Annexure 12

RISK ASSESSMENT REPORT

for

"Proposed Manufacturing of Speciality Chemicals and Agro Chemical Products"

By

M/s. Crimsun Organics Private Limited

At

SIPCOT Industrial Area

Plot NO. C-9, C-10 & C-11

VILLAGE: Kudikadu,

TALUK: Cuddalore

DISTRICT: Cuddalore

STATE: Tamil Nadu

Report Prepared by

(NABET Accredited vide Certificate No. NABET/EIA/1619/RA0083 Valid Till: 13-10-2019 & MoEF Recognized Lab vide F. No. Q-15018/7/2017-CPW)
HUBERT ENVIRO CARE SYSTEMS (P) LTD, CHENNAI

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ABBREVIATIONS

IMD	India Meterological Department
ALARP	As Low As Reasonably Practical
TNO	Thai National Observatory
NFPA	National Fire Protection Association
LFL	Lower Flammability Limit
UFL	Upper Flammability Limit
AAQ	Ambient Air Quality

1 INTRODUCTION

1.1 Purpose of the report

The purpose of the study is to identify and assess those hazards and risks arising from proposed “Proposed Manufacturing of Specialty Chemicals and Agro Chemical Products “” at Cuddalore SIPCOT Industrial Area, Plot No. C-9, C-10 & C-11, Kudikadu Village, Cuddaloe Taluk and District, Tamil Nadu State. M/s. Crimsun Organics Private Limited (COPL) is seeking Environmental Clearance.

Based on the available studies & plant layout, the potential scenarios which can cause significant consequences like Dispersion of vapour cloud, fire and explosion scenarios were identified.

The purpose of the study includes the following:

- To identify and assess those hazards and risks with NFPA rating.
- To eliminate or reduce to As Low As Reasonably Practical (ALARP) in terms of risk to human health, risk of injury, risk of damage to plant, equipment and environment, business interruption or loss etc.,
- To Suggest On-site and Off-site mitigative Measures.

1.2 Scope of the study

Hazard Identification and Risk Analysis including identification, screening of scenarios, consequence analysis of the various risk scenarios, recommendation and preparation of reports and relevant drawing showing damage and risk contours.

The scope of the study mainly involves:

- Identifications of Hazards
- Consequence modelling
  - ❖ Dispersion of Vapour cloud
  - ❖ Flash fire
  - ❖ Pool fire
  - ❖ Jet fire
  - ❖ Explosion
- Impact limits identifications
- Contour mapping of the risk on the layouts.
- Mitigating measures for handling and storage to reduce impacts & prevent incidents.

1.3 Methodology adopted

The Risk Assessment has been carried out by using the ALOHA software 5.4.5 (Aerial Locations of Hazardous Atmospheres) which was developed by office of Emergency management, EPA and Emergency Response Division, NOAA & PHAST Lite software 7.11 (Licence number 1603-120331(S-28502)) developed by DNV GL AS 2014.

1.4 Basic Facilities details

The basic facilities available in the layout are Solvent Storage tanks, Production block. The plant layout is shown in **Figure 1-1**.

Figure 1-1 Plant Layout

1.5 Storage tank details

The details of the storage tank are shown in **Table 2-1.**

Table 1-1 Storage tank details

S. no	Chemicals mixture Names	Quantity (MT)	Dia. (m)	Height/ Length (m)	Volume (m3)	No. of Tanks	Internal Temp. (^oC)	Internal Pressure (bar)	Type of Storage	Type (Vertical/ Horizontal)
1.	Sodium hydroxide (48%)	15	2.5	3	15	1	30-45	Atmospheric Pressure	AG Tank	Vertical
2.	Sulphuric Acid	20	2.5	3	15	1			AG Tank	Vertical
3.	Thionyl Chloride	15	2.5	3	15	1			AG Tank	Vertical
4.	Conc. HCl	15	2.5	4	20	1			AG Tank	Vertical
5.	Bromine	20	2.5	3	15	1			AG Tank	Vertical
6.	Liquor Ammonia (25%)	10	2.5	4	20	1			AG Tank	Vertical
7.	Toluene	20	3	4.5	30	1			UG Tank	Horizontal
8.	Methanol	20	3	4.5	30	1			UG Tank	Horizontal
9.	Cyclohexane	20	3	4.5	30	1			UG Tank	Horizontal
10.	Xylene	20	3	4.5	30	1			UG Tank	Horizontal
11.	Ethyl Alcohol	20	2.5	4	20	1			AG Tank	Vertical
12.	N Hexane	18	3	4.5	30	1			UG Tank	Horizontal
13.	Dimethylformamide (DMF)	10	2.5	3	15	1			AG Tank	Vertical
14.	Ethyl acetate	10	2.5	4	20	1			AG Tank	Vertical
15.	Dichloromethane (MDC)	15	2.5	3	15	1			AG Tank	Vertical
16.	1,2- Dichloroethane (EDC)	15	2.5	3	15	1			AG Tank	Vertical

1.6 Pipeline details

All the pipelines operated are at ambient temperature and atmospheric pressure conditions only. The details of the pipelines are shown in **Table 1-2.**

Table 1-2 Pipeline details

S. No	Pipe No./Name	Pipeline dia (mm)	Pipe Volume (Liters)	Pipeline length (m)	Operating Tempe (oc)	Operating Pressure (bar)	Chemical flowing	Connected to and from
1.	Sodium hydroxide (48%)	25	20	40	30-45	Atmospheric Pressure	Sodium hydroxide (48%)	Tank to Day tank
2.	Sulphuric Acid	25	29	60			Sulphuric Acid	Tank to Day tank
3.	Thionyl Chloride	25	29	60			Thionyl Chloride	Tank to Day tank
4.	Conc. HCl	25	29	60			Conc. HCl	Tank to Day tank
5.	Bromine	25	20	40			Bromine	Tank to Day tank
6.	Liquor Ammonia (25%)	25	20	40			Liquor Ammonia (25%)	Tank to Day tank
7.	Toluene	25	88	180			Toluene	Tank to Day tank
8.	Methanol	25	88	180			Methanol	Tank to Day tank
9.	Cyclohexane	25	88	180			Cyclohexane	Tank to Day tank
10.	Xylene	25	88	180			Xylene	Tank to Day tank
11.	Ethyl Alcohol	25	28	50			Ethyl Alcohol	Tank to Day tank
12.	N Hexane	25	88	180			N Hexane	Tank to Day tank
13.	Dimethyl formamide (DMF)	25	25	50			Dimethyl formamide (DMF)	Tank to Day tank
14.	Ethyl acetate	25	25	50			Ethyl acetate	Tank to Day tank
15.	Dichloromethane (MDC)	25	25	50			Dichloromethane (MDC)	Tank to Day tank
16.	1,2- Dichloroethane (EDC)	25	25	50			1,2- Dichloroethane (EDC)	Tank to Day tank

2 RISK ASSESSMENT METHODOLOGY

2.1 Identification of hazards & release scenarios

A technique commonly used to generate an incident list is to consider potential leaks and ruptures of all process pipelines and vessels/tanks. The following data were collected to envisage scenarios:

- Solvent Tank conditions (Operating temperature, pressure)
- Dimensions of the storage tank and pipelines
- Atmospheric conditions viz. Temperature, Humidity and Wind direction

2.1.1 Selection

The goal of selection is to limit the total number of incident outcome cases to be studied to a manageable size. The purpose of incident outcome selection is to develop a set of incident outcomes that must be studied for each incident included in the finalized incident study list. Each incident needs to be considered separately. Using the list of incident outcomes, the risk analyst needs to determine which may result from each incident. While the analyst can decide whether an incident involving the loss of a process chemical to the atmosphere needs to be examined using dispersion analysis because of potential toxic gas effects, what happens if the same material is immediately ignited on release.

2.1.2 Characterizing the Failures

Accidental release of flammable or toxic vapours can result in severe consequences. Delayed ignition of flammable vapours can result in blast overpressures covering large areas. This may lead to extensive loss of life and property. Toxic clouds may cover yet larger distances due to the lower threshold values in relation to those in case of explosive clouds (the lower explosive limits). In contrast, fires have localized consequences. Fires can be put out or contained in most cases; there are few mitigating actions one can take once a vapor cloud gets released. Major accident hazards arise, therefore, consequent upon the release of flammable or toxic vapors or BLEVE in case of pressurized liquefied gases. In an industry, main hazard arises due to storage and handling of hazardous chemicals. To formulate a structured approach to identification of hazards and understanding of contributory factors is essential.

2.1.3 Inventory

Inventory Analysis is commonly used in understanding the relative hazards and short listing of release scenarios. Inventory plays an important role in regard to the potential hazard. A practice commonly used to generate an incident list is to consider potential leaks and major releases from fractures of pipelines and vessels containing sizable inventories. The potential vapor release (source strength) depends upon the quantity of liquid release, the properties of the materials and the operating conditions (pressure, temperature). If all these influencing parameters are combined into a matrix and vapor source strength computed for each release case, a ranking should become a credible exercise.

2.1.4 Loss of Containment

Liquid Release may be instantaneous. Failure of a vessel leading to an instantaneous outflow assumes the sudden appearance of such a major crack that practically all of the contents above the crack shall be released in a very short time.

The more likely event is the case of liquid release from a hole in a pipe connected to the vessel. The flow rate will depend on the size of the hole as well as on the pressure in front of the hole, prior to the accident. Such pressure is basically dependent on the pressure in the vessel.

The vaporization of released liquid depends on the vapor pressure and weather conditions. Such consideration and others have been kept in mind both during the initial listing as well as during the short listing procedure. Initial listing of all significant inventories in the process plants was carried out. This ensured no omission through in advertence.

2.1.5 Factors considered for identification of hazards

In any installation, main hazard arises due to loss of containment during handling of flammable and toxic chemicals. The Chemicals are classified according to the properties and hazard class given by National Fire Protection Association (NFPA) is responsible for 380 codes and standards that are designed to minimize the risk and effects of fire by establishing criteria for building, processing, design, service and installation.

NFPA classification (**Table 2-1**) for Health, Flammability & Reactivity of a chemical is on a scale from 0-4 least to worst. As per the NFPA Rating on the scale from 0-4 the chemicals having 3 & 4 are considered are highly hazardous and considered for analysis.

Table 2-1 NFPA Classification

Rating	Health	Fire
0	No hazard	will not burn
1	Can cause significant irritation	must be preheated before ignition occur
2	Can cause temporary incapacitation or residual injury	must be heated or high ambient temperature to burn
3	Can cause serious or permanent injury	can be ignited under almost all ambient
4	Can be lethal	Will vaporize and readily burn at normal temp

NFPA provides standard for the chemicals to reduce the risk of fire and other hazards which are mentioned in **Table 2-2.**

Table 2-2 Chemical properties and classification

S. No	Chemical	Boiling Point (°C)	Flash point (°C)	NFPA Rating		
				Health	Fire	Reactivity
1.	Sodium hydroxide (48%)	1388	NA	3	0	1
2.	Sulphuric Acid	270	NA	3	0	2
3.	Thionyl Chloride	76	NA	4	0	2
4.	Conc. HCl	108.58	NA	3	0	1
5.	Bromine	58.78	NA	3	0	0
6.	Liquor Ammonia (25%)	NA	NA	2	0	0
7.	Toluene	110.6	4.44	2	3	0
8.	Methanol	64.5	12	2	3	0
9.	Cyclo hexane	80.7	-18	1	3	0
10.	Xylene	138.5	24	2	3	0
11.	Ethyl Alcohol	78.5	18.5	2	3	0
12.	N Hexane	68	-22.5	2	3	0
13.	Dimethyl formamide (DMF)	153	57.77	1	2	0
14.	Ethyl acetate	99.4	-2	2	3	2
15.	Dichloromethane (MDC)	39.75	NA	2	1	0
16.	1,2- Dichloroethane (EDC)	13	83.5	2	3	0

As per the NFPA rating, the chemicals like Sodium hydroxide (48%), Sulphuric Acid, Thionyl Chloride, Conc. HCl, Bromine exhibit health hazard, however acids are reactable with water and may mislead the interpretation so risk assessment was not carried out. Toluene, Methanol, Cyclo hexane, Xylene, Ethyl Alcohol, N Hexane, are stored underground and Ethyl acetate and 1,2- Dichloroethane (EDC) are stored above ground which exhibits fire hazards.

2.2 Types of outcome events

In this section of the report we describe the probabilities associated with the sequence of occurrences which must take place for the incident scenarios to produce hazardous effects and the modelling of their effects.

Considering the present case, the outcomes expected are

- Jet fire
- Flash Fire
- Vapour Cloud
- Pool Fire

2.2.1 Jet fire

Jet fire occurs when a pressurized release (of a flammable gas or vapour) is ignited by any source. They tend to be localized in effect and are mainly of concern in establishing the potential for domino effects and employee safety zones rather than for community risks.

The jet fire model is based on the radiant fraction of total combustion energy, which is assumed to arise from a point slowly along the jet flame path. The jet dispersion model gives the jet flame length.

2.2.2 Flash fire

A flash fire is the non-explosive combustion of a vapour cloud resulting from a release of flammable material into the open air, which after mixing with air, ignites. A flash fire results from the ignition of a released flammable cloud in which there is essentially no increase in combustion rate. The ignition source could be electric spark, a hot surface, and friction between moving parts of a machine or an open fire. Part of the reason for flash fires is that, flammable fuels have a vapour temperature, which is less than the ambient Temperature. Hence, as a result of a spill, they are dispersed initially by the negative buoyancy of cold vapors and subsequently by the atmospheric turbulence. After the release and dispersion of the flammable fuel the resulting vapour cloud is ignited and when the fuel vapour is not mixed with sufficient air prior to ignition, it results in diffusion fire burning. Therefore the rate at which the fuel vapour and air are mixed together during combustion determines the rate of burning in the flash fire.

The main dangers of flash fires are radiation and direct flame contact. The size of the flammable cloud determines the area of possible direct flame contact effects. Radiation effects on a target

depend on several factors including its distance from the flames, flame height, flame emissive power, local atmospheric transitivity and cloud size.

2.2.3 Vapor cloud

Vapour cloud is the result of flammable materials in the atmosphere, a subsequent dispersion phase, and after some delay an ignition of the vapour cloud. Turbulence is the governing factor in blast generation, which could intensify combustion to the level that will result in an explosion. Obstacles in the path of vapour cloud or when the cloud finds a confined area, as under the bullets, often create turbulence. Insignificant level of confinement will result in a flash fire. The vapour cloud will result in overpressures.

It may be noted that vapour cloud has been responsible for very serious accidents involving severe property damage and loss of lives.

2.2.4 Pool fire

This represents a situation when flammable liquid spillage forms a pool over a liquid or solid surface and gets ignited. Flammable liquids can be involved in pool fires where they are stored and transported in bulk quantities. Early pool fire was caused when the steady state is reached between the outflow of flammable material from the container and complete combustion of the flammable material when the ignition source is available. Late pool fires are associated with the difference between the release of material and the complete combustion of the material simultaneously. Late pool fires are common when large quantity of flammable material is released within short time.

2.3 Heat Radiation

The effect of fire on a human being is in the form of burns. There are three categories of burn such as first degree, second degree and third degree burns. The consequences caused by exposure to heat radiation are a function of:

- The radiation energy onto the human body [kW/m^2];
- The exposure duration [sec];
- The protection of the skin tissue (clothed or naked body).

The limits for 1% of the exposed people to be killed due to heat radiation, and for second-degree burns are given in **Table 2-3**:

Table 2-3 Damages to Human Life Due to Heat Radiation

Exposure Duration	Radiation energy (1% lethality, kW/m2)	Radiation energy for 2nd degree burns, kW/m2	Radiation energy for first degree burns, kW/m2
10 sec	21.2	16	12.5
30 sec	9.3	7	4

The effects due to incident radiation intensity are given in **Table 2-4.**

Table 2-4 Effects due To Incident Radiation Intensity

	TYPE OF DAMAGE
0.7	Equivalent to Solar Radiation
1.6	No discomfort for long exposure
4.0	Sufficient to cause pain within 20 sec. Blistering of skin (first degree burns are likely)
9.5	Pain threshold reached after 8 sec. second degree burns after 20 sec.
12.5	Minimum energy required for piloted ignition of wood, melting plastic tubing's etc.
37.5	Heavy Damage to process equipment

2.4 Type of damage

The actual results would be less severe due to the various assumptions made in the models arising out of the flame geometry, emissivity, angle of incidence, view factor and others. The radiative output of the flame would be dependent upon the fire size, extent of mixing with air and the flame temperature. Some fraction of the radiation is absorbed by carbon dioxide and water vapour in the intervening atmosphere. Finally, the incident flux at an observer location would depend upon the radiation view factor, which is a function of the distance from the flame surface, the observer's orientation and the flame geometry.

Assumptions made for the study

- The lethality of a jet fire is assumed to be 100% for the people who are caught in the flame. Outside the flame area, the lethality depends on the heat radiation distances.
- For the flash fires lethality is taken as 100% for all the people caught outdoors and for 10% who are indoors within the flammable cloud. No fatality has been assumed outside the flash fire area.

2.5 Explosion

In case of vapour cloud explosion, two physical effects may occur:

1. A flash fire over the whole length of the explosive gas cloud;
2. A blast wave, with typical peak overpressures circular around ignition source.

For the blast wave, the lethality criterion is based on:

A peak overpressure of 0.1bar will cause serious damage to 10% of the housing/structures. Falling fragments will kill one of each eight persons in the destroyed buildings.

The following damage criteria may be distinguished with respect to the peak over pressures resulting from a blast wave is shown in **Table 2-5.**

Table 2-5 Effects of Overpressure

Peak Overpressure	Damage Type	Description
0.30 bar	Heavy Damage	Major damage to plant equipment structure
0.10 bar	Moderate Damage	Repairable damage to plant equipment & structure
0.03 bar	Significant Damage	Shattering of glass
0.01 bar	Minor Damage	Crack in glass

Assumptions for the study

- Overpressure more than 0.3 bar corresponds approximately with 50% lethality.
- An overpressure above 0.2 bar would result in 10% fatalities.
- An overpressure less than 0.1 bar would not cause any fatalities to the public.
- 100% lethality is assumed for all people who are present within the cloud proper.

3 CONSEQUENCE ANALYSIS

3.1 Scenarios possible

As large number of failure cases can lead to the same type of consequences, representative failure cases are selected for this analysis. The failure cases are based on conservative assumptions. Typically, failure models considered 100% catastrophic rupture of tanks. The scenarios are discussed one at a time.

