data for ammonium hydroxide

General
Synonyms: ammonia solution (typically contains between 12% and 44% ammonia before dilution), dilute ammonia, concentrated ammonia. [Data for ammonia gas, NH_3, is available Annexure.]
Molecular formula: NH_4OH
CAS No: 1336-21-6
EC No: 215-647-6
Physical data
Appearance: colourless liquid
Melting point:
Boiling point:
Vapour density: 1.2
Vapour pressure: 115 mm at 20 C (depends on solution strength)
Specific gravity: typically 0.9 (depends on solution strength)
Flash point: none
Explosion limits: 16 - 27%
Autoignition temperature: 651 C
Stability
Stable. Incompatible with copper, copper alloys, acids, galvanised iron, zinc, aluminium, bronze, dimethyl sulphate, mercury, alkali metals..
Toxicology
Concentrated solution is extremely damaging to eyes. Even contact with dilute ammonia solution can lead to serious eye damage. Harmful if swallowed or inhaled and in contact with skin. Very destructive of mucous membranes. Corrosive - causes burns. Typical TLV 25 ppm. Typical STEL 35 ppm. Typical PEL 50 ppm.
Toxicity data
(The meaning of any toxicological abbreviations which appear in this section is given Annexure .)
ORL-RAT LD50 350 mg kg^{-1}
Risk phrases
(The meaning of any risk phrases which appear in this section is given Annexure .)
R34 R37.
Personal protection
Good quality safety glasses with side protection against splashes. Good ventilation. Do not work in the open laboratory with concentrated ammonium hydroxide solution.
Safety phrases
(The meaning of any safety phrases which appear in this section is given Annexure .)
S7 S26 S45.

Safety (MSDS) data for Hydrochloric acid (concentrated)

General

Synonyms: muriatic acid, chlorohydric acid. [Data for dilute Hydrochloric acid can be found Annexure .]
Molecular formula: HCl
CAS No: 7647-01-0
EC No: 231-595-7
Annex I Index No: 017-002-01-X

Physical data

Appearance: clear colourless or slightly yellow liquid with pungent odour. Concentrated acid is fuming.
Melting point: -25 C
Boiling point: 109 C
Specific gravity: 1.19
Vapour pressure:
Flash point:
Explosion limits:
Autoignition temperature:

Stability

Stable. Avoid heat, flames. Incompatible with most common metals, amines, metal oxides, acetic anhydride, propiolactone, vinyl acetate, mercuric sulphate, calcium phosphide, formaldehyde, alkalies, carbonates, strong bases, sulphuric acid, chlorosulphonic acid.

Toxicology

Extremely corrosive. Inhalation of vapour can cause serious injury. Ingestion may be fatal. Liquid can cause severe damage to skin and eyes. TLV 5 ppm.

Toxicity data

(The meaning of any abbreviations which appear in this section is given Annexure .)
ORL-RBT LD50 900 mg kg^{-1}
IPR-MUS LD50 40 mg kg^{-1}
IHL-RAT LC50 3124 ppm/1h.
IHL-HMN LCLO 1300 ppm 30min

Risk phrases

(The meaning of any risk phrases which appear in this section is given Annexure .)
R23 R24 R25 R34 R36 R37 R38. Transport information (The meaning of any UN hazard codes which appear in this section is given Annexure .) UN No 1789. Packing group II. Major hazard class 8.0. Transport category 2.

Environmental information

Lethal to fish from 25 mg/l up. Toxic for aquatic organisms due to pH shift.

Personal protection

Safety glasses or face mask, gloves. Effective ventilation.

Safety phrases

(The meaning of any safety phrases which appear in this section is given Annexure .)
S26 S36 S37 S39 S45.

Safety (MSDS) data for hydrogen peroxide, 50% solution

General

Synonyms: albone 30, albone 35, albone 50, albone 70, albone 35cg, albone 50cg, albone 70cg, interox, kastone, perone 30, perone 35, perone 50. Data also applies to solutions of similar strength.
Note: Typical concentrations lie in the range 3%-35%. Solutions of much higher concentration (e.g. 60% and above) present significantly increased risks, and should not be used unless such strength is absolutely essential.
Molecular formula: $H_2 O_2$
CAS No: 7722-84-1
EC No: 231-765-0

Physical data

Appearance: colourless liquid
Melting point: ca. -28 C
Boiling point: ca. 114 C
Specific gravity: typically near 1.19
Vapour pressure: 23.3 at 30 C
Flash point:
Explosion limits:
Autoignition temperature:

Stability

Unstable - readily decomposes to water and oxygen. Light sensitive. May develop pressure in the bottle - take care when opening. Forms potentially explosive compounds with ketones, ethers, alcohols, hydrazine, glycerine, aniline, sodium borate, urea, sodium carbonate, triethylamine, sodium fluoride, sodium pyrophosphate and carboxylic acid anhydrides. Materials to avoid include combustibles, strong reducing agents, most common metals, organic materials, metallic salts, alkali, porous materials, especially wood, asbestos, soil, rust, strong oxidizing agents.