3.2 Weather probabilities

3.2.1 Wind velocity & stability class

As per CPR 18E there are 6 representative weather classes are given in **Table 3-1.**

Table 3-1 Pasquill – Giffard Atmospheric Stability

S.No.	Stability Class	Weather Conditions
1	A	Very unstable - Sunny, light wind
2	A/B	Unstable - as with A only less sunny or more windy
3	B	Unstable - as with A/B only less sunny or more windy
4	B/C	Moderately unstable – moderate sunny and moderate wind
5	C	Moderately unstable – very windy / sunny or overcast / light wind
6	C/D	Moderate unstable – moderate sun and high wind
7	D	Neutral – little sun and high wind or overcast / windy night
8	E	Moderately stable – less overcast and less windy night
9	F	Stable – night with moderate clouds and light / moderate wind
10	G	Very stable – possibly fog

3.2.2 Weather input

The atmospheric data for the moderate and worst scenario is shown in **Table 3-2.**

Table 3-2 Atmospheric data (Manual Inputs considered)

Weather Conditions	**Moderate**	
Wind speed (m/s)	1.5	5
Stability Class	D	
Wind Direction	E to W	
Temperature (°C)	32	
Humidity (%)	80	
Source	IMD	

3.3 Accident scenarios for this project

3.3.1 Consequence analysis for the solvent tank considered

The input detail of storage solvent tank is given in **Table 3-3**.

Table 3-3 Input details of storage tank

S. no	Chemicals mixture Names	Quantity (MT)	Dia. (m)	Length (m)	Volume (m3)	No. of Tanks	Internal Temp. (^oC)	Internal Pressure (bar)	Type of Storage	Type (Vertical/ Horizontal)
1.	Bromine	15	2.5	4	15	1	30-35	Atmospheric	Above Ground	Vertical
2.	Ethyl Alcohol	15	2.5	4	20	1			Above Ground	Vertical
3.	Dimethyl Formamide (DMF)	10	2.5	3.5	15	1			Above Ground	Vertical
4.	Ethyl acetate	10	2.5	4	20	1			Above Ground	Vertical
5.	1,2- Dichloro Ethane (EDC)	15	2.5	3.5	15	1			Above Ground	Vertical

As per the NFPA rating, the fire hazard is observed in all the chemicals. The chemicals like Sodium hydroxide (48%), Sulphuric Acid, Thionyl Chloride, Conc. HCl, Bromine exhibit health hazard, however acids are reactable with water and may mislead the interpretation so risk assessment was not carried out. Toluene, Methanol, Cyclo hexane, Xylene, Ethyl Alcohol, N Hexane, are stored underground and Ethyl acetate and 1,2- Dichloroethane (EDC) are stored above ground which exhibits fire hazards.

Consequence Results

Scenario -1: Leak of Ethanol.

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
SOURCE STRENGTH: Leak from hole in vertical cylindrical tank Flammable chemical escaping from tank (not burning) Tank Diameter: 2.5 meters Tank Length: 4 meters Tank Volume: 19.6 cubic meters Tank contains liquid Internal Temperature: 32° C Chemical Mass in Tank: 13.5 tons Tank is 80% full Circular Opening Diameter: 0.01 meters Opening is 2.40 meters from tank bottom Ground Type: Default soil Ground Temperature: equal to ambient Max Puddle Diameter: Unknown Release Duration: ALOHA limited the duration to 1 hour Max Average Sustained Release Rate: 1.42 kilograms/min (averaged over a minute or more) Total Amount Released: 54.1 kilograms Note: The chemical escaped as a liquid and formed an evaporating puddle. The puddle spread to a diameter of 7.3 meters.	**SOURCE STRENGTH:** Leak from hole in vertical cylindrical tank Flammable chemical escaping from tank (not burning) Tank Diameter: 2.5 meters Tank Length: 4 meters Tank Volume: 19.6 cubic meters Tank contains liquid Internal Temperature: 32° C Chemical Mass in Tank: 13.5 tons Tank is 80% full Circular Opening Diameter: 0.01 meters Opening is 2.40 meters from tank bottom Ground Type: Default soil Ground Temperature: equal to ambient Max Puddle Diameter: Unknown Release Duration: ALOHA limited the duration to 1 hour Max Average Sustained Release Rate: 2.22 kilograms/min (averaged over a minute or more) Total Amount Released: 91.8 kilograms Note: The chemical escaped as a liquid and formed an evaporating puddle. The puddle spread to a diameter of 6.3 meters.

Case- 1 Toxic Area of Vapor cloud

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
THREAT ZONE: Model Run: Gaussian **Red** : no recommended LOC value --- (N/A = ERPG-3) **Orange**: less than 10 meters(10.9 yards) --- (3300 ppm = ERPG-2) **Note**: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Yellow**: less than 10 meters(10.9 yards) --- (1800 ppm = ERPG-1) **Note**: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.	**THREAT ZONE:** **Model Run**: Gaussian **Red** : no recommended LOC value --- (N/A = ERPG-3) **Orange**: less than 10 meters(10.9 yards) --- (3300 ppm = ERPG-2) **Note**: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Yellow**: less than 10 meters(10.9 yards) --- (1800 ppm = ERPG-1) **Note**: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

Case-2 Flammable Area of Vapor cloud

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
THREAT ZONE: **Threat Modeled:** Flammable Area of Vapor Cloud Model Run: Gaussian **Red** : less than 10 meters(10.9 yards) --- (19800 ppm = 60% LEL = Flame Pockets) Note: Threat zone was not drawn because effects of near-field	**THREAT ZONE:** **Threat Modeled**: Flammable Area of Vapor Cloud Model Run: Gaussian **Red** : less than 10 meters(10.9 yards) --- (19800 ppm = 60% LEL = Flame Pockets) Note: Threat zone was not drawn because effects of near-field

patchiness make dispersion predictions less reliable for short distances. **Yellow**: less than 10 meters(10.9 yards) --- (3300 ppm = 10% LEL) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.	patchiness make dispersion predictions less reliable for short distances. **Yellow**: less than 10 meters(10.9 yards) --- (3300 ppm = 10% LEL) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

Case-3 Blast Area of Vapor cloud

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
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: Gaussian No explosion: no part of the cloud is above the LEL at any time	**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: Gaussian No explosion: no part of the cloud is above the LEL at any time

Case-4 Thermal radiation from pool fire

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
SOURCE STRENGTH: Leak from hole in vertical cylindrical tank Flammable chemical is burning as it escapes from tank	

Tank Diameter: 2.5 meters Tank Length: 4 meters Tank Volume: 19.6 cubic meters

Tank contains liquid Internal Temperature: 32° C

Chemical Mass in Tank: 13.5 tons Tank is 80% full Circular Opening Diameter: 0.01 meters

Opening is 2.40 meters from tank bottom Max Puddle Diameter: Unknown

Max Flame Length: 3 meters Burn Duration: ALOHA limited the duration to 1 hour

Max Burn Rate: 3.61 kilograms/min Total Amount Burned: 209 kilograms

Note: The chemical escaped as a liquid and formed a burning puddle.

The puddle spread to a diameter of 1.7 meters.

THREAT ZONE:

Threat Modeled: Thermal radiation from pool fire

Red : less than 10 meters(10.9 yards) --- (10.0 kW/(sq m) = potentially lethal within 60 sec)

Orange: less than 10 meters(10.9 yards) --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)

Yellow: less than 10 meters(10.9 yards) --- (2.0 kW/(sq m) = pain within 60 sec)

Case-5 Thermal radiation from Fireball

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D

SOURCE STRENGTH:

BLEVE of flammable liquid in vertical cylindrical tank

Tank Diameter: 2.5 meters Tank Length: 4 meters

Tank Volume: 19.6 cubic meters

Tank contains liquid

Internal Storage Temperature: 32° C Chemical Mass in Tank: 13.5 tons Tank is 80% full

Percentage of Tank Mass in Fireball: 100% Fireball Diameter: 134 meters Burn Duration: 9 seconds

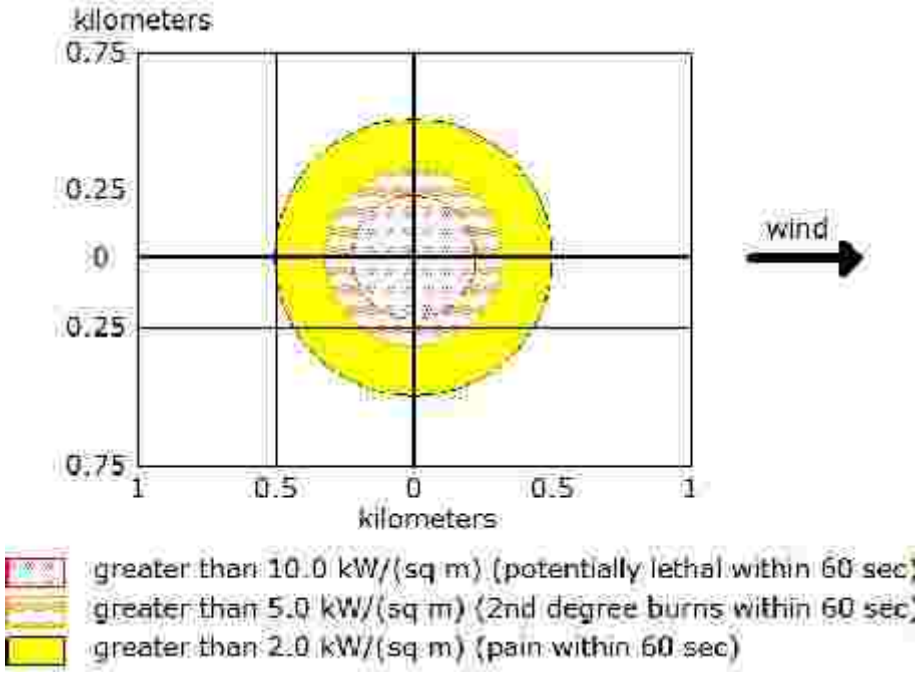
THREAT ZONE:

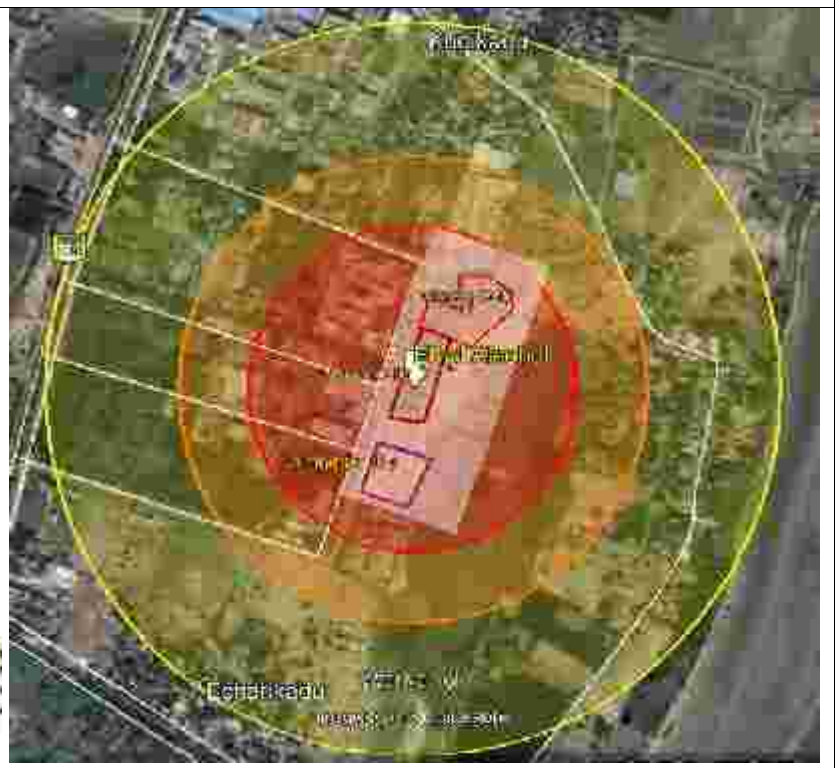
Threat Modeled: Thermal radiation from fireball

Red : 215 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)

Orange: 308 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)

Yellow: 483 meters --- (2.0 kW/(sq m) = pain within 60 sec)





Scenario -2: Leak of Dimethyl Formamide Storage tank.

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
SOURCE STRENGTH: Leak from hole in vertical cylindrical tank Flammable chemical escaping from tank (not burning) Tank Diameter: 2.5 meters Tank Length: 3.5 meters Tank Volume: 17.2 cubic meters Tank contains liquid Internal Temperature: 32° C Chemical Mass in Tank: 14.2 tons Tank is 80% full Circular Opening Diameter: 0.01 meters Opening is 2.10 meters from tank bottom Ground Type: Default soil Ground Temperature: equal to ambient Max Puddle Diameter: Unknown Release Duration: ALOHA limited the duration to 1 hour Max Average Sustained Release Rate: 207 grams/min (averaged over a minute or more) Total Amount Released: 7.20 kilograms Note: The chemical escaped as a liquid and formed an evaporating puddle. The puddle spread to a diameter of 7.9 meters.	**SOURCE STRENGTH:** Leak from hole in vertical cylindrical tank Flammable chemical escaping from tank (not burning) Tank Diameter: 2.5 meters Tank Length: 3.5 meters Tank Volume: 17.2 cubic meters Tank contains liquid Internal Temperature: 32° C Chemical Mass in Tank: 14.2 tons Tank is 80% full Circular Opening Diameter: 0.01 meters Opening is 2.28 meters from tank bottom Ground Type: Default soil Ground Temperature: equal to ambient Max Puddle Diameter: Unknown Release Duration: ALOHA limited the duration to 1 hour Max Average Sustained Release Rate: 738 grams/min (averaged over a minute or more) Total Amount Released: 24.7 kilograms Note: The chemical escaped as a liquid and formed an evaporating puddle. The puddle spread to a diameter of 7.6 meters.

Case- 1 Toxic Area of Vapor cloud

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
THREAT ZONE: Model Run: Gaussian **Red** : less than 10 meters(10.9 yards) --- (530 ppm = AEGL-3 [60 min]) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Orange**: 13 meters --- (91 ppm = AEGL-2 [60 min]) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Yellow**: no recommended LOC value --- (N/A = AEGL-1 [60 min])	

Case-2 Flammable Area of Vapor cloud

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
THREAT ZONE: Threat Modeled: Flammable Area of Vapor Cloud Model Run: Gaussian **Red** : less than 10 meters(10.9 yards) --- (13800 ppm = 60% LEL = Flame Pockets) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Yellow**: less than 10 meters(10.9 yards) --- (2300 ppm = 10% LEL) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.	

Case-3 Blast Area of Vapor cloud

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
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: Gaussian No explosion: no part of the cloud is above the LEL at any time	

Case-4 Thermal radiation from pool fire

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D

SOURCE STRENGTH:

Leak from hole in vertical cylindrical tank

Flammable chemical is burning as it escapes from tank

Tank Diameter: 2.5 meters Tank Length: 3.5 meters Tank Volume: 17.2 cubic meters

Tank contains liquid Internal Temperature: 32° C Chemical Mass in Tank: 14.2 tons Tank is 80% full

Circular Opening Diameter: 0.01 meters Opening is 2.10 meters from tank bottom

Max Puddle Diameter: Unknown Max Flame Length: 3 meters

Burn Duration: ALOHA limited the duration to 1 hour

Max Burn Rate: 3.96 kilograms/min Total Amount Burned: 228 kilograms

Note: The chemical escaped as a liquid and formed a burning puddle.

The puddle spread to a diameter of 1.6 meters.

THREAT ZONE:

Threat Modeled: Thermal radiation from pool fire

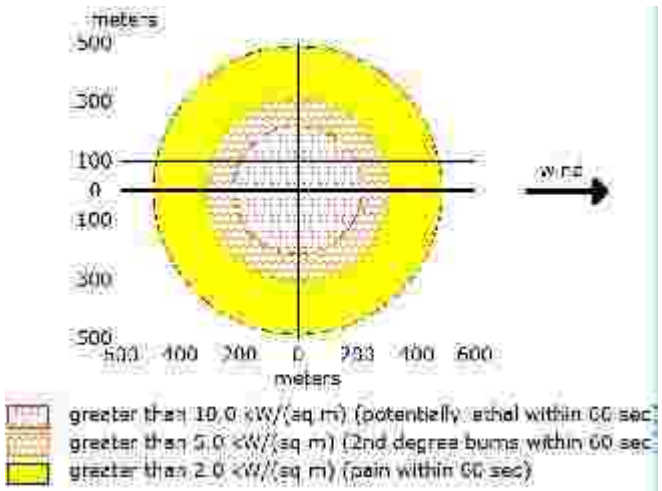
Red : less than 10 meters(10.9 yards) --- (10.0 kW/(sq m) = potentially lethal within 60 sec)

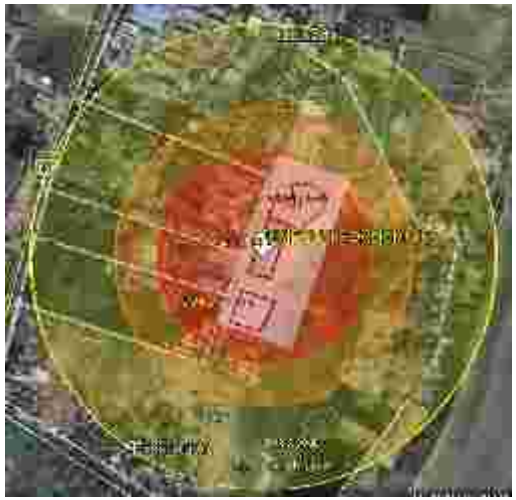
Orange: less than 10 meters(10.9 yards) --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)

Yellow: less than 10 meters(10.9 yards) --- (2.0 kW/(sq m) = pain within 60 sec)

Case-5 Thermal radiation from Fireball

Wind speed- 1.5 m/s **Stability Class**- D		**Wind speed**- 5 m/s **Stability Class**- D
SOURCE STRENGTH:		
BLEVE of flammable liquid in vertical cylindrical tank		
Tank Diameter: 2.5 meters	Tank Length: 3.5 meters	Tank Volume: 17.2 cubic meters
Tank contains liquid		
Internal Storage Temperature: 32° C	Chemical Mass in Tank: 14.2 tons	Tank is 80% full
Percentage of Tank Mass in Fireball: 100%	Fireball Diameter: 136 meters	Burn Duration: 10 seconds
THREAT ZONE:		
Threat Modeled: Thermal radiation from fireball		
Red : 217 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)		
Orange: 312 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)		
Yellow: 490 meters --- (2.0 kW/(sq m) = pain within 60 sec)		





Scenario -3: Leak of Ethyl Acetate Storage tank.

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
SOURCE STRENGTH: Leak from hole in vertical cylindrical tank Flammable chemical escaping from tank (not burning) Tank Diameter: 2.5 meters Tank Length: 4.5 meters Tank Volume: 22.1 cubic meters Tank contains liquid Internal Temperature: 32° C Chemical Mass in Tank: 17.2 tons Tank is 80% full Circular Opening Diameter: 0.01 meters Opening is 3.15 meters from tank bottom Ground Type: Default soil Ground Temperature: equal to ambient Max Puddle Diameter: Unknown Release Duration: ALOHA limited the duration to 1 hour Max Average Sustained Release Rate: 2.55 kilograms/min (averaged over a minute or more) Total Amount Released: 104 kilograms Note: The chemical escaped as a liquid and formed an evaporating puddle. The puddle spread to a diameter of 6.0 meters.	**SOURCE STRENGTH:** Leak from hole in vertical cylindrical tank Flammable chemical escaping from tank (not burning) Tank Diameter: 2.5 meters Tank Length: 4.5 meters Tank Volume: 22.1 cubic meters Tank contains liquid Internal Temperature: 32° C Chemical Mass in Tank: 17.2 tons Tank is 80% full Circular Opening Diameter: 0.01 meters Opening is 3.15 meters from tank bottom Ground Type: Default soil Ground Temperature: equal to ambient Max Puddle Diameter: Unknown Release Duration: ALOHA limited the duration to 1 hour Max Average Sustained Release Rate: 3.3 kilograms/min (averaged over a minute or more) Total Amount Released: 153 kilograms Note: The chemical escaped as a liquid and formed an evaporating puddle. The puddle spread to a diameter of 4.7 meters.

Case- 1 Toxic Area of Vapor cloud

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
THREAT ZONE: Model Run: Heavy Gas **Red** : less than 10 meters(10.9 yards) --- (10000 ppm = PAC-3) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Orange**: 17 meters --- (1700 ppm = PAC-2) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Yellow**: 21 meters --- (1200 ppm = PAC-1) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.	**THREAT ZONE:** Model Run: Gaussian **Red** : less than 10 meters(10.9 yards) --- (10000 ppm = PAC-3) 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) --- (1700 ppm = PAC-2) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Yellow**: less than 10 meters(10.9 yards) --- (1200 ppm = PAC-1) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

Case-2 Flammable Area of Vapor cloud

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
THREAT ZONE: Threat Modeled: Flammable Area of Vapor Cloud Model Run: Heavy Gas **Red** : less than 10 meters(10.9 yards) --- (13080 ppm = 60% LEL = Flame Pockets) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Yellow**: 14 meters --- (2180 ppm = 10% LEL) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.	**THREAT ZONE:** Threat Modeled: Flammable Area of Vapor Cloud Model Run: Gaussian **Red** : less than 10 meters(10.9 yards) --- (13080 ppm = 60% LEL = Flame Pockets) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Yellow**: less than 10 meters(10.9 yards) --- (2180 ppm = 10% LEL) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

Case-3 Blast Area of Vapor cloud

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
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** : LOC was never exceeded --- (8.0 psi = destruction of buildings) **Orange**: less than 10 meters(10.9 yards) --- (3.5 psi = serious injury likely) Yellow: less than 10 meters(10.9 yards) --- (1.0 psi = shatters glass)	**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: Gaussian No explosion: no part of the cloud is above the LEL at any time

Case-4 Thermal radiation from pool fire

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
SOURCE STRENGTH: Leak from hole in vertical cylindrical tank Flammable chemical is burning as it escapes from tank Tank Diameter: 2.5 meters Tank Length: 4.5 meters Tank Volume: 22.1 cubic meters Tank contains liquid Internal Temperature: 32° C Chemical Mass in Tank: 17.2 tons Tank is 80% full Circular Opening Diameter: 0.01 meters Opening is 3.15 meters from tank bottom Max Puddle Diameter: Unknown Max Flame Length: 3 meters Burn Duration: ALOHA limited the duration to 1 hour Max Burn Rate: 3.85 kilograms/min Total Amount Burned: 226 kilograms Note: The chemical escaped as a liquid and formed a burning puddle. The puddle spread to a diameter of 1.3 meters.	
THREAT ZONE: Threat Modeled: Thermal radiation from pool fire **Red** : less than 10 meters(10.9 yards) --- (10.0 kW/(sq m) = potentially lethal within 60 sec) **Orange**: less than 10 meters(10.9 yards) --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec) **Yellow**: less than 10 meters(10.9 yards) --- (2.0 kW/(sq m) = pain within 60 sec)	**THREAT ZONE:** Threat Modeled: Thermal radiation from pool fire **Red** : less than 10 meters(10.9 yards) --- (10.0 kW/(sq m) = potentially lethal within 60 sec) **Orange**: less than 10 meters(10.9 yards) --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec) **Yellow**: less than 10 meters(10.9 yards) --- (2.0 kW/(sq m) = pain within 60 sec)

Case-5 Thermal radiation from Fireball

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D

SOURCE STRENGTH:

BLEVE of flammable liquid in vertical cylindrical tank

Tank Diameter: 2.5 meters Tank Length: 4.5 meters Tank Volume: 22.1 cubic meters

Tank contains liquid

Internal Storage Temperature: 32° C Chemical Mass in Tank: 17.2 tons Tank is 80% full

Percentage of Tank Mass in Fireball: 100%

Fireball Diameter: 145 meters Burn Duration: 10 seconds

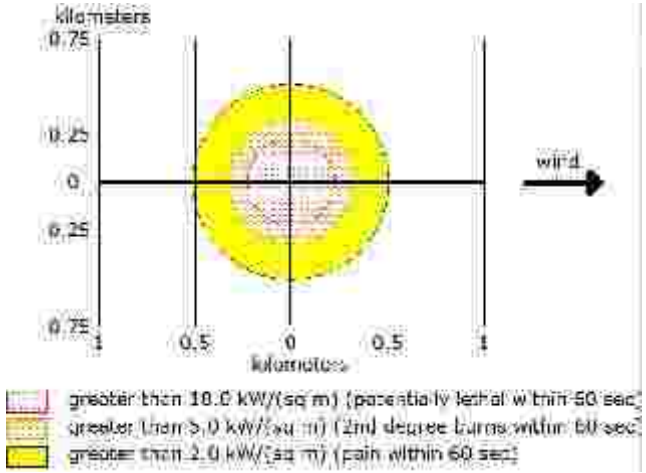
THREAT ZONE:

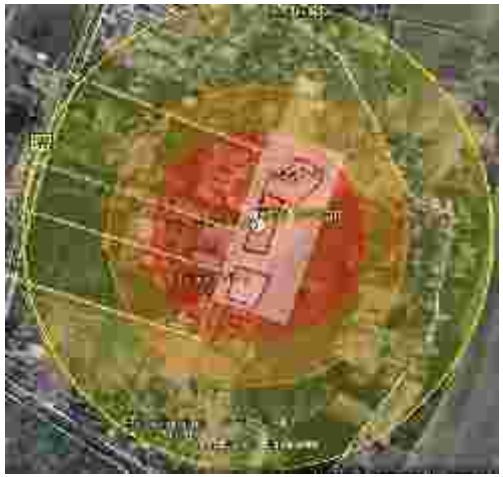
Threat Modeled: Thermal radiation from fireball

Red : 225 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)

Orange: 324 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)

Yellow: 509 meters --- (2.0 kW/(sq m) = pain within 60 sec)



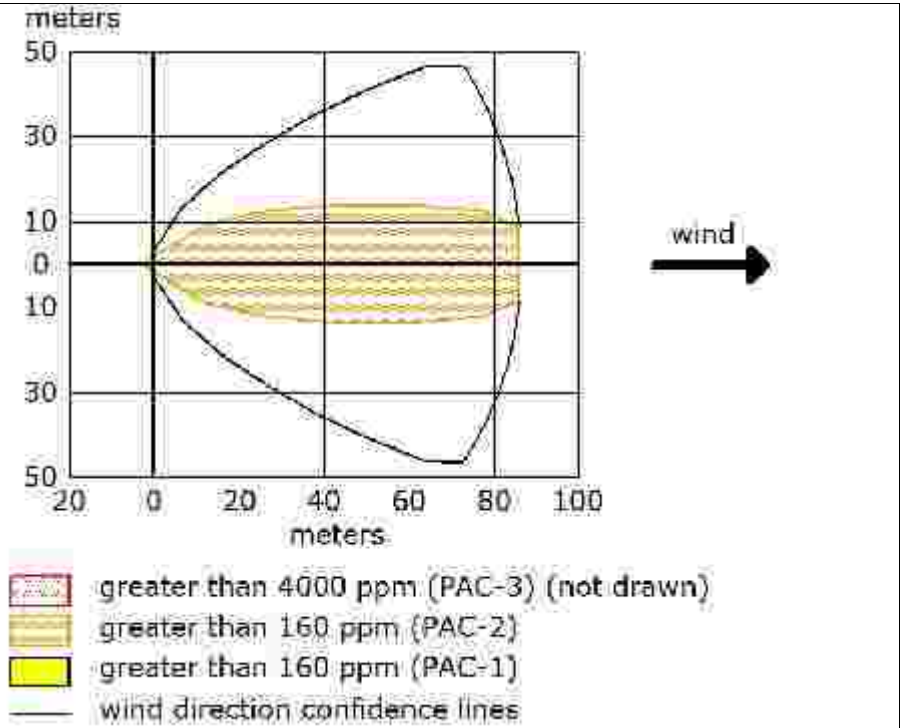


Scenario -4: Leak of 1, 2-Dichloro Ethane Storage tank.

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
SOURCE STRENGTH: Leak from hole in vertical cylindrical tank Flammable chemical escaping from tank (not burning) Tank Diameter: 2.5 meters Tank Length: 3.5 meters Tank Volume: 17.2 cubic meters Tank contains liquid Internal Temperature: 32° C Chemical Mass in Tank: 17.5 tons Tank is 80% full Circular Opening Diameter: 0.01 meters Opening is 2.45 meters from tank bottom Ground Type: Default soil Ground Temperature: equal to ambient Max Puddle Diameter: Unknown Release Duration: ALOHA limited the duration to 1 hour Max Average Sustained Release Rate: 3.68 kilograms/min (averaged over a minute or more) Total Amount Released: 169 kilograms Note: The chemical escaped as a liquid and formed an evaporating puddle. The puddle spread to a diameter of 4.5 meters.	**SOURCE STRENGTH:** Leak from hole in vertical cylindrical tank Flammable chemical escaping from tank (not burning) Tank Diameter: 2.5 meters Tank Length: 3.5 meters Tank Volume: 17.2 cubic meters Tank contains liquid Internal Temperature: 32° C Chemical Mass in Tank: 17.5 tons Tank is 80% full Circular Opening Diameter: 0.01 meters Opening is 2.45 meters from tank bottom Ground Type: Default soil Ground Temperature: equal to ambient Max Puddle Diameter: Unknown Release Duration: ALOHA limited the duration to 1 hour Max Average Sustained Release Rate: 4.04 kilograms/min (averaged over a minute or more) Total Amount Released: 204 kilograms Note: The chemical escaped as a liquid and formed an evaporating puddle. The puddle spread to a diameter of 3.6 meters.

Case- 1 Toxic Area of Vapor cloud

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
THREAT ZONE: Model Run: Heavy Gas **Red** : 14 meters --- (4000 ppm = PAC-3) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Orange**: 86 meters --- (160 ppm = PAC-2) **Yellow**: 86 meters --- (160 ppm = PAC-1)	**THREAT ZONE:** Model Run: Gaussian **Red** : less than 10 meters(10.9 yards) --- (4000 ppm = PAC-3) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Orange**: 36 meters --- (160 ppm = PAC-2) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Yellow**: 36 meters --- (160 ppm = PAC-1) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

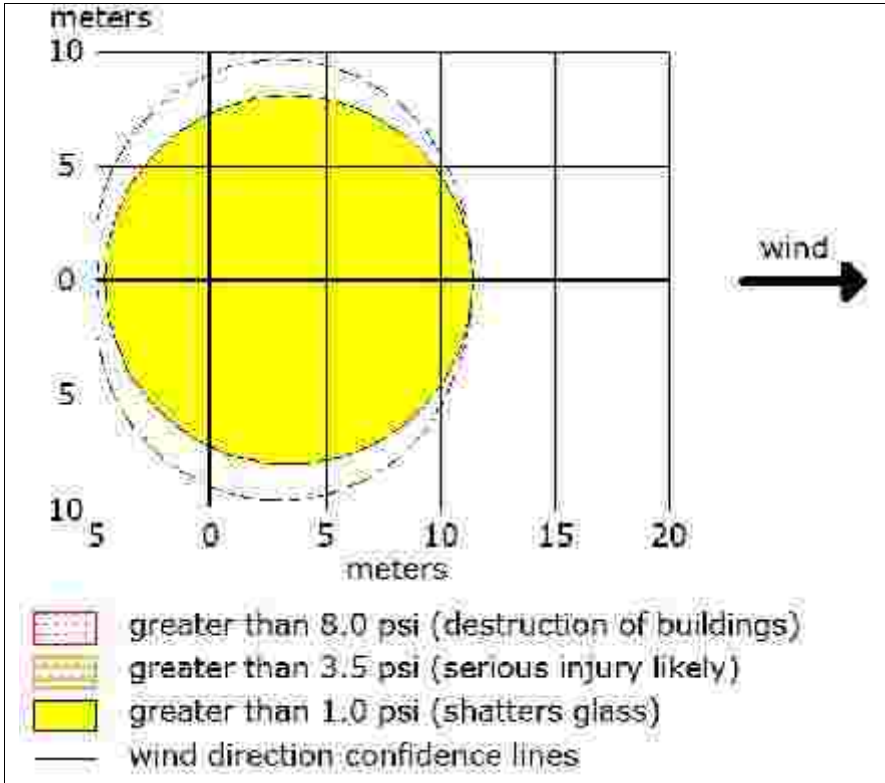

meters
50
30
10
0
10
30
50
20
0
20
40
60
80
100
meters
wind
greater than 4000 ppm (PAC-3) (not drawn)
greater than 160 ppm (PAC-2)
greater than 160 ppm (PAC-1)
wind direction confidence lines

--NA--

--NA--

Case-2 Flammable Area of Vapor cloud

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
THREAT ZONE: Threat Modeled: Flammable Area of Vapor Cloud Model Run: Heavy Gas **Red** : less than 10 meters(10.9 yards) --- (32400 ppm = 60% LEL = Flame Pockets) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Yellow**: 11 meters --- (5400 ppm = 10% LEL) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.	**THREAT ZONE:** Threat Modeled: Flammable Area of Vapor Cloud Model Run: Gaussian **Red** : less than 10 meters(10.9 yards) --- (32400 ppm = 60% LEL = Flame Pockets) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Yellow**: less than 10 meters(10.9 yards) --- (5400 ppm = 10% LEL) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.


meters
10
5
0
5
10
5
0
5
10
15
20
meters
wind
greater than 8.0 psi (destruction of buildings)
greater than 3.5 psi (serious injury likely)
greater than 1.0 psi (shatters glass)
wind direction confidence lines

--NA--

--NA--

Case-3 Blast Area of Vapor cloud

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D

SOURCE STRENGTH:

Leak from hole in vertical cylindrical tank

Flammable chemical escaping from tank (not burning)

Tank Diameter: 2.5 meters Tank Length: 3.5 meters Tank Volume: 17.2 cubic meters

Tank contains liquid Internal Temperature: 32° C

Chemical Mass in Tank: 17.5 tons Tank is 80% full

Circular Opening Diameter: 0.01 meters Opening is 2.45 meters from tank bottom

Ground Type: Default soil Ground Temperature: equal to ambient

Max Puddle Diameter: Unknown

Release Duration: ALOHA limited the duration to 1 hour

Max Average Sustained Release Rate: 4.04 kilograms/min

(averaged over a minute or more)

Total Amount Released: 204 kilograms

Note: The chemical escaped as a liquid and formed an evaporating puddle.

The puddle spread to a diameter of 3.6 meters.

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: Gaussian

No explosion: no part of the cloud is above the LEL at any time

Case-4 Thermal radiation from Pool fire

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D

SOURCE STRENGTH:

Leak from hole in vertical cylindrical tank

Flammable chemical is burning as it escapes from tank

Tank Diameter: 2.5 meters Tank Length: 3.5 meters Tank Volume: 17.2 cubic meters

Tank contains liquid Internal Temperature: 32° C Chemical Mass in Tank: 17.5 tons Tank is 80% full

Circular Opening Diameter: 0.01 meters Opening is 2.45 meters from tank bottom Max Flame Length: 2 meters

Burn Duration: ALOHA limited the duration to 1 hour Max Burn Rate: 4.4 kilograms/min Total Amount Burned: 252 kilograms

Note: The chemical escaped as a liquid and formed a burning puddle.

The puddle spread to a diameter of 1.7 meters.