Toxicology

Toxic. Corrosive - can causes serious burns. Eye contact can cause serious injury, possibly blindness. Harmful by inhalation, ingestion and skin contact. Typical OEL 1 ppm.

Transport information

(The meaning of any UN hazard codes which appear in this section is given ANNEXURE- .) UN Major hazard class 5.1. Packing group II. UN No 2014. EMS No 5.1-02.

Personal protection

Safety glasses are essential; acid-resistant gloves are suggested. Suitable ventilation.

Safety phrases

(The meaning of any safety phrases which appear in this section is given ANNEXURE- .)
S3 S28 S37 S39 S45

Safety (MSDS) data for sodium hydroxide

General

Synonyms: caustic soda, soda lye, lye, white caustic, aetznatron, ascarite, Collo-Grillrein, Collo-Tapetta, sodium hydrate, fotofoil etchant, NAOH, STCC 4935235, sodium hydroxide pellets, Lewis red devil lye
Molecular formula: NaOH
CAS No: 1310-73-2
EC No: 215-185-5
Annex I Index No: 011-002-00-6

Physical data

Appearance: odourless white solid (often sold as pellets)
Melting point: 318 C
Boiling point: 1390 C
Vapour density:
Vapour pressure: 1 mm Hg at 739 C
Specific gravity: 2.12
Flash point: n/a
Explosion limits: n/a
Autoignition temperature:
Water solubility: High (Note: dissolution in water is highly exothermic)

Stability

Stable. Incompatible with a wide variety of materials including many metals, ammonium compounds, cyanides, acids, nitro compounds, phenols, combustible organics. Hygroscopic. Heat of solution is very high and may lead to a dangerously hot solution if small amounts of water are used. Absorbs carbon dioxide from the air.

Toxicology

Very corrosive. Causes severe burns. May cause serious permanent eye damage. Very harmful by ingestion. Harmful by skin contact or by inhalation of dust. Typical TLV 2 mg m^{-1}.

Toxicity data

(The meaning of any abbreviations which appear in this section is given ANNEXURE- .)
IPR-MUS LD50 40 mg kg^{-1}

Irritation data

(The meaning of any abbreviations which appear in this section is given ANNEXURE- .)
EYE-MKY 1%/24h sev
SKN-RBT 500 mg/24h sev
EYE-RBT 1% sev

Risk phrases

(The meaning of any risk phrases which appear in this section is given ANNEXURE- .)
R35.

Transport information

(The meaning of any UN hazard codes which appear in this section is given ANNEXURE- .)
UN Major hazard class 8.0. Packing group II. UN No 1823. EMS No 8.0-06. **Personal protection**

Safety glasses, adequate ventilation, Neoprene or PVC gloves.

Safety phrases

(The meaning of any safety phrases which appear in this section is given ANNEXURE- .)
S26 S37 S39 S45.

Safety (MSDS) data for Thionyl chloride

General

Synonyms: sulfur chloride oxide, sulfurous oxychloride, sulfinyl chloride, sulfurous dichloride, thionyl dichloride
Molecular formula: $SOCl_2$
CAS No: 7719-09-7
EINECS No: 231-748-8
EU number 016-015-00-0

Physical data

Appearance: colourless, pale yellow or reddish liquid with a suffocating odour
Melting point: -104 C
Boiling point: 76 C
Vapour density: 4.6 (air = 1)
Vapour pressure: 97 mm Hg at 20 C
Density (g cm^{-3}): 1.64
Water solubility: decomposes

Stability

Reacts violently with water. Incompatible with most common metals, strong reducing agents, strong bases, alcohols, amines.

Toxicology

Poison. May be fatal if inhaled. Causes severe burns. May cause serious eye damage. Typical TLV 1 ppm STEL.

Toxicity data

(The meaning of any abbreviations which appear in this section is given ANNEXURE.)
IHL-RAT LD50 500 ppm/1h

Risk phrases

(The meaning of any risk phrases which appear in this section is given ANNEXURE)
R14 R20 R22 R29 R34 R35 R37.

Personal protection

Safety glasses, gloves, good ventilation.

Safety phrases

(The meaning of any safety phrases which appear in this section is given ANNEXURE)
S26 S36 S37 S39 S45.

Safety (MSDS) data for maleic acid

General

Synonyms: cis-butenedioic acid, toxilic acid
Molecular formula: HOCOCH:CHOOH
CAS No: 110-16-7
EC No:

Physical data

Appearance: white powder or crystals
Melting point: 138 C
Boiling point:
Vapour density:
Vapour pressure:
Density (g cm^{-3}): 1.59
Flash point:
Explosion limits:
Autoignition temperature:
Water solubility: appreciable

Stability

Stable. Combustible. Incompatible with strong oxidizing agents, bases.

Toxicology

Harmful if swallowed. Corrosive - causes irritation or burns.

Toxicity data

(The meaning of any abbreviations which appear in this section is given in Annexure.)
ORL-RAT LD50 708 mg kg^{-1}
ORL-MUS LD50 2400 mg kg^{-1}

Risk phrases

(The meaning of any risk phrases which appear in this section is given in Annexure.)
R22 R34.