THREAT ZONE:

Threat Modeled: Thermal radiation from pool fire

Red : less than 10 meters(10.9 yards) --- (10.0 kW/(sq m) = potentially lethal within 60 sec)

Orange: less than 10 meters(10.9 yards) --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)

Yellow: less than 10 meters(10.9 yards) --- (2.0 kW/(sq m) = pain within 60 sec)

Case-5 Thermal radiation from Fireball

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D

SOURCE STRENGTH:

BLEVE of flammable liquid in vertical cylindrical tank

Tank Diameter: 2.5 meters Tank Length: 3 meters Tank Volume: 14.7 cubic meters Tank contains liquid

Internal Storage Temperature: 32° C Chemical Mass in Tank: 15 tons Tank is 80% full

Percentage of Tank Mass in Fireball: 100% Fireball Diameter: 138 meters Burn Duration: 10 seconds

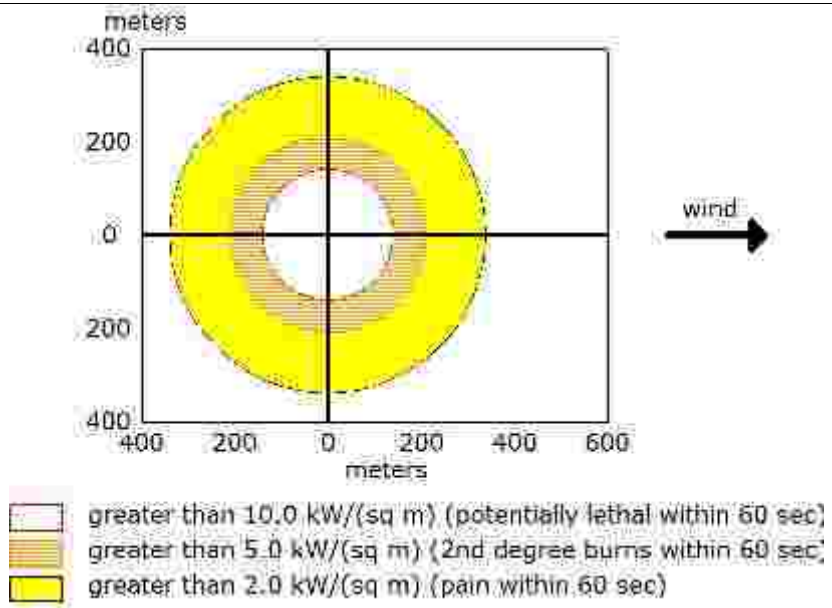
THREAT ZONE:

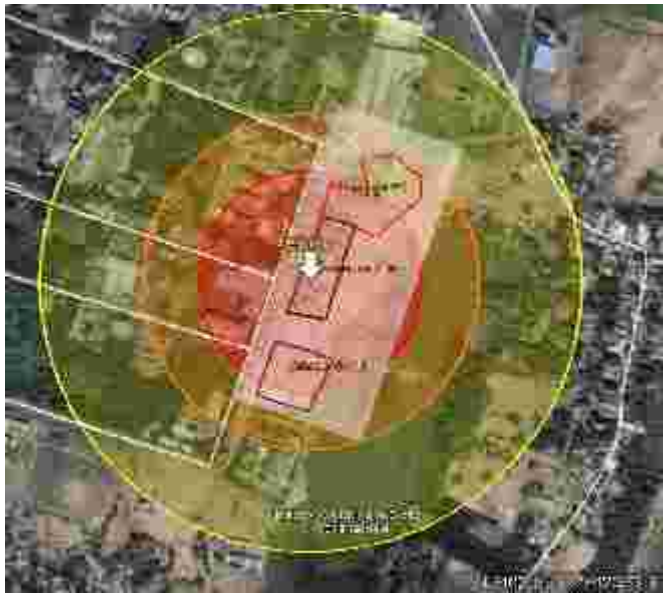
Threat Modeled: Thermal radiation from fireball

Red : 140 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)

Orange: 211 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)

Yellow: 340 meters --- (2.0 kW/(sq m) = pain within 60 sec)

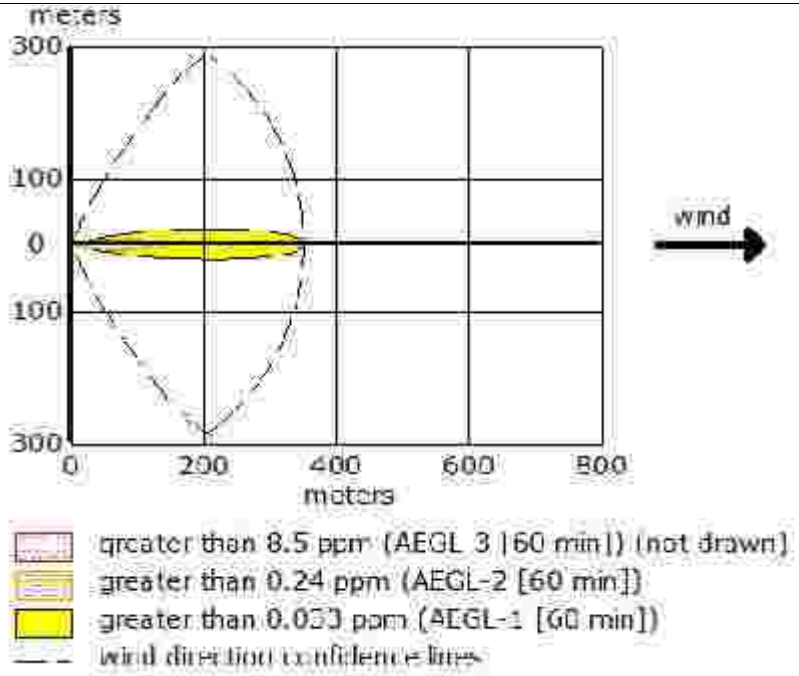
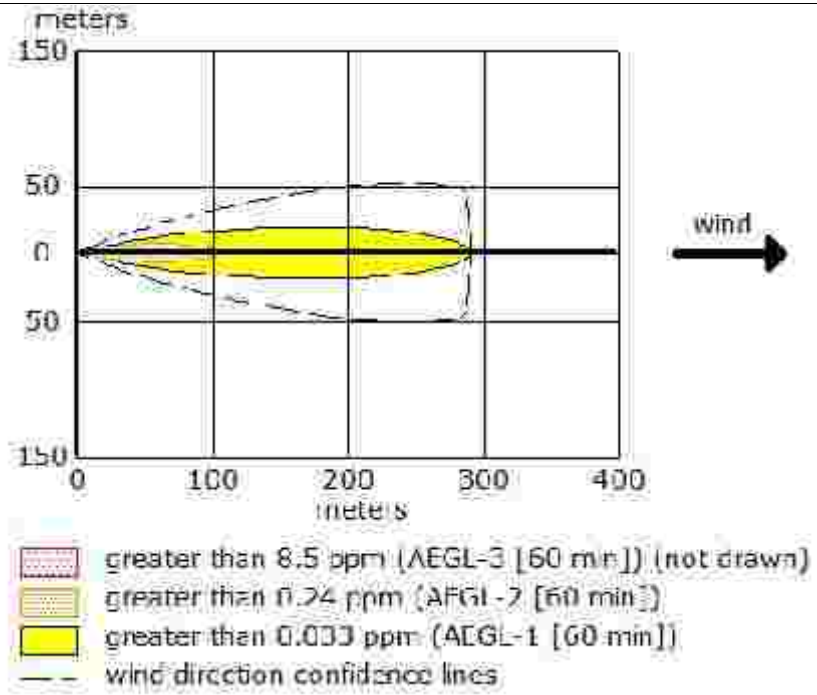




Scenario -5: Leak of Bromine Storage tank.

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
SOURCE STRENGTH: Leak from hole in vertical cylindrical tank Non-flammable chemical is escaping from tank Tank Diameter: 2.5 meters Tank Length: 3.5 meters Tank Volume: 17.2 cubic meters Tank contains liquid Internal Temperature: 32° C Chemical Mass in Tank: 20 tons Tank is 34% full Circular Opening Diameter: 0.04 inches Opening is 1.05 meters from tank bottom Ground Type: Default soil Ground Temperature: equal to ambient Max Puddle Diameter: Unknown Release Duration: ALOHA limited the duration to 1 hour Max Average Sustained Release Rate: 32 grams/min (averaged over a minute or more) Total Amount Released: 1.16 kilograms Note: The chemical escaped as a liquid and formed an evaporating puddle. The puddle spread to a diameter of 0.5 meters.	**SOURCE STRENGTH:** Leak from hole in vertical cylindrical tank Non-flammable chemical is escaping from tank Tank Diameter: 2.5 meters Tank Length: 3.5 meters Tank Volume: 17.2 cubic meters Tank contains liquid Internal Temperature: 32° C Chemical Mass in Tank: 20 tons Tank is 34% full Circular Opening Diameter: 0.04 inches Opening is 1.05 meters from tank bottom Ground Type: Default soil Ground Temperature: equal to ambient Max Puddle Diameter: Unknown Release Duration: ALOHA limited the duration to 1 hour Max Average Sustained Release Rate: 66.3 grams/min (averaged over a minute or more) Total Amount Released: 3.17 kilograms Note: The chemical escaped as a liquid and formed an evaporating puddle. The puddle spread to a diameter of 0.3 meters.

Case- 1 Toxic Level of Concern

Wind speed- 1.5 m/s **Stability Class**- D	**Wind speed**- 5 m/s **Stability Class**- D
THREAT ZONE: Model Run: Gaussian **Red** : 20 meters --- (8.5 ppm = AEGL-3 [60 min]) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Orange**: 123 meters --- (0.24 ppm = AEGL-2 [60 min]) **Yellow**: 355 meters --- (0.033 ppm = AEGL-1 [60 min])	**THREAT ZONE:** Model Run: Gaussian **Red** : 17 meters --- (8.5 ppm = AEGL-3 [60 min]) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. **Orange**: 102 meters --- (0.24 ppm = AEGL-2 [60 min]) **Yellow**: 291 meters --- (0.033 ppm = AEGL-1 [60 min])
	


ALOHA Source Point

SUMMARY OF RESULTS AND OBSERVATIONS

- As per the NFPA rating, all 8 chemicals are observed as fire hazard, Dichloroethane and Methanol as health hazards acid.
- Risk assessment is done for storages with max. Capacity only.
- The Scenarios are modelled with stability class D with 1.5 m/s and 5 m/s wind speed.
- The consequence analysis study has been carried out for different scenarios like catastrophic rupture and leaks with various hole sizes.
- All the hazards are observed in West direction due to the wind, which is blowing from East direction.
- The Thermal radiation from Fireball from bleve scenario of Ethanol storage tank is estimated a max distance for explosion is 483 m (for 1.5 m/s Class D) & 483 m (for 5 m/s Class D). The receptors are Shasun Pharma limited towards NW, Loyal Super Fabrics towards N, , Asian Paints towards W, DFE Pharma towards W, SIPCOT Industrial Road towards W, Morgan Industries towards NNE.
- The Thermal radiation from Fireball from bleve scenario of Dimethyl Formamideis estimated a max distance for explosion is 490 m (for 1.5 m/s Class D) & 490 m (for 5 m/s Class D). The receptors are Shasun Pharma limited towards NW, Loyal Super Fabrics towards N, Asian Paints towards W, DFE Pharma towards W, SIPCOT Industrial Road towards W, Morgan Industries towards NNE.
- The Thermal radiation from Fireball from bleve scenario of Ethyl Acetate estimated a max distance for explosion is 324 m (for 1.5 m/s Class D) & 324 m (for 5 m/s Class D). The receptors are Shasun Pharma limited towards NW, Loyal Super Fabrics towards N, Asian Paints towards W, DFE Pharma towards W, SIPCOT Industrial Road towards W, Open area towards E.
- The Thermal radiation from Fireball from bleve scenario of 1, 2-Dichloro Ethane estimated a max distance for explosion is 86 m (for 1.5 m/s Class D) & 36 m (for 5 m/s Class D). The receptors are Asian Paints towards W, SIPCOT Industrial Road towards W,
- The Thermal radiation from Fireball from leak scenario of Bromine estimated a max distance for explosion is 355 m (for 1.5 m/s Class D) & 291 m (for 5 m/s

Class D). The receptors are Asian Paints towards W, DFE Pharma towards W, SIPCOT Industrial Road towards W.

- Mitigative measures are provided to avoid hazards.

Summary of consequences for Storage Tanks observed with major receptors are given in **Table 3 4**.

Table 3-4 Summary of consequences for Storage Tanks observed with major receptors

S. No	Scenario	Event	Impact	Conc.	Consequence Distance (m)		Major Receptors around the Site.
					Category 1.5/D	Category 5/D	
1	Leak of Ethanol Storage tank	Toxic area ofVapor cloud	Red (High)	NA	-	-	Within the facility
			Orange (Medium)	3300 PPM	<10m	<10m	
			Yellow (Low)	1800 PPM	<10m	<10m	
		Flammable area of Vapor Cloud	Red	19800 PPM	<10m	<10m	Within the facility
			Yellow	3300 PPM	<10m	<10m	
		Blast Area of Vapor Cloud	Red	-	-	-	Within the facility
			Orange	-	-	-	
			Yellow	-	-	-	
		Pool Fire	Red (High)	10 KW/m^2	<10m	<10m	Within the facility
			Orange (Medium)	5 KW/m^2	<10m	<10m	
			Yellow (Low)	2 KW/m^2	<10m	<10m	
		Thermal radiation from Fireball	Red (High)	10 KW/m^2	215	215	Shasun Pharma limited , NW Loyal Super Fabrics , N Asian Paints, W DFE Pharma, W SIPCOT Industrial Road, W Open area, E
			Orange (Medium)	5 KW/m^2	308	308	Morgan Industries, NNE, Kawan Pharma, WNW SIPCOT Industrial Road, W Open area, E
			Yellow (Low)	2 KW/m^2	483	483	Echankadu Village, SSW Kudikadu Village, N SIPCOT Industrial Road, W

							Open area, E
2	Leak of Dimethyl Formamide Storage tank	Toxic area of Vapor cloud	Red (High)	530 ppm = AEGL-3 [60 min])	10	10	Within the facility
			Orange (Medium)	91 ppm = AEGL-2 [60 min])	13	13	
			Yellow (Low)	N/A = AEGL-1 [60 min])	NA	NA	
		Flammable area of Vapor Cloud	Red	13800 PPM	< 10	< 10	Within the facility
			Yellow	2300 PPM	< 10	< 10	
		Pool Fire	Red (High)	-	-	-	Within the facility
			Orange (Medium)	-	-	-	
			Yellow (Low)	-	-	-	
		Thermal radiation from Fireball	Red (High)	10 KW/m^2	217	217	Shasun Pharma limited , NW Loyal Super Fabrics , N Asian Paints, W DFE Pharma, W SIPCOT Industrial Road, W Open area, E
			Orange (Medium)	5 KW/m^2	312	312	Morgan Industries, NNE, Kawan Pharma, WNW SIPCOT Industrial Road, W Open area, E
			Yellow (Low)	2 KW/m^2	490	490	Echankadu Village, SSW Kudikadu Village, N SIPCOT Industrial Road, W Open area, E
3	Leak of Ethyl Acetate Storage tank	Toxic area of Vapor cloud	Red (High)	10000 PPM	<10	<10	Within the facility
			Orange (Medium)	1700 PPM	17	<10	
			Yellow (Low)	1200 PPM	21	<10	
		Flammable	Red	13080 PPM	<10	<10	Within the facility

		area of Vapor Cloud	Yellow	2180 PPM	14	<10	
		Blast Area of Vapor Cloud	Red (High)	8 PSI	LOC	-	Within the facility
			Orange (Medium)	3.5 PSI	<10	-	
			Yellow (Low)	1 PSI	<10	-	
		Pool Fire	Red (High)	10 KW/m^2	<10	<10	Within the facility
			Orange (Medium)	5 KW/m^2	<10	<10	
			Yellow (Low)	2 KW/m^2	<10	<10	
		Thermal radiation from Fireball	Red (High)	10 KW/m^2	225		Shasun Pharma limited , NW Loyal Super Fabrics , N Asian Paints, W DFE Pharma, W SIPCOT Industrial Road, W Open area, E
			Orange (Medium)	5 KW/m^2	324		
4	Leak of 1, 2-Dichloro Ethane Storage tank	Toxic area of Vapor cloud	Red (High)	4000 PPM	14	<10	
			Orange (Medium)	160 PPM	86	36	Asian Paints, W SIPCOT Industrial Road, W
			Yellow (Low)	160 PPM	86	36	Asian Paints, W SIPCOT Industrial Road, W
		Flammable area of Vapor Cloud	Red	32400 PPM	<10	<10	Within the facility
			Yellow	5400 PPM	11	<10	
		Blast Area of Vapor Cloud	Red (High)	-	-	-	Within the facility
			Orange (Medium)	-	-	-	
			Yellow (Low)	-	-	-	
		Pool Fire	Red (High)	10 KW/m^2	<10	<10	Within the facility
			Orange (Medium)	5 KW/m^2	<10	<10	

			Yellow (Low)	2 KW/m^2	<10	<10	
		Thermal radiation from Fireball	Red (High)	10 KW/m^2	140		Shasun Pharma limited , NW Loyal Super Fabrics , N Asian Paints, W DFE Pharma, W SIPCOT Industrial Road, W Open area, E
			Orange (Medium)	5 KW/m^2	211		Morgan Industries, NNE, Kawan Pharma, WNW SIPCOT Industrial Road, W Open area, E
			Yellow (Low)	2 KW/m^2	340		
5	Leak of Bromine Storage tank	Toxic Level of Concern	Red (High)	8.5 PPM	20	17	Within the Facility
			Orange (Medium)	0.24 PPM	123	102	Asian Paints, W DFE Pharma, W SIPCOT Industrial Road, W
			Yellow (Low)	0.033 PPM	355	291	

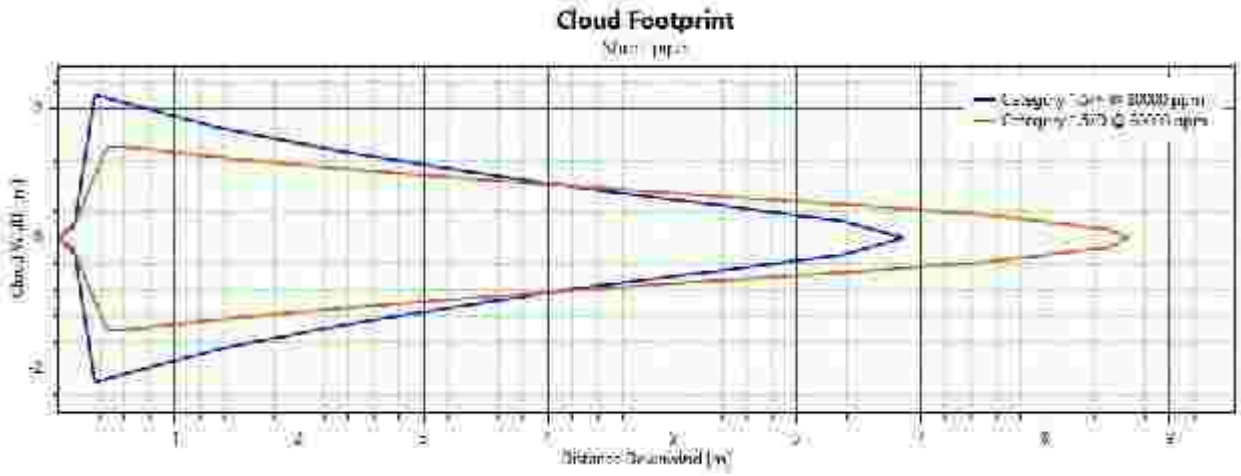
3.4 Pipeline Considered for Consequence Analysis