Personal protection

Safety glasses. Avoid breathing dust.

Safety phrases

(The meaning of any safety phrases which appear in this section is given in Annexure.)

Safety (MSDS) data for p-toluenesulfonic acid

General

Synonyms: 4-methylbenzenesulfonic acid, cyzac 4040, K-cure 1040, manro ptsa 65E, manro ptsa 65H, manro ptsa 65 LS, p-toluenesulphonic acid, p-methylbenzenesulphonic acid, 4-toluenesulfonic acid, 4-toluenesulphonic acid, p-tolylsulfonic acid, tosic acid, p-methylbenzenesulfonic acid, TSA-HP, TSA-MH, P-TSA
Molecular formula: $C_7H_8O_3S.H_2O$
CAS No: 6192-52-5
EC No:

Physical data

Appearance: white crystals
Melting point: 103 - 106 C
Boiling point:
Vapour density:
Vapour pressure:
Specific gravity: 1.45
Flash point: 184 C
Explosion limits:
Autoignition temperature:

Stability

Stable. Incompatible with strong oxidizing agents, strong bases, most common metals. Protect from moisture.

Toxicology

May be harmful by inhalation, ingestion or skin absorption. Extremely destructive of mucous membranes. Severe irritant.

Toxicity data

(The meaning of any abbreviations which appear in this section is given Annexure)
ORL-RAT LD50 2480 mg kg^{-1} ORL-QAL LD50 >316 mg kg^{-1}

Risk phrases

(The meaning of any risk phrases which appear in this section is given Annexure)
R36 R37 R38.

Transport information

(The meaning of any UN hazard codes which appear in this section is given Annexure)
UN No 2585. Packing group III. Hazard class 8.0.

Personal protection

Safety glasses and rubber gloves. Adequate ventilation.

Safety phrases

(The meaning of any safety phrases which appear in this section is given Annexure)
S22 S26 S36 S37 S39 S45.

Abbreviations used in Toxicity data

The table below gives the main abbreviations which will be found in the toxicity data for chemicals listed on these (and many other) web pages.

asn	Aspergillus nidulans
ast	Ascites tumor
bcs	Bacillus subtilis
bfa	body fluid assay
bmr	bone marrow
brd	bird (domestic or lab)
bwd	wild bird species
chd	child
ckn	chicken
CL	ceiling concentration
clr	Chlamydomonas reinhardi
ctl	cattle
cyt	cytogenetic analysis
D	day
dck	duck
dlt	cominant lethal test
dmg	Drosophila melanogaster
dnd	DNA damage
dni	DNA inhibition
dnr	nNA repair
dns	unscheduled DNA synthesis
dom	domestic animal (goat, sheep)
dpo	Drcsophila pseudo-obscura
emb	embryo
esc	Escherichia cold
eug	Euglena gracilis
eye	administration into eye (irritant)
fb	fiber
fbr	fibroblast

frg	frog
gm	gram
gpg	guinea pig
grb	gerbil
grh	grasshopper
H	hour
ham	hamster
hla	HeIa cell
hma	host-mediated assay
hmi	Haemophilus influenzae
hmn	human
hor	horse, donkey
I	intermittent
ial	intraaural
IARC	International Agency for Research on Cancer
iat	intraarterial
ice	intracerebral
icv	intracervical
idr	intradermal
idu	intraduodenal
ihl	inhalation
imm	immersion
imp	implant
ims	intramuscular
inf	infant
ipc	intraplacental
ipl	intrapleural
ipr	intraperitoneal
irn	intrarenal
isp	intraspinal

itr	intratracheal
itt	intratesticular
iu	international unit
iut	intrauterine
ivg	intravaginal
ivn	intravenous
kdy	kidney
kg	kilogram
klp	Klebsiella pneumoniae
L	liter
LC50	lethal concentration 50 percent kill
LCLo	lowest published lethal concentration
LD50	lethal dose 50 percent kill
LDlo	lowest published lethal dose
leu	leukocyte
Liq	liquid
lng	lung
lvr	liver
lym	lymphocyte
M	minute
m3	cubic meter
mam	mammal (species unspecified)
man	man
ug	microgram
umol	micromole
mg	milligram
mky	monkey
mL	milliliter
MLD	mild irritation effects
mma	microsomal mutagenicity assay
mmo	mutation in microorganisms
mmol	millimole
mmr	mammary gland
mnt	micronucleus test
MOD	moderate irritation effects
mol	mole

mppcf	million particles per cubic foot
mrc	gene conversion and mitotic recombination
msc	mutation in mammalian somatic cells
mul	multiple routes
mus	mouse
n/a	not available
ng	nanogram
nml	non-mammalian species
nmol	nanomole
NOAEL	No Observed Adverse Effect Level
nsc	Neurospora crassa
ocu	ocular
ofs	other fish
omi	other microorganisms
oms	other mutation test systems
oin	other insects
open	open irritation test
orl	oral
ORM	Other Regulated Material (DoT)
oth	other cell types
otr	oncogenic transformation
ovr	ovary
par	parenteral
pg	picogram
pgn	pigeon
pic	phage inhibition capacity
pig	pig
Pk	peak concentration
pmol	picomole
post	after birth
ppb	parts per billion (v/v)
pph	parts per hundred (v/v) (percent)
ppm	parts per million (v/v)

ppt	parts per trillion (v/v)
preg	pregnant
qal	quail
rat	rat
rbt	rabbit
rec	rectal
rns	rinsed with water
S	second
sal	salmon
sat	Salmonella typhimurium
sce	sister chromatic exchange
scu	subcutaneous
SEV	severe irritation effects
skn	administration onto skin
sln	sex chromosome loss and nondisjunction
slt	specific locus test
slw	silkworm
smc	Saccharomyces cerevisiae
spm	sperm morphology
spr	sperm

sql	squirrel
srm	Serratia marcescens
ssp	Schizosaccharomyces pombe
STEL	short term exposure limit
TC	toxic concentration (other than lowest concentration)
TCLo	lowest published toxic concentration
TD	toxic dose (other than lowest toxic dose)
TDLo	lowest published toxic dose
tes	testis
TLV	Threshold Limit Value
tod	toad
trk	turkey
trn	heritable translocation test
TWA	time weighted average
unr	unreported
W	week
wmn	woman
Y	Year

EC Safety Phrases

Under EC legislation, data sheets available in the UK now contain codes for certain "safety phrases", shown as S1, S17 etc. These phrases are also extensively used elsewhere in the world. Safety phrase codes have the following meanings:

- S1 Keep locked up.
- S2 Keep out of the reach of children.
- S3 Keep in a cool place.
- S4 Keep away from living quarters.
- S5 Keep contents under ... (there follows the name of a liquid).
- S6 Keep under ... (there follows the name of an inert gas).
- S7 Keep container tightly closed.
- S8 Keep container dry.
- S9 Keep container in a well-ventilated place.
- S12 Do not keep the container sealed.
- S13 Keep away from food, drink and animal foodstuffs.
- S14 Keep away from ... (a list of incompatible materials will follow).
- S15 Keep away from heat.
- S16 Keep away from sources of ignition.
- S17 Keep away from combustible material.
- S18 Handle and open container with care.
- S20 When using, do not eat or drink.
- S21 When using do not smoke.
- S22 Do not breathe dust.
- S23 Do not breathe vapour.
- S24 Avoid contact with skin.
- S25 Avoid contact with eyes.
- S26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
- S27 Take off immediately all contaminated clothing.
- S28 After contact with skin, wash immediately with plenty of soap-suds.
- S29 Do not empty into drains.
- S30 Never add water to this product.
- S33 Take precautionary measures against static discharges.
- S35 This material and its container must be disposed of in a safe way.
- S36 Wear suitable protective clothing.
- S37 Wear suitable gloves.
- S38 In case of insufficient ventilation, wear suitable respiratory equipment.
- S39 Wear eye / face protection.
- S40 To clean the floor and all objects contaminated by this material, use .... (there follows suitable cleaning material).
- S41 In case of fire and / or explosion do not breathe fumes.
- S42 During fumigation / spraying wear suitable respiratory equipment.

- S43 In case of fire use ... (there follows the type of fire-fighting equipment to be used.)
- S45 In case of accident or if you feel unwell, seek medical advice immediately (show the label whenever possible.)
- S46 If swallowed, seek medical advice immediately and show this container or label.
- S47 Keep at temperature not exceeding...
- S48 To be kept wet with (there follows a material name).
- S49 Keep only in the original container.
- S50 Do not mix with ...
- S51 Use only in well ventilated areas.
- S52 Not recommended for interior use on large surface areas.
- S53 Avoid exposure - obtain special instructions before use.
- S56 Dispose of this material and its container at hazardous or special waste collection point.
- S57 Use appropriate container to avoid environmental contamination.
- S59 Refer to manufacturer / supplier for information on recovery / recycling.
- S60 This material and its container must be disposed of as hazardous waste.
- S61 Avoid release to the environment. Refer to special instructions / safety data sheets.
- S62 If swallowed, do not induce vomitting; seek medical advice immediately and show this container or label.

Glossary Definition - Hazard Codes

- Class 1 Explosive
  - 1.1 Substances with a mass explosion hazard
  - 1.2 Substances which present a projection hazard but no mass explosion hazard
  - 1.3 Substances which present both a fire hazard and a minor blast or projection hazard (or both) but not a mass explosion hazard
  - 1.4 No significant hazard
  - 1.5 Very insensitive substances with a mass explosion hazard
  - 1.6 Very insensitive articles with no mass explosion hazard
- Class 2 Gases
  - 2.1 Flammable gases
  - 2.2 Non-flammable, non-toxic gases
  - 2.3 Toxic gases
- Class 3 Flammable liquids
- Class 4 Flammable solids
  - 4.1 Flammable solids, self-reactive substances and solid desensitized explosives
  - 4.2 Materials liable to spontaneous combustion
  - 4.3 Substances which, in contact with water, release flammable gases
- Class 5. Oxidizing substances and organic peroxides
  - 5.1 Oxidizing agents
  - 5.2 Organic peroxides
- Class 6 Toxic and infectious substances
  - 6.1 Toxic substances
  - 6.2 Infectious substances
- Class 7 Radioactive substances and articles
- Class 8 Corrosive substances
- Class 9 Miscellaneous dangerous substances