S. No	Pipe No./Name	Pipeline dia (mm)	Pipe Volume (Liters)	Pipeline length (m)	Operating Tempe (oc)	Operating Pressure (bar)	Chemical flowing	Connected to and from
1.	Liquor Ammonia (25%)	25	20	40	35-40	Atmospheric	Liquor Ammonia (25%)	Tank to Day tank
2.	Toluene	25	88	180			Toluene	Tank to Day tank
3.	Methanol	25	88	180			Methanol	Tank to Day tank
4.	Xylene	25	88	180			Xylene	Tank to Day tank
5.	Ethyl Alcohol	25	28	50			Ethyl Alcohol	Tank to Day tank
6.	N Hexane	25	88	180			N Hexane	Tank to Day tank

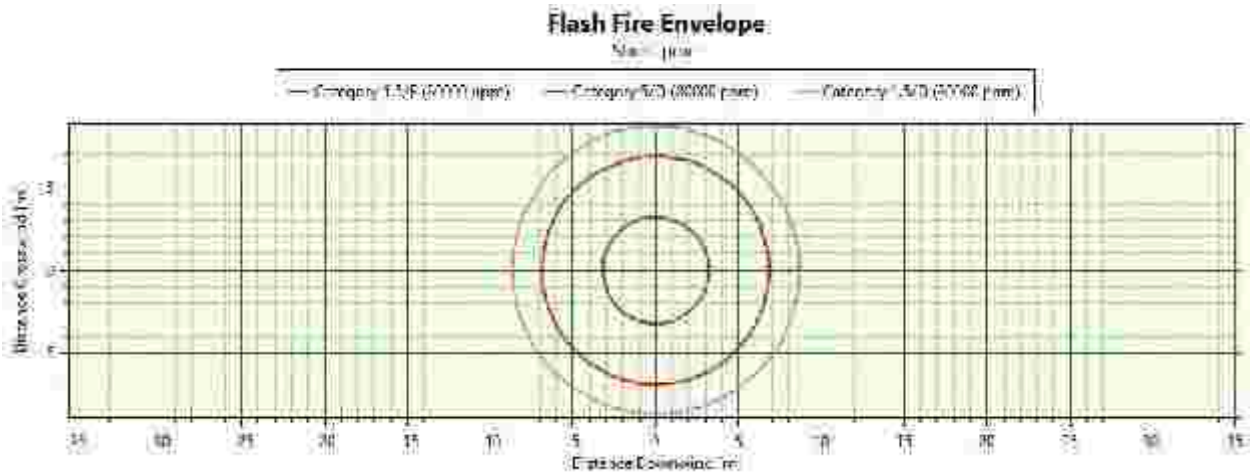
3.5 Contours Maps for Pipelines

Scenario-1 Liquor Ammonia Pipeline – Short Pipe

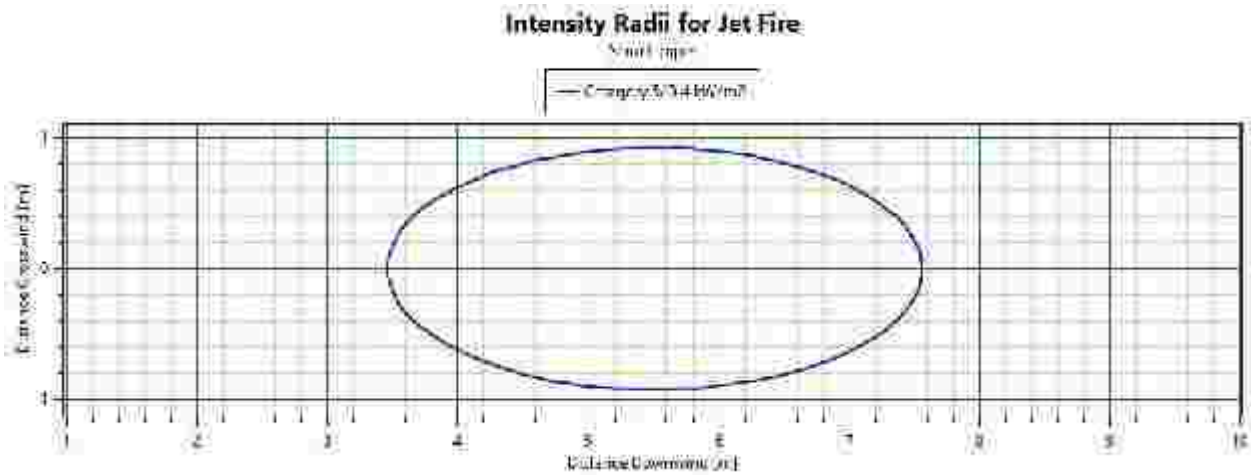
a. Dispersion of vapour cloud



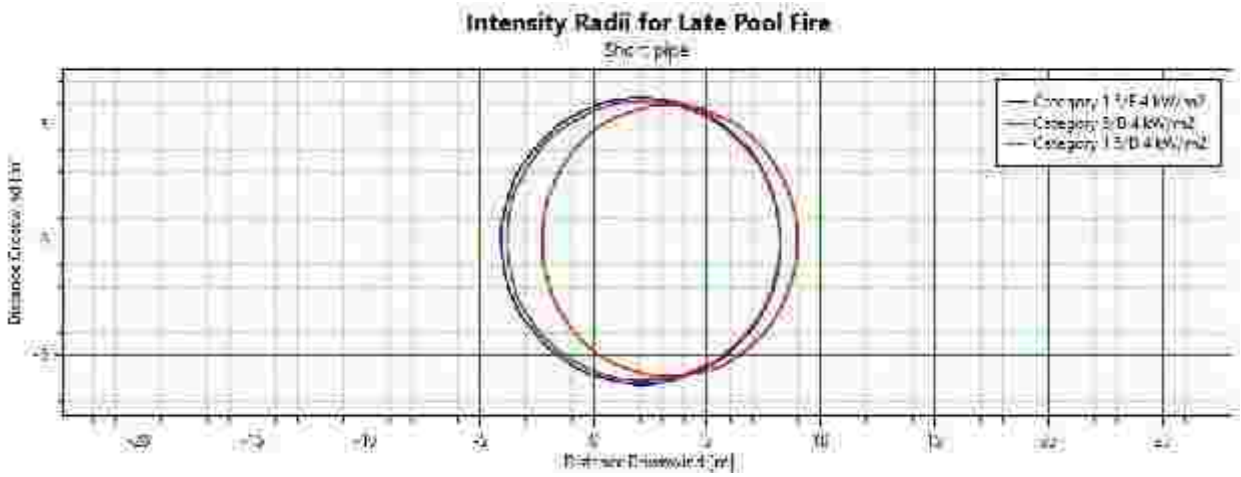
b. Flash Fire



c. Intensity Radii for Jet Fire

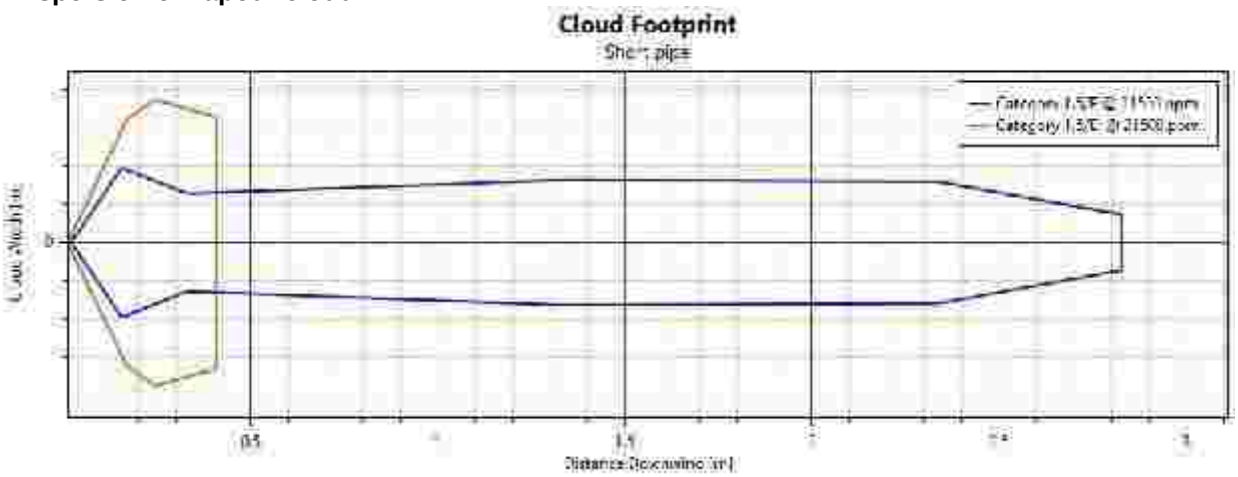


d. Intensity Radii for Pool Fire

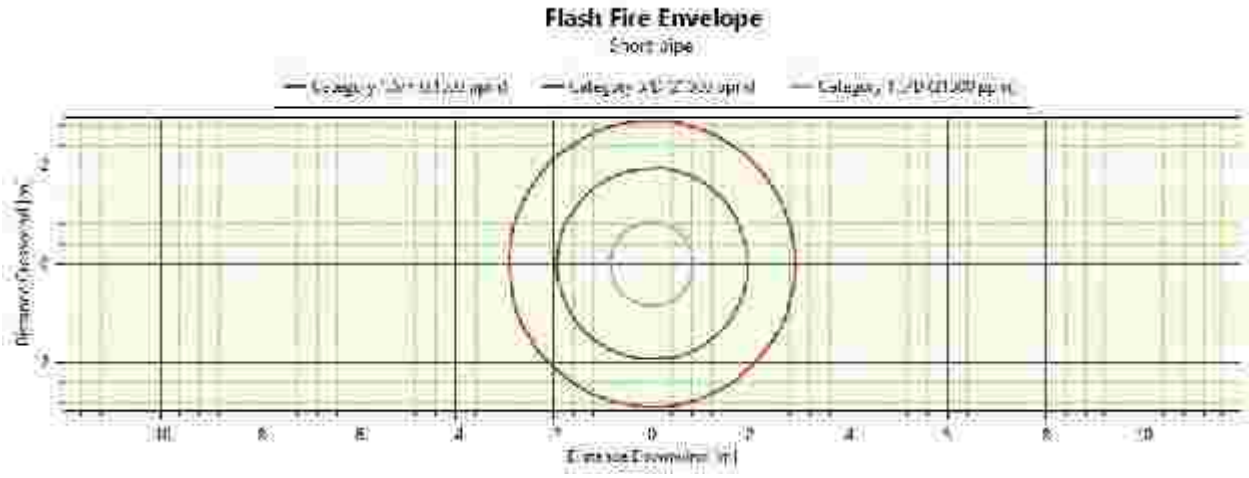


Scenario-2 Ethanol Pipeline – Short Pipe

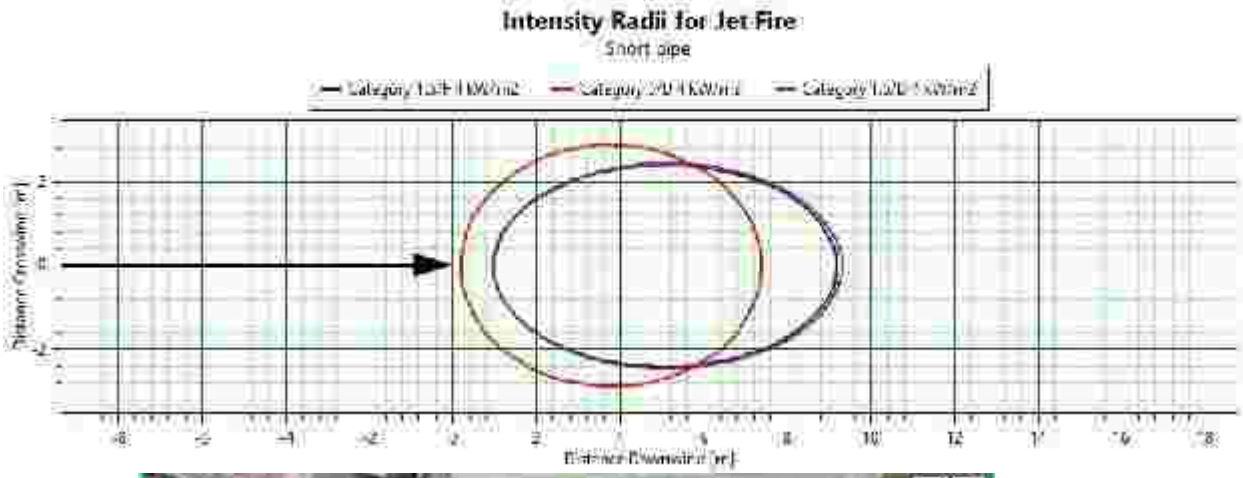
a. Dispersion of vapour cloud



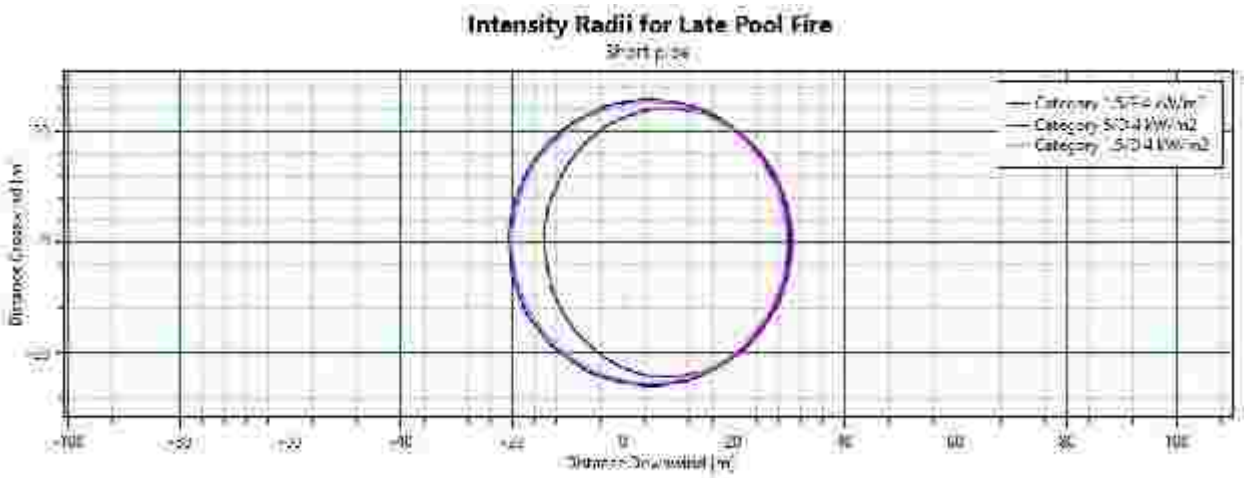
b. Flash Fire



c. Intensity Radii for Jet Fire

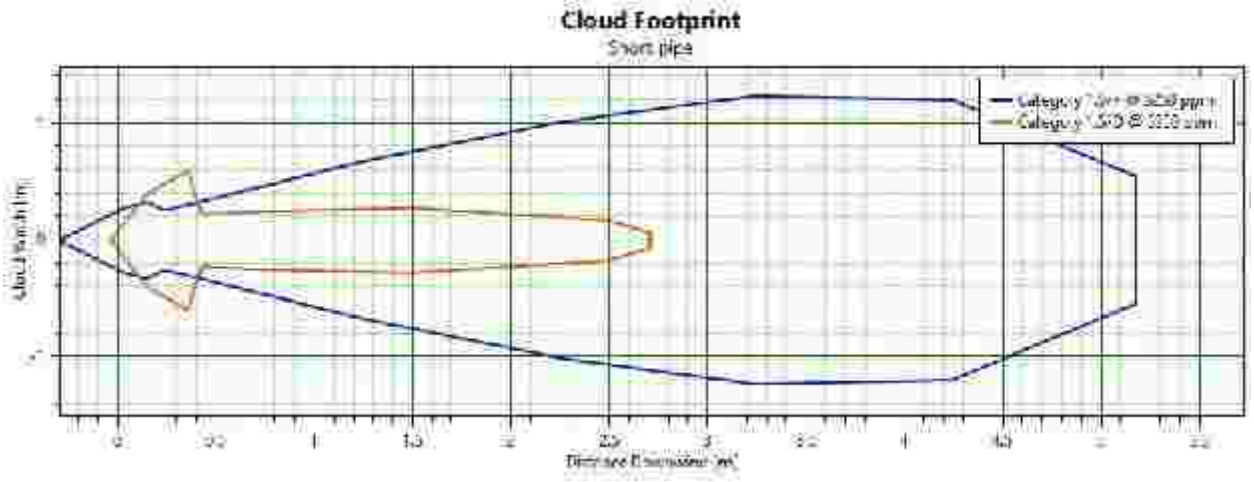


d. Intensity Radii for Pool Fire



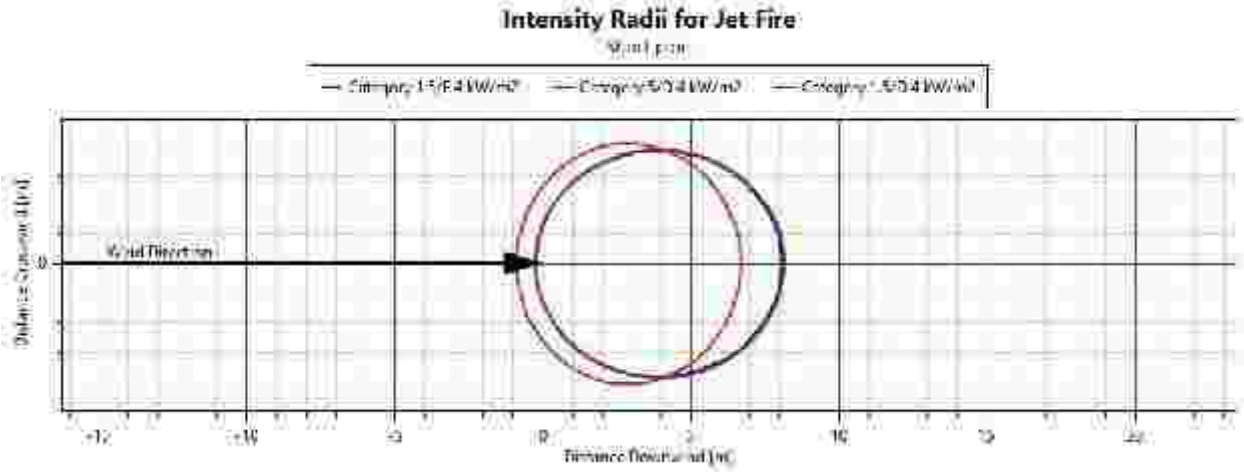
Scenario-3 Hexane Pipeline – Short Pipe

a. Dispersion of vapour cloud

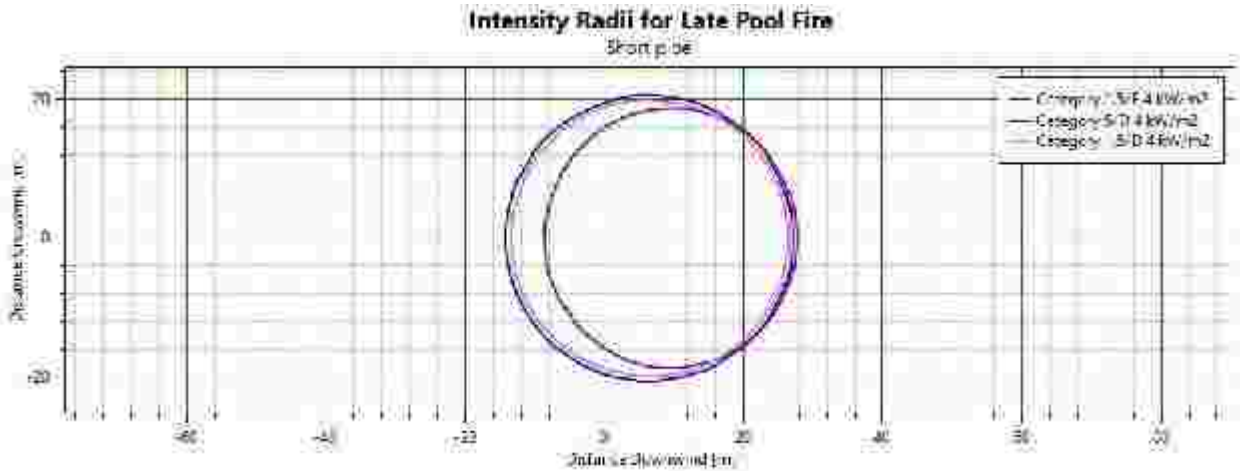


b. Flash Fire

c. Intensity Radii for Jet Fire

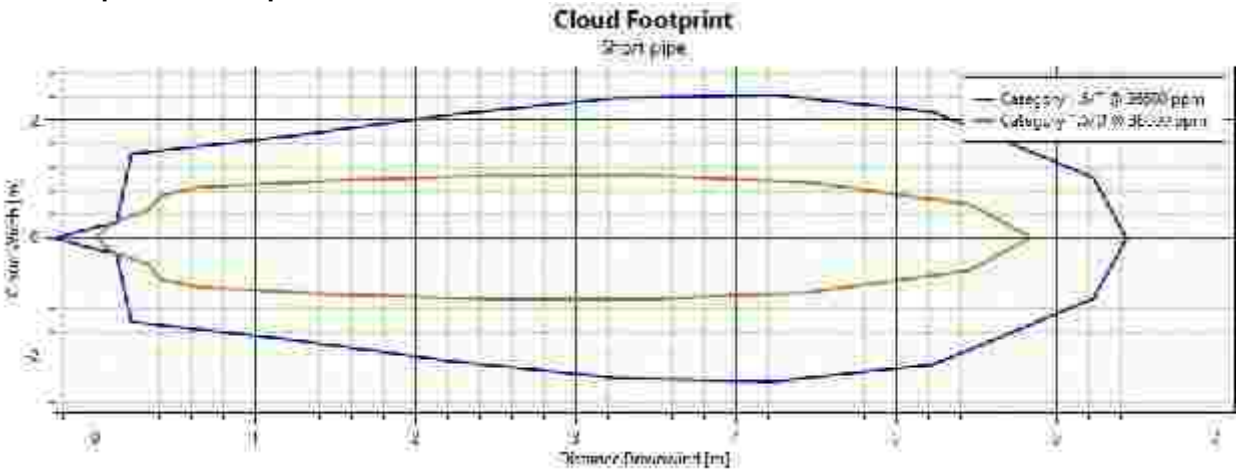


d. Intensity Radii for Pool Fire



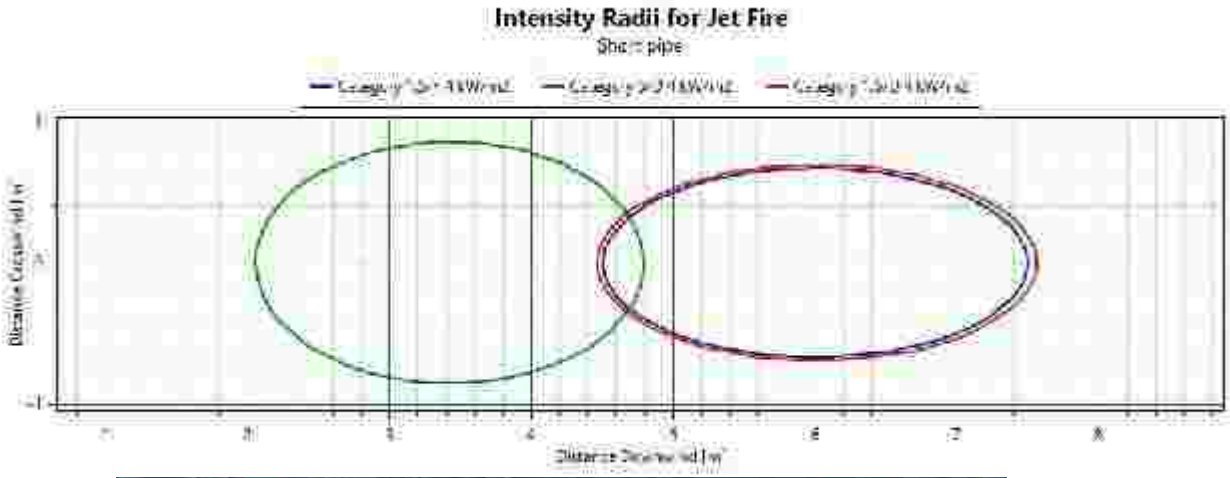
Scenario-4 Methanol Pipeline – Short Pipe

a. Dispersion of vapour cloud

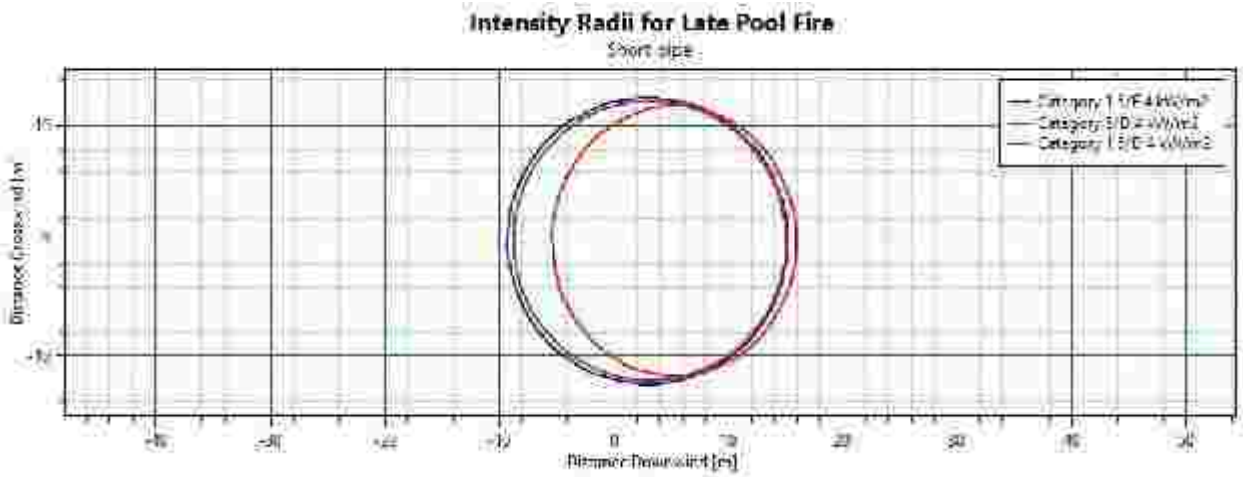


b. Flash Fire

c. Intensity Radii for Jet Fire

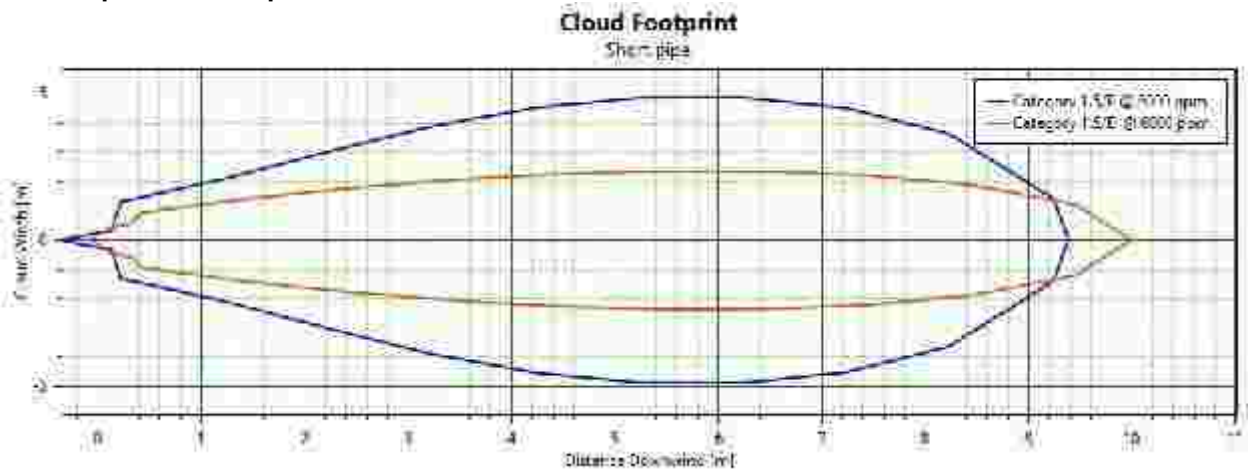


d. Intensity Radii for Pool Fire

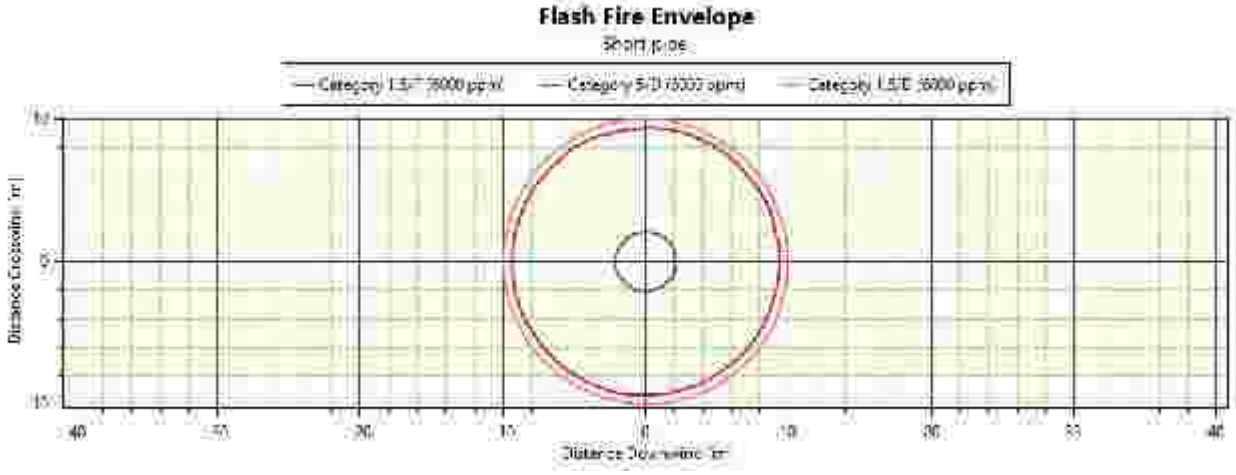


Scenario-5 Toluene Pipeline – Short Pipe

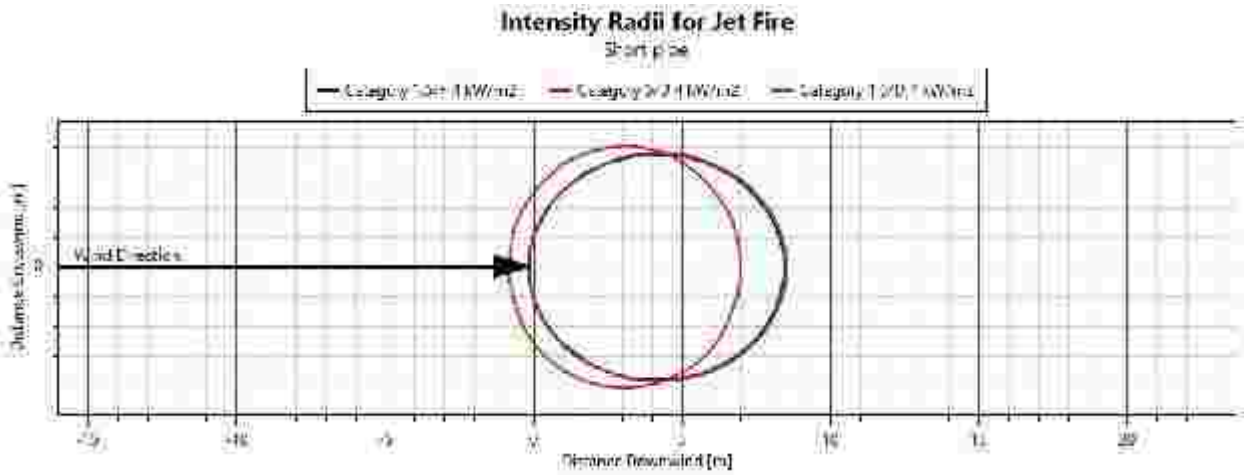
a. Dispersion of vapour cloud



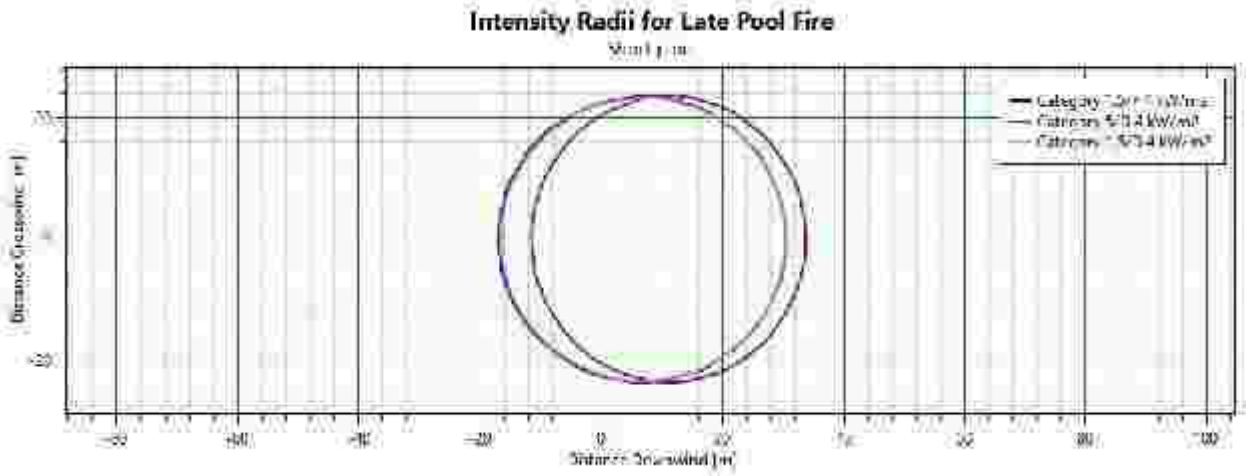
b. Flash Fire



c. Intensity Radii for Jet Fire

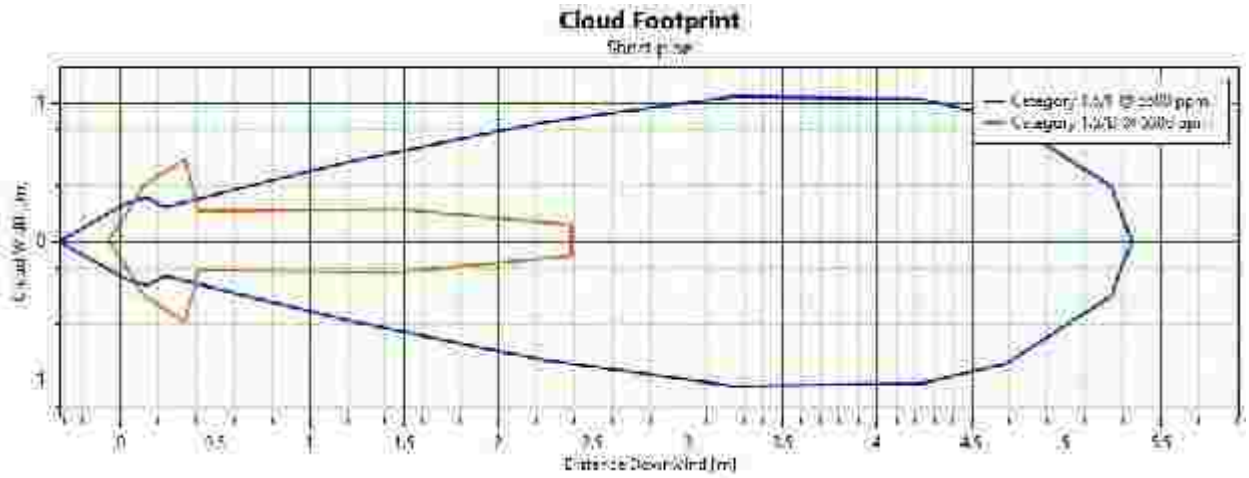


d. Intensity Radii for Pool Fire

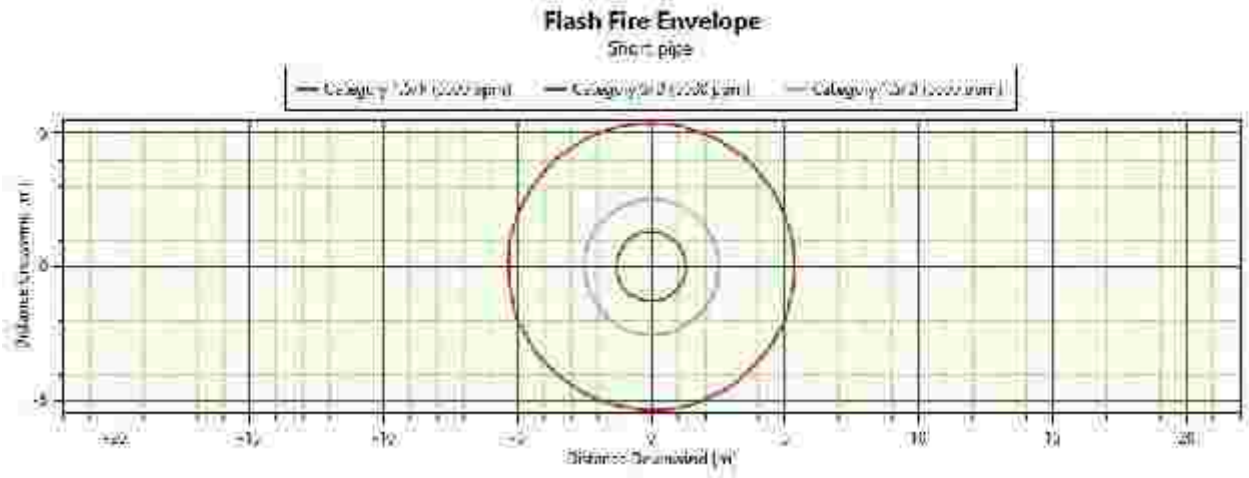


Scenario-5 Xylene Pipeline – Short Pipe

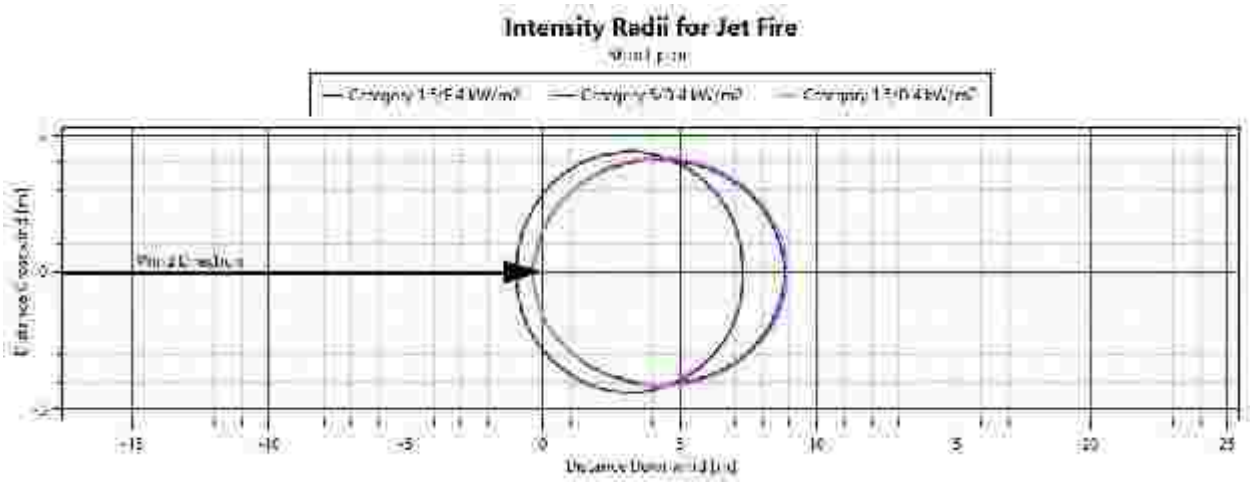
a. Dispersion of vapour cloud



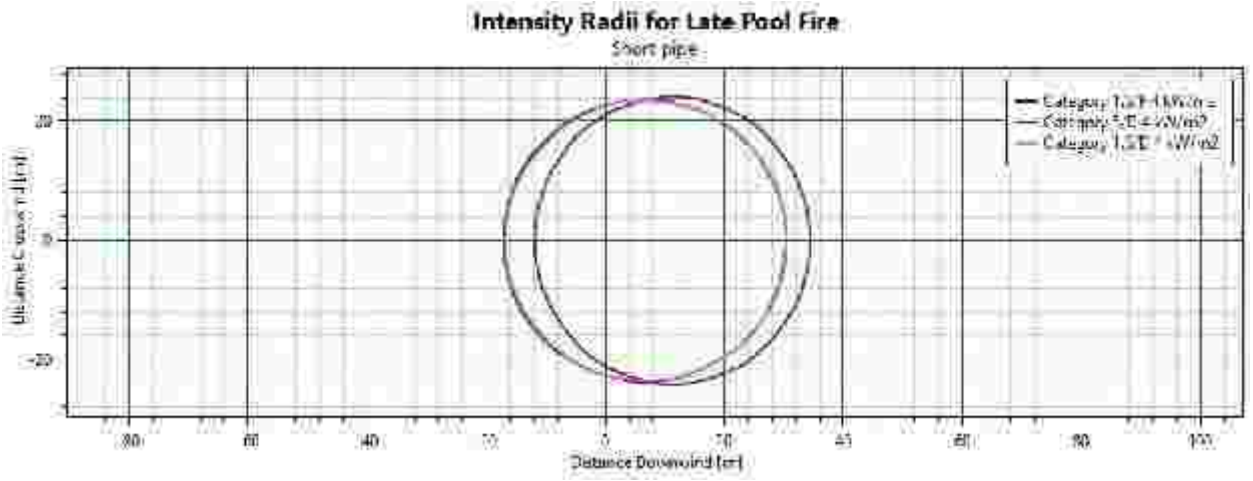
b. Flash Fire



c. Intensity Radii for Jet Fire



d. Intensity Radii for Pool Fire


Intensity Radii for Late Pool Fire
Short pipe
Distance Downwind [m]


0.00
0.06
0.12
km

3.6 Consequence Analysis Results for Pipelines

Table 3-5: Summary of Consequence Analysis Results for Pipelines

S. No	Description	Scenario	Event	Impact criteria	Consequence Distance (m)			Major Receptors
					Category 1.5/F	Category 5/D	Category 1.5/D	
1.	Liquor Ammonia Pipeline	Short Pipe	Dispersion of vapour cloud	UFL(250000)	1.52165	0.866904	1.62673	Within the facility
				LFL(160000)	2.53239	1.25464	3.27145	
				LFL Frac (80000)	6.86019	3.2241	8.65736	
			Jet Fire	4 kW/m2	Not Reached	7.55523	Not Reached	
				12.5 kW/m2	Not Reached	Not Reached	Not Reached	
				37.5 kW/m2	Not Reached	Not Reached	Not Reached	
			Pool Fire	4 kW/m2	8.20952	9.92791	8.18239	
				12.5 kW/m2	4.20542	4.83661	4.2765	
				37.5 kW/m2	Not Reached	Not Reached	Not Reached	
			Flash Fire	80000 PPM	6.86019	3.2241	8.65736	
				160000 PPM	2.53239	1.25464	3.27145	
2.	Ethanol Pipeline	Short Pipe	Dispersion of vapour cloud	UFL(190000)	0.474026	0.522895	0.52672	Within the facility
				LFL(43000)	0.565797	1.27089	0.779093	
				LFL Frac (21500)	2.90553	1.93877	0.846346	
			Jet Fire	4 kW/m2	9.17925	7.37922	9.29546	
				12.5 kW/m2	8.78415	5.9523	8.86764	
				37.5 kW/m2	Not Reached	Not Reached	Not Reached	
			Pool Fire	4 kW/m2	8.43052	9.95096	8.57168	
				12.5 kW/m2	4.73798	7.03067	4.88141	
				37.5 kW/m2	3.01347	3.93812	3.15955	
			Flash Fire	21500 PPM	2.90553	1.93877	0.846346	
				43000PPM	0.565797	1.27089	0.779093	

S. No	Description	Scenario	Event	Impact criteria	Consequence Distance (m)			Major Receptors
					Category 1.5/F	Category 5/D	Category 1.5/D	
3.	Methanol Pipeline	Short Pipe	Dispersion of vapour cloud	UFL(360000)	0.2474	0251149	0.240006	Within the facility
				LFL(73000)	3.62632	1.17085	1.5787	
				LFL Frac (36500)	6.44322	1.50755	5.83759	
			Jet Fire	4 kW/m2	7.49442	4.79458	7.45594	
				12.5 kW/m2	Not Reached	Not Reached	Not Reached	
				37.5 kW/m2	Not Reached	Not Reached	Not Reached	
			Pool Fire	4 kW/m2	15.1938	15.9371	15.0748	
				12.5 kW/m2	8.30412	10.4287	8.31719	
				37.5 kW/m2	Not Reached	Not Reached	Not Reached	
			Flash Fire	8333.33 PPM	6.444322	1.50755	5.83759	
				16666.7 PPM	3.62632	1.17085	1.5787	
4.	Toluene Pipeline	Short Pipe	Dispersion of vapour cloud	UFL(71000)	0.432682	0.546674	0.446671	Within the facility
				LFL(12000)	6.2995	1.34645	5.68685	
				LFL Frac(6000)	9.37819	2.10381	9.98006	
			Jet Fire	4 kW/m2	8.43829	6.96522	8.52602	
				12.5 kW/m2	6.75089	5.46045	6.83064	
				37.5 kW/m2	Not Reached	Not Reached	Not Reached	
			Flash Fire	6000 PPM	9.37819	2.10381	9.98006	
				12000 PPM	6.2995	1.34645	5.68685	
			Pool Fire	4 kW/m2	30.4823	33.801	30.453	
				12.5 kW/m2	15.4911	22.098	15.6827	
				37.5 kW/m2	6.23966	6.96524	6.37509	
5.	Hexane Pipeline	Short Pipe	Dispersion of vapour cloud	UFL(76800)	0.420444	0.512676	0.40882	Within the facility
				LFL(10500)	2.77133	1.3159	0.813107	
				LFL Frac(5250)	5.30786	1.32758	2.74121	
			Jet Fire	4 kW/m2	8.06366	6.68084	8.14965	
				12.5 kW/m2	6.40297	5.21645	6.47907	
				37.5 kW/m2	Not Reached	4.07765	Not Reached	

S. No	Description	Scenario	Event	Impact criteria	Consequence Distance (m)			Major Receptors
					Category 1.5/F	Category 5/D	Category 1.5/D	
			Flash Fire	6000 PPM	5.30786	1.32758	2.74121	
				12000 PPM	2.77133	1.3159	0.803107	
			Pool Fire	4 kW/m2	27.1134	27.696	26.4265	
				12.5 kW/m2	14.2979	18.7017	14.2265	
				37.5 kW/m2	4.88615	6.64519	5.05726	
6.	Xylene Pipeline	Short Pipe	Dispersion of vapour cloud	UFL(76800)	0.425554	0.498511	0.409261	Within the facility
				LFL(10500)	2.54814	1.30023	0.804496	
				LFL Frac(5250)	5.34661	1.31001	2.52461	
			Jet Fire	4 kW/m2	8.81518	7.31977	8.91807	
				12.5 kW/m2	7.0877	5.7422	7.1785	
				37.5 kW/m2	6.34708	4.60855	6.43403	
			Flash Fire	6000 PPM	5.34661	1.31001	2.52461	
				12000 PPM	2.54814	1.30023	0.804496	
			Pool Fire	4 kW/m2	30.44494	34.3506	30.5861	
				12.5 kW/m2	15.5368	22.3263	15.7678	
				37.5 kW/m2	6.49121	7.40677	6.6935	

3.7 Summary of results and observations for pipeline scenarios

- The Consequence analysis study is carried out for the Liquor Ammonia, N-Hexane, Ethanol, Xylene, Methanol and Toluene pipelines connecting from tanks to day tanks
- As per the NFPA rating, the chemicals like Sodium hydroxide (48%), Sulphuric Acid, Thionyl Chloride, Conc. HCl, Bromine exhibit health hazard, however acids are reactable with water and may mislead the interpretation so risk assessment was not carried out. Toluene, Methanol, Cyclo hexane, Xylene, Ethyl Alcohol, N Hexane, are stored underground and Ethyl acetate and 1,2- Dichloroethane (EDC) are stored above ground which exhibits fire hazards.
- All the hazards are observed in W direction due to the wind blowing from East to West.
- It is observed for all scenarios of pipelines connected to storage Tank, the estimated max distance is 30.58 m and the major receptors are confined within the facility.
- Mitigative measures for storage tanks are proposed to avoid hazards.

4 MITIGATIVE MEASURES

4.1 Summary of risk analysis and findings

1. All statutory appurtenances requirement with reference to safety and fire protection have been incorporated in the design.
2. Necessary preventive and protective measures are proposed for storage tanks and handling.

4.2 Recommendations for improving safety

The following measures are considered for enhancing the safety standards at site:-

1. Operator training and retraining should be a continuous effort and Mock Drills should be carried out regularly on identified scenarios.
2. Work Permit System should be strictly enforced and should not be allowed to be circumvented.