Glossary Definition - Hazard Codes

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  - 4.3 Substances which, in contact with water, release flammable gases
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  - 5.1 Oxidizing agents
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  - 6.1 Toxic substances
  - 6.2 Infectious substances
- Class 7 Radioactive substances and articles
- Class 8 Corrosive substances
- Class 9 Miscellaneous dangerous substances

SITE DATA:
Location: HARIKA DRUGS, KANKUNTA, INDIA
Building Air Exchanges Per Hour: 0.30 (unsheltered single storied)
Time: January 11, 2018 1138 hours ST (using computer's clock)

CHEMICAL DATA:
Chemical Name: ISOPROPANOL (IPA) Molecular Weight: 60.10 g/mol
PAC-1: 400 ppm PAC-2: 400 ppm PAC-3: 12000 ppm
IDLH: 2000 ppm LEL: 20000 ppm UEL: 127000 ppm
Ambient Boiling Point: 82.0° C
Vapor Pressure at Ambient Temperature: 0.057 atm
Ambient Saturation Concentration: 57,551 ppm or 5.76%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 2 miles/hour from ese at 3 meters
Ground Roughness: open country Cloud Cover: 5 tenths
Air Temperature: 25° C Stability Class: B
No Inversion Height Relative Humidity: 50%

1. SOURCE STRENGTH:
Evaporating Puddle (Note: chemical is flammable)
Puddle Area: 4.9 square meters Puddle Volume: 25 cubic meters
Ground Type: Concrete Ground Temperature: 25° C
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Average Sustained Release Rate: 108 grams/min
(averaged over a minute or more)
Total Amount Released: 6.47 kilograms

THREAT ZONE:
Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Gaussian
Red : less than 10 meters(10.9 yards) --- (20000 ppm = LEL)
Note: Threat zone was not drawn because effects of near-field patchiness
make dispersion predictions less reliable for short distances.
Orange: less than 10 meters(10.9 yards) --- (2000 ppm = 10% LEL)
Note: Threat zone was not drawn because effects of near-field patchiness
make dispersion predictions less reliable for short distances.

Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Gaussian
Red : less than 10 meters(10.9 yards) --- (20000 ppm = LEL)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
Orange: less than 10 meters(10.9 yards) --- (2000 ppm = 10% LEL)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

2. SOURCE STRENGTH:

Evaporating Puddle (Note: chemical is flammable)
Puddle Area: 4.9 square meters Puddle Volume: 25 cubic meters
Ground Type: Concrete Ground Temperature: 25° C
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Average Sustained Release Rate: 108 grams/min
(averaged over a minute or more)
Total Amount Released: 6.47 kilograms

THREAT ZONE:

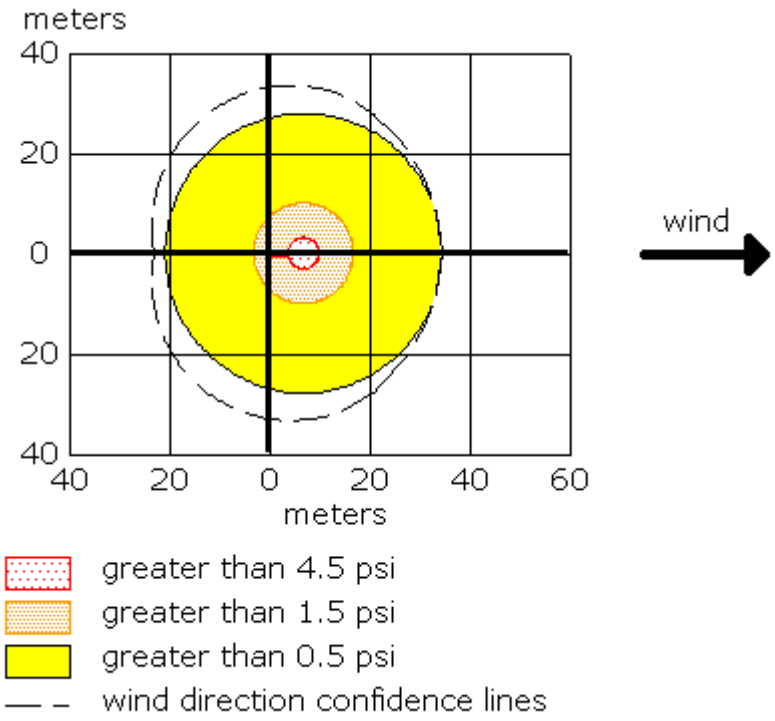
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Time of Ignition: 5 minutes after release begins
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Gaussian
No explosion: no part of the cloud is above the LEL at the given time

Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Time of Ignition: 5 minutes after release begins
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Gaussian
No explosion: no part of the cloud is above the LEL at the given time

3.SOURCE STRENGTH:

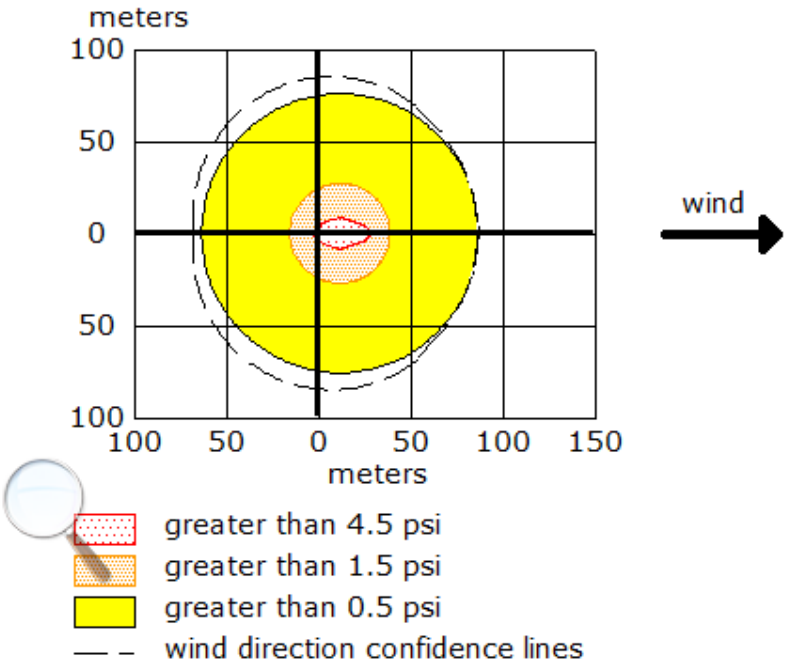
Direct Source: 0.108 kilograms/min Source Height: 0
Release Duration: 60 minutes
Release Rate: 108 grams/min
Total Amount Released: 6.48 kilograms

THREAT ZONE:
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Heavy Gas
Red : 10 meters --- (4.5 psi)
Orange: 17 meters --- (1.5 psi)
Yellow: 35 meters --- (0.5 psi)



Acetone

SITE DATA:
Location: HARIKA DRUGS S.REDDY, INDIA
Building Air Exchanges Per Hour: 0.48 (unsheltered single storied)
Time: December 3, 2017 1323 hours ST (using computer's clock)
CHEMICAL DATA CAS Number: 67-64-1 Molecular Weight: 58.08 g/mol
AEGL-1 (60 min): 200 ppm AEGL-2 (60 min): 3200 ppm AEGL-3 (60 min): 5700 ppm
LEL: 26000 ppm UEL: 130000 ppm
Ambient Boiling Point: 55.6° C
Vapor Pressure at Ambient Temperature: 0.30 atm
Ambient Saturation Concentration: 308,201 ppm or 30.8%
ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 2 meters/second from ese at 3 meters
Ground Roughness: open country Cloud Cover: 5 tenths
Air Temperature: 25° C Stability Class: B
No Inversion Height Relative Humidity: 50%
SOURCE STRENGTH:
Direct Source: 150 kilograms Source Height: 0
Release Duration: 1 minute
Release Rate: 2.5 kilograms/sec
Total Amount Released: 150 kilograms
THREAT ZONE:
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Heavy Gas
Red : 28 meters --- (4.5 psi)
Orange: 39 meters --- (1.5 psi)
Yellow: 87 meters --- (0.5 psi)

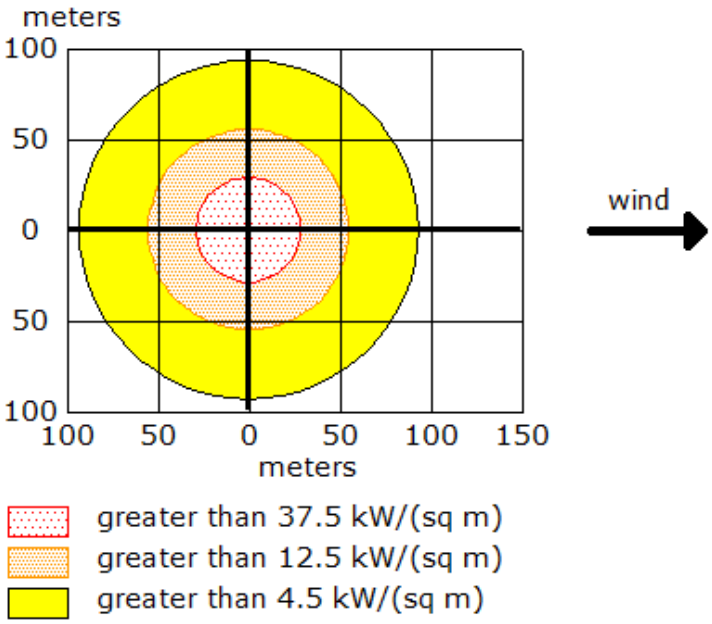


SOURCE STRENGTH:

BLEVE of flammable liquid in vertical cylindrical tank
Tank Diameter: 0.5 meters Tank Length: 1.02 meters
Tank Volume: 200 liters
Tank contains liquid
Internal Storage Temperature: 2° C
Chemical Mass in Tank: 150 kilograms
Tank is 92% full
Percentage of Tank Mass in Fireball: 100%
Fireball Diameter: 31 meters Burn Duration: 3 seconds

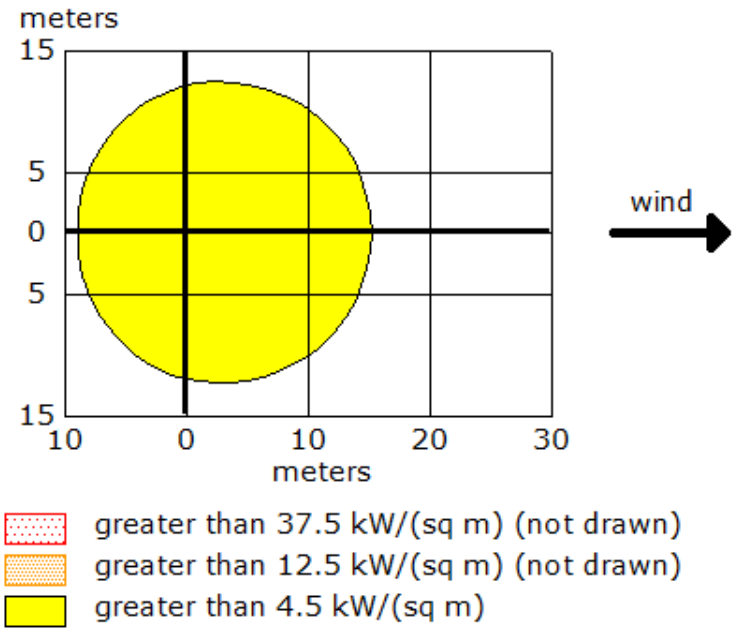
THREAT ZONE:

Threat Modeled: Thermal radiation from fireball
Red : 29 meters --- (37.5 kW/(sq m))
Orange: 55 meters --- (12.5 kW/(sq m))
Yellow: 93 meters --- (4.5 kW/(sq m))



SOURCE STRENGTH:

Leak from hole in vertical cylindrical tank
Flammable chemical is burning as it escapes from tank
Tank Diameter: 0.5 meters Tank Length: 1.02 meters
Tank Volume: 200 liters
Tank contains liquid Internal Temperature: 2° C
Chemical Mass in Tank: 150 kilograms
Tank is 92% full
Circular Opening Diameter: 6 centimeters
Opening is 10 centimeters from tank bottom
Max Flame Length: 8 meters Burn Duration: 3 minutes
Max Burn Rate: 66.3 kilograms/min
Total Amount Burned: 135 kilograms
Note: The chemical escaped as a liquid and formed a burning puddle.
The puddle spread to a diameter of 5.5 meters.



THREAT ZONE:

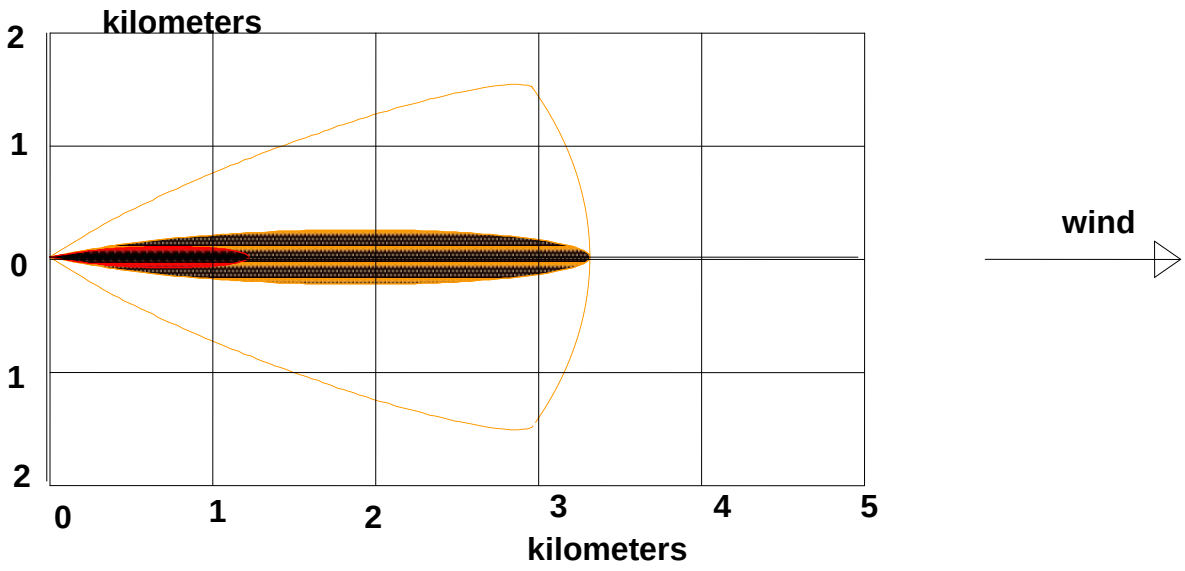
Threat Modeled: Thermal radiation from pool fire
Red : less than 10 meters(10.9 yards) --- (37.5 kW/(sq m))
Orange: less than 10 meters(10.9 yards) --- (12.5 kW/(sq m))
Yellow: 15 meters --- (4.5 kW/(sq m))