3. Hoses should be inspected and tested every three monthly for the recommended test pressure.
4. Static protection and integrity of explosion proof equipment should be ensured through regular inspection. Every electrical equipment and lighting features should meet explosion proof requirement, in classified area.
5. Smoking and carrying smoking material are to be strictly prohibited.
6. Interlock to be provided in the storage tank.
7. Earth link may be connected to pump circuit to ensure startup only after providing tank earth - connection.
8. Safety Procedures and Do’s and Don’ts should be prepared and displayed in handling and storage area.
9. Conveyor sides should have plastic guide strips in preference to metallic strips to prevent friction and consequent hazards.
10. Periodic inspection of Pipelines and painting to be done to avoid corrosion and subsequent leak.
11. The Plant commissioning has an important role to ensure long term safety. Proper cleaning and flushing of the system should be ensured in storage area and fire hydrant system to avoid possible hold up of welding slag’s, bolts, nuts etc. which could hamper smooth operation.
12. All the solvents are being distributed across the production plants through closed pipe lines and transfer pumps that will minimize fugitive loses.

13. The Environment team are trained on industrial hygiene and sampling / testing techniques.
14. The local exhaust ventilation is provided at storage locations which are connected to the scrubbers.
15. All the chemicals will be stored in proper designated place. The storage place will be well ventilated.
16. The floor will be tiled (acid/alkaline proof).
17. Non compatible items should not be stored together.
18. Dyke wall to be provided around the tank.
19. Fire extinguisher and Hydrant point shall be provided.
20. Fire fighting network shall be provided.
21. Solvent storage tank shall be earthed.

5 DISASTER MANAGEMENT PLAN

5.1 Objectives

a. To establish a method of systematic, safe and orderly evacuation in the least possible time, to a safe area or by the nearest safe means of way out.
b. Control the accidents.
c. Rapid control and containment of hazardous situation.
d. Rescue and treatment of casualties.
e. Safeguard people (both at site and neighbourhood).
f. Minimize damage to property and environment.
g. Identify casualties, notify their relatives and render necessary help to them.
h. Proper training of the concerned person.
i. Prevent recurrence.
j. Be capable of dealing with largest incident that can reasonably be foreseen.
k. Have sufficient flexibility with a view to handling the emergency efficiently and avoiding unnecessary calling outside agencies like external fire brigade.

5.2 Basic forms of Emergency

a. Fire
b. Explosion
c. Toxic release
d. Natural disaster (earth quake, flooding, tsunami etc.)
e. A combination of more than one

5.3 Types of Emergency

5.3.1 On-site Emergency

If an accident/ incident takes place in a factory, its effects are confined to the factory premises, involving only the persons working in the factory and the property inside the factory it is called as On-site Emergency.

It can be again classified as minor and major emergency based on severity of the incident.

Minor Emergency (Evacuation is not required)

In the case of minor emergency there will be no evacuation siren and the respective department personnel will handle the same with assistance of Safety Squad.

Major Emergency (Evacuation is required)

In case of major emergency there will be emergency siren and situation is tackled as per the plan.

5.3.2 Off-site Emergency

If the accident is such that it affects inside the factory are uncontrollable and it may spread outside the factory premises, it is called as Off-site Emergency.

Assessment reveals that an Off-site emergency is a very remote possibility in our factory. If there is a situation, first we shall avail the service of local police to warn and advice the local public about things to do to save them from the effect of emergency situation.

Moreover, the factory is located not in industrial area and, there are no residential houses in factory surrounding area.

5.4 Causes of Emergency

The emergency may caused by factors like failure of system, human error, sabotage and natural calamities like earth quake, flooding etc.

Irrespective of cause, the emergency will generally manifest itself in one of the three basic forms i.e. fire, explosion and release of toxic substance.

5.5 Safety, Health & Environment Policy

1. Assurance of Safety, Protection of Health & Environment is prime function and responsibility of the Management and the Management will inculcate the safety behavior down the line through exemplary behavior.
2. All the employees are periodically trained & informed about the hazards to which they are exposed & Safety measures to be taken including personal protective equipment.
3. To provide the resources required for Safety, Health and Environment protection.
4. We affirm to reduce the wastages, recycle the resources and disposal of wastages will be as per statutory norms.
5. All our facilities will be operated & maintained by the prescribed Standard Operating Procedures covering routine & non-routine activities.
6. All the accidents / near-miss accidents will be investigated thoroughly for their root cause to avoid recurrence. Corrective and preventive actions applicable for the same will be enforced.
7. Health, Safety & Environmental performance is constantly measured through periodic audits of facility for continuous improvements.

5.6 Mitigation Measures Required

a. Fire Hydrant System
b. Fire Extinguisher
c. Emergency Equipments / PPEs
d. Eye Wash Fountain and Safety Shower
e. Work Zone Monitoring Equipments
f. Wind Sack / Wind Direction Indicator
g. Occupational Health Centre
h. First Aid Boxes

5.7 Emergency Shutting Down Procedure

1. Critical operations will be shut down by the respective technician / operator upon getting the necessary instruction from the shift in charge. An emergency shutdown can be done after getting approval from Incident Controller / Site Controller.
2. Utility Controls will be shut off by maintenance personnel who will know the location and operation of main controls for gas, solvent and electrical supply leading into the building.
3. An emergency shutdown of computers should be accomplished in the event of a severe electrical storm. If time permits, exit the program and shut off the computer power supply.