Thionyl chloride

Location: HARIKA DRUGS S.REDDY, INDIA
Building Air Exchanges Per Hour: 0.48 (unsheltered single storied)
Time: December 3, 2017 0940 hours ST (using computer's clock)

CHEMICAL DATA:
Warning: THIONYL CHLORIDE can react with water and/or water vapor to produce hydrochloric acid, sulfur dioxide and heat. ALOHA cannot accurately predict the air hazard if a reaction occurs.
Chemical Name: THIONYL CHLORIDE Molecular Weight: 118.97 g/mol
AEGL-1 (60 min): N/A AEGL-2 (60 min): 2.4 ppm AEGL-3 (60 min): 14 ppm
Ambient Boiling Point: 75.2° C
Vapor Pressure at Ambient Temperature: 0.16 atm
Ambient Saturation Concentration: 159,725 ppm or 16.0%
ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 2 meters/second from ESE at 3 meters
Ground Roughness: open country Cloud Cover: 5 tenths
Air Temperature: 25° C
Stability Class: B (user override)
No Inversion Height Relative Humidity: 50%
SOURCE STRENGTH:
Direct Source: 300 kilograms Source Height: 0
Release Duration: 1 minute
Release Rate: 5 kilograms/sec
Total Amount Released: 300 kilograms

THREAT ZONE: (GAUSSIAN SELECTED)
Model Run: Gaussian
Red : 1.2 kilometers --- (14 ppm)
Orange: 3.3 kilometers --- (1 ppm)



greater than 14 ppm

greater than 1 ppm

wind direction confidence lines

SOURCE STRENGTH:

Direct Source: 300 kilograms/hr Source Height: 0

Release Duration: 60 minutes

Release Rate: 5 kilograms/min

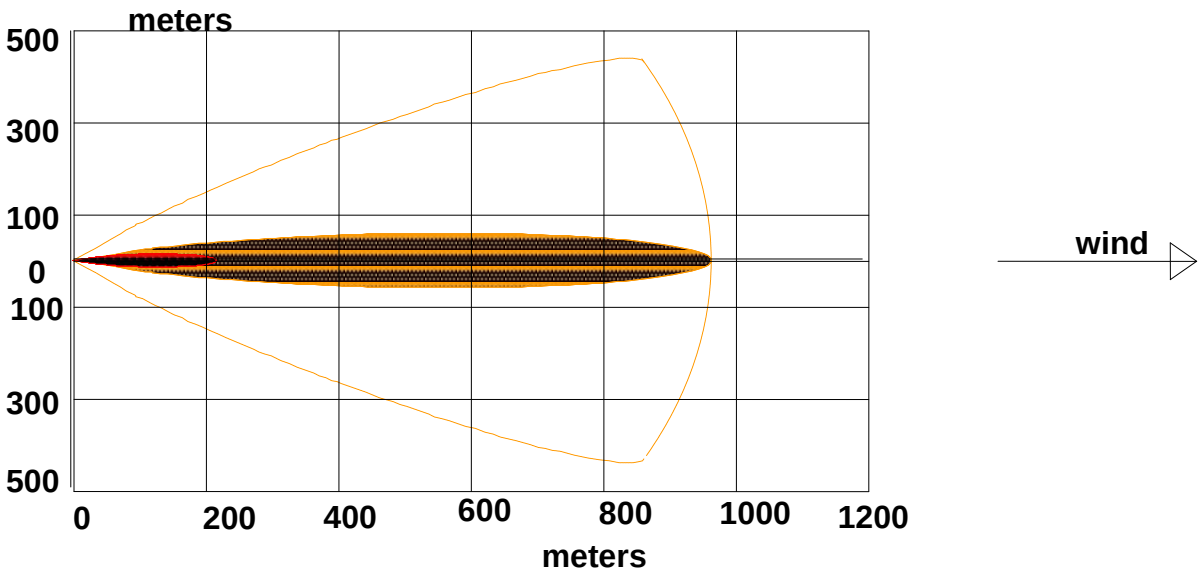
Total Amount Released: 300 kilograms

THREAT ZONE: (GAUSSIAN SELECTED)

Model Run: Gaussian

Red : 218 meters --- (14 ppm)

Orange: 965 meters --- (1 ppm)



greater than 14 ppm

greater than 1 ppm

wind direction confidence lines