5.8 Control Room

Control Room also termed as Emergency Control Centre (ECC) is a place from which all the decisions with regard to actions for control of emergency, rescue and medical treatment are made. Security office is considered as emergency control centre. It contains the following facilities.

a. Communication equipment
b. Copies of emergency management plan
c. Emergency escape route map
d. List of emergency contact numbers
e. Emergency light
f. Location of emergency supplies like PPEs / emergency equipments, layout of fire fighting system, assembly point etc.
g. Emergency organization team details

5.9 Alert Action Plan during Working & Non-Working Hours

5.9.1 Alert Action Plan during Working Hours

It can be divided as follows

a. Detection

b. Decision
c. Annunciation
d. Reaction
e. Recovery and Return to normal activities

a) Detection

The detection of any mishap like fire, explosion or toxic release is identified by either sensors or by any person working in the plant to activate alarm system.

b) Decision

The Department Head / Shift in-charge (Incident Controller) has to assess the size and nature of emergency and to decide whether it is a minor or major emergency and then to inform Site Controller immediately.

c) Annunciation

Site Controller will get complete information of the incident, assess the incident and if require pass an order to security to wail Emergency Siren through which every Department will come to know about the emergency, then accordingly they will plan to evacuate from their respective Departments.

d) Emergency Siren pattern,

This alarm will blow in the high pitch and low pitch level with interval of 15 sec between two blows. The mechanism will be in the form of waves of high and low frequency for 3 minutes.

e) Reaction

After hearing the emergency siren, all should stop their activities in a safe manner.
Except Emergency Organization Team members, all should come to safe assemble area and stay there for head count and for further instruction of Site Controller.
Emergency Organization Team members should act as per their pre- determined responsibility to;

i. To localize the emergency and if possible to eliminate it
ii. Minimize the effects of accident on people and property

f) Recovery and return to normal activities

Once Emergency is mitigated, normalcy is restored; head count is matched, then Site Controller will pass an order to Security to wail All Clear Signal.
All Clear Signal Siren pattern. It is a continuous alarm for one minute.

After hearing the All Clear Signal, all can move to their respective work places to start their normal activities.

5.9.2 Alert Action Plan during Non-Working Hours

During non working hours, i.e., in holidays, there will be no production activities. As we are carrying only batch processes, all the equipments (both process and utility) will be shut down and no chemical storage inside the production areas during holidays and also ensure the cleaning and good housekeeping.

All the 365 days Fire Hydrant System and Fire alarm systems are kept in active mode, to monitor this technical person and security persons will present round the clock throughout the year to tackle the worst case scenario in case of emergency.

5.10 On Site Emergency Planning

A. Constitution of Teams

a. Fire Fighters / Rescuers

b. First Aiders

c. Maintenance Team

a. Fire Fighters / Rescuers

- The fire fighters / rescuers shall attempt to extinguish or control the fire / prevent further toxic leakage without taking personal risk before the arrival of the fire brigade / other external agency.
- The fire fighters / rescuers shall also attempt to save the lives of people who are unable to ensure their own survival without assistance.

b. First Aiders

- The First Aiders shall get ready the first aid equipment, proceed to designated area and set up First Aid Point in coordination with Site Controller.

c. Maintenance Team

The Maintenance Team shall;

- The maintenance team shall go to important controlling areas like Fire Hydrant Pump House, DG area etc.

B. Define Roles And Responsibilities In Brief

In the event of emergency, nominated individuals / teams are given specific responsibilities; separate from their day to day activities.

The Emergency Organization Team consist,

a. Site Controller (SC)
b. Incident Controller (IC)
c. Emergency Co-ordinator – HR & Admin
    i. Hospital, Law & Order
    ii. Head Count
d. Emergency Co-ordinator Maintenance
e. Emergency Co-ordinator Safety Squad
    i. Fire Fighters / Rescuer
    ii. First Aider

C.1. Roles and responsibilities of Emergency Organization Team members

a. Site Controller (SC)

Site Controller is a person who has ultimate control over the affairs of the company during emergencies inside the plant. His responsibilities include;

- He should go to the Emergency Control Centre as soon as he is aware of the emergency and take over the situation.
- Get complete information of the incident.
- Assess the incident and if require pass an order to security to wail Emergency Siren.
- Remain in ECC and establish the contact with Incident Controller and guide him about the actions to be taken.
- Arrange for additional help as requested by Incident Controller with the help of Emergency Coordinators.
- If required call outside services like fire brigade, medical facility, water tankers, police etc with the help of Emergency Coordinators.
- Guide and control the traffic movements in evacuation.
- Establish communication and liaise with agencies like Department of Factories and Boilers, Pollution Control Board, Police and other Government Officials.
- Inform Incident Controller about missed people if any, after head count has been done.
- To issue authorized statements to the news media.
- Once situation is controlled, head count matched then instructs security to wail ‘All Clear Signal’.
- Rehabilitation of affected areas after the emergency.

b. Incident Controller (IC)

Incident Controller is a person who is responsible for incident control measures, rescue operations and mitigation of emergency situation on Coordination with Site Controller. His responsibilities include;

- Proceed to the incident spot as information is received.
- Assess the size and nature of emergency and communicate the same to Site Controller and keep in touch with Site Controller till the emergency is mitigated / controlled.
- Start and direct all emergency control operations with the help of Emergency Coordinator - Safety Squads.
- Request Site Controller for additional help like Safety Squads from other Departments, fire brigades etc.
- Direct shut down of the processes / plants and also nearby plants.
- Ensure evacuation of all personnel in coordination with Site Controller.
- Once emergency is mitigated, normalcy is observed, instruct Site Controller for the same.

c. Emergency Coordinator – HR & Admin

HR & Admin team consist two persons, one person will be stationed at the Emergency Control Centre during the emergency to handle hospital, fire, police and other inquiries under instruction of Site Controller and other person will carry out headcount at assembly point and pass on the absentee information to the Site Controller.

i. Emergency Coordinator Hospital, Law & Order

His responsibilities shall include -

- Proceed to the Emergency Control Centre and report to Site Controller.
- Ensure the gates are closed.
- With the help of security, control crowd at gate as per instruction from Site Controller.
- Deploy one guard at main gate with instructions not to allow / send any personnel, vehicles inside except fire tender and ambulance.
- Keep ready the list of important telephone numbers and contact numbers of police and other law and other agencies.
- Inform other statutory departments, corporate office as per instruction from Site Controller.
- Inform relatives / contact persons of the injured accordingly.

- Get hold of medical management procedure / list, hospital / telephone numbers, accordingly.
- Call the respective medical institute as per the instruction from Site Controller.
- Prepare a sequential report of the incident.

ii. Emergency Coordinator Head Count

His responsibilities shall include -

- Proceed to the Emergency Control Centre and report to Site Controller
- Ensure carrying Master Attendance Copy.
- Proceed to assembly point and collect attendance sheet from respective department.
- Compare the list and look for missing personnel if any.
- Inform Site Controller about the same.

d. Emergency Co-ordinator Maintenance

Emergency Co-ordinator Maintenance will take care of emergency control systems like Fire Hydrant System, DG units etc and also mobilize the tool and other emergency equipments as per the instruction of Site Controller.

- One of the co-ordinator will move to Fire Hydrant pump house and switch on /off the pump as per the instruction of Site Controller.
- One of the co-ordinator will move to Generator room and switch on / off as per the instruction of Site Controller.
- One of the co-ordinator will be available on phone and act as per the instruction of Site Controller.

e. Emergency Co-ordinator Safety Squad

Emergency Co-ordinator Safety Squads will fight the emergency to mitigate it and to protect life, property.

i. Emergency Co-ordinator Fire Fighters / Rescuer

- Proceed to the incident spot along with emergency equipments and report to Incident Controller.
- Set up emergency equipment.
- Act as per the instruction of Incident Controller.
- Make quick assessment of the injured and arrange to shift with the help of Incident Controller to safer place for first aid.
- Send one co-ordinator of the team along with injured.
- Search for missed ones and do rescue operation for the needy.

ii. Emergency Co-ordinator First aider

- Proceed to Emergency Control Centre along with team and report to Site Controller.
- Set up emergency equipments.
- Be ready to receive and to provide first aid to victim and to help the ambulance staff.
- Make quick assessment of the injured and arrange to send victim to hospital with the coordination of Site Controller.
- Send one co-ordinator of the team to hospital along with injured with medical management procedures.

C.2. Roles and responsibilities of persons other than Emergency Organization Team members

- Do not venture out for help.
- Be available in the Department till evacuation is called.
- After hearing the Emergency siren, all should stop their work in a safe manner immediately.
- All work permits will be cancelled automatically.
- All should come to Safe Assembly Area (In front of Safety Office).
- While coming to Safe Assemble Area,
  - Do not run, walk brisk.
  - Do not use lift, use only staircase.
  - Do not block staircase, use hand rail. Come in a line.
  - Do not obstruct / block the path to Emergency Organization Team members.
- Do not go back for your belongings.
- Do not use telephone except for emergency purpose.
- Follow instructions of Site Controller in Safe Assemble Area.
- After All Clear Signal, all can go back to their respective places / Departments.

C. Notification of Emergency

The notification of any mishap like fire, explosion or toxic release is identified by either sensors or by any person working in the plant. If detection by sensors, alarm system will get activated or if it by a person, he will activate alarm system. As soon as Incident Controller aware of the emergency, he will rush to incident spot and assess the size and nature of emergency and communicate the same to Site Controller.

D. Declaration of Emergency

Site Controller will be the person to decide whether the situation warrants evacuation of the premises or is a localized incident. This individual will be termed as the declarer of emergency. Immediately the declarer will make arrangements to give information to the Executive Director.

Once an emergency requiring evacuation has been decided upon by the declarer, the Emergency will be declared by putting on the Emergency Siren.

E. Evacuation of Personnel

All Safety Squad co-ordinators from the Department where the incident has occurred and from other Department will reach earliest to the point of incident. All other people working in the factory will assemble at designated assembly point i.e., in front of Safety Department after hearing the Emergency Siren.

The Emergency co-ordinators will assist in directing the individuals to the assembly point.

F. Accounting of Personnel

The Emergency Co-ordinator HR & Admin, Head Count Person will conduct head count as per particular days attendance record at the assembly point to account for persons working inside the factory and also for visitors / vendors present inside the premises. Information on missing persons will immediately convey to Site Controller.

G. Controlling of Emergency

The Safety Squad member from the affected area and Safety Squad members from other Departments will attempt to control / mitigate the emergency situation under the supervision of Incident Controller and instruction of Site Controller.

H. Arrangements for Medical Treatment

Any person injured in the incident and subsequently, will be treated by Emergency coordinator, First Aider.

First Aid team member will accompany the injured to hospital. In the event of additional medical help, the injured will be shift to recommended Hospital.

I. Information to the Relatives of the Injured

The relatives of injured will be informed by Emergency Coordinator HR & Admin for Hospital, Law & Order. The communications to the relatives of injured will be through telecom or by a messenger. The clear address of availability of the injured person (if hospitalized) will be communicated to his relatives.

J. Information to the Government Authorities

The Emergency Coordinator HR & Admin for Hospital, Law and Order is the person to inform and get help from Fire Station, Police and other Government Hospitals in coordinating with Site Controller.

K. Law & Order

Site Controller will take over and control emergency in coordination with Incident Controller and other Emergency Coordinators.

The Executive Director will arrange to send information regarding the incident to the Director of Factories, Government of Tamil Nadu.

L. All Clear Signal

Once Emergency is mitigated, normalcy is restored; head count is matched, then Site Controller will pass an order to Security to wail All Clear Signal.

After hearing the All Clear Signal, all can move to their respective work places to start their normal activities.

5.11 Offsite Emergency Plan

5.11.1 Preamble

An offsite emergency arising out of chemical hazards in one, which has potential to cause serious damage or loss of life beyond the plant boundary. In addition, Accidents during transportation of hazardous chemicals by road, rail, pipeline etc. can cause offsite emergencies. Emergency services such as Police, Fire, Medical etc., need to be prepared to handle such situations promptly and effectively.

It is mandatory under Rule 16 of the Hazardous Chemical Rules for District authorities to prepare an off-site emergency plan in respect of clusters of hazardous chemical industries or at locations where accidents are likely to have an off-site adverse effect.

In order to be in a state of preparedness to respond to the accidents and minimize their adverse impacts on the offsite population, requires an offsite emergency plan to be prepared by the District Controller for every District or Industrial Areas as applicable.

5.11.2 Objective

The objective of the present assignment is to prepare an area specific Offsite Emergency Action Plan for Crimson Organic private limited which can be practically implemented / activated at a short notice to ensure minimal impact on life and property due to emergencies arising out of Chemical Accidents or during Transportation of Hazardous Chemicals in the district.

The plan should be regularly updated when there are changes occurring in the Industrial set up, Transportation Aspects, Key Manpower and Administrative Changes etc., Regular drills, Training of key persons, increasing safety awareness etc is extremely important areas that must be looked into for sound preparedness.

5.11.3 Offsite Emergency Control

After the "Bhopal Gas Tragedy" (Methyl Isocyanides- MIC Poisonous and toxic gas release Accident at Union Carbide, 1984) the Government felt an immediate need to be more conscious about handling of Hazardous Chemicals. Central control room Centre or Offsite Industrial Emergency Control Room "OIECR" should be established by company. It should work under the Governing Council. The Governing Council should be headed under the chairmanship by District Collector & Magistrate.

The Governing Council Members are the permanent Ex. Officio Members to manage the affairs of the Emergency Control Room.

5.11.4 Emergency Instruction to the General Public

The Notification of Emergency

The emergency can be declared by following media to alert or alarm the public;

1. Public address system
2. Blow horns/Bells
3. Sirens / Hooters
4. Telephone message / Fax Messages / Hot lines/ Pager / E-mail / Mobile Phone / Satellite system
5. Sending messages through a messenger
6. Rushing personally to the Central Control Room or to the nearest Police Department or Fire Department for declaration of emergency.
7. Raising of Flag for denoting the level of natural calamities
8. Ham Radio
9. By any other source by which information can reach to the public in time.

5.11.5 Category of Alarm Systems

The following alarm system may be considered which will identify the various level of emergency.

5.11.5.1 First Level Warning (Fire Alarm)

- For an accident / incident within the unit

- Hooter / Siren – Short, intermittent

5.11.5.2 Second Level Warning

- When the District Authority receives information that a toxic or flammable gas has leaked then the siren has to be sounded in order to facilitate early evacuations from the unit.
- Siren – A wailing short and long intermittent siren notification of emergency.

5.11.5.3 Third Level Warning (All Clear)

- When the District Authority considers that the accident / incident is under control, emergency is withdrawing and it is safe for re-entry.
- Siren – A wailing, long and continues, intermittent siren.

5.11.6 Fire Fighting System

In order to tackle great risk of fire explosion, spillage of hazardous liquid or release of toxic gases, fire fighting system should be mobilized under chief fire officer. The operational response will be coordinated from the Central Control Room.

5.11.7 General Instruction to the Public

A major emergency may affect areas outside the works. The surrounding public will be alerted with public address system by Police or Government Authorities or nearby industrial concerns. The siren / hooter will blow to indicate arising the emergency situation.

It will be indicated which kind of emergency raised, Start the Radio / TV for further instruction & act accordingly. So that public will take prompt action to protect them-selves or rush to the safe shelter as instructed by the authority.

First of all to ascertain which type of emergency arised.

1. Fire
2. Explosion
3. Gas Leakage / Release
4. Collapse of Building, Brusting of Vessel etc.
5. Natural Calamities.

If gas leakage emergency arised, ascertain probability of gas whether flammable, toxic or poisonous. The following actions are suggested as per prevailing situation: Otherwise follow the instruction as issued by the authority.

5.11.7.1 Flammable Gas :

a. Be calm, don't get panicky
b. Do not light Cigarette etc
c. Shut down open flame, gas and electrical instruments or any source of ignition
d. Do not move any vehicle in the area
e. Do not go near the incident & don't allow any others
f. Shut down the windows, doors etc. & seat open ground or terrace.
g. Follow the instruction as directed by the authority.

5.11.7.2 Toxic Poisonous Gas

a. Cover your nose with wet hand kerchief / cloth and breath through it.
b. Come out in open, check the wind direction and move away quickly in perpendicular direction of wind. (cross wind direction)
c. Immediately go & try to get to a higher elevation, if gas is heavier than air (like chlorine, as it settles in low lying area)

Follow the instruction and reach safe shelter as instructed notified by Government Authority or Public authority.

5.11.7.3 General Instruction:

(A) DON'T

1. Do not get panicky, be calm
2. Do not approach the site of incident as a spectator
3. Do not approach unnecessarily for information or more enquires
4. Do not allow unnecessarily crowd nearby incident place
5. Do not believe in rumors unnecessarily

(B) DO'S

1. Listen radio, TV or Public Addressing System.
2. Emergency will be communicated by public addressing system / TV / Radio or siren (Siren-code wailing sound for one minute)
3. Follow the instruction & convey to others accordingly
4. On announcement of withdrawal of emergency or clearance Siren, start your routine work
5. On enquiry, deposit your statement as required by authority at the time of investigating the incident
6. Co-operate, help and assist the person(s) / authority handling the emergency and rescue operation.

5.11.8 Security & Police

Security, protection of life & property and traffic control & maintenance of law and order should be taken care by police. During an emergency duties and responsibilities of the police may be:

a) Cordoning of the incident area
b) Warning public about the hazards
c) Traffic Control
d) Assist fire fighting services
e) Assist first-aid medical teams
f) Assist evacuation and ensure protection of property in evacuated areas.

Different phases of emergency management practices would be as under:

a) Before the Crisis

Proper planning of manpower, transport and communication network to coordinate possible incident areas and regulation of traffic should be made for each industry in the area.

b) During the Crisis

The Security Commander of the area will set in motion the relevant contingency plan to control the operation.

c) After the Crisis

Protect property in the evacuated area.

d) Media

The Control Room should release up-to-date information to the media to the people.

5.12 Summary & Conclusion

Major hazards from the hazardous material storage have been identified and evaluated using Aloha software. This report discussed the impacts due to accidental releases of flammable, explosive and toxic chemicals from the storage tanks. The Consequence analysis is conducted in order to assess the level of impacts associated with storage and handling of hazardous chemicals. The storage tanks will be located within Site boundary and the surrounding is ideal without external interface. The location is safe for storage and handling of solvents. All other hazards are easily within control limits and away from habitation area.