7.1 PUBLIC CONSULTATIONS

The proposed project site is situated in Chincholi MIDC area. Hence, as per Environmental Impact Assessment (EIA) Notification No.S.O.1533 (E)" dated 14th September 2006; and amendment thereat, the proposed project does not requires conducting of public hearing. The EIA report has been complied by incorporating required information with regards to the project as mentioned in the standard Terms of Reference (ToRs) issued by MoEFCC vide letter No.IA-J-11011/189/2018-IA-II (I) dated on 9th August 2018 to BAL.

7.2 RISK ASSESSMENT REPORT

The study of risk assessment report in respect of proposed project was done by Functional Area Expert (FAE) **Mr. Vinod Sahasrabuddhe.** The proposed project would be formulated in such a fashion and manner, so that utmost care of safety norms and Environment Protection Act shall be taken care of.

7.3 BRIEF DESCRIPTION REGARDING PROJECT

BAL's management has planned to go for establishment of Organic and speciality Chemicals manufacturing unit. It involves number of equipments like reactors, condensers and distillation columns. The process involves solvents like Mono Isopropyl ammine, Methyl isobutyl ketone, Diphenylamine, N-Butyl ThiphosphoricTriamide, Methyl amine, Ethyl amine and Di Methyl Carbonate.

7.4 OBJECTIVE OF THE RISK AND HAZARD ANALYSIS

1) Identify hazards and nature of hazard in the process, storage and handling of hazardous chemicals.
2) Carry out Qualitative risk analysis for the process and suggest mitigation measures.
3) Carry out Quantitative risk analysis of the storage of hazardous chemicals and estimate the threat zones for Most Credible and Worst-case scenarios.
4) Suggest mitigation measures to reduce the risk/probability of the accident to the minimum.
5) Incorporate these measures for ensuring safe operations and safe layout and for effective preparation of On-site and Off-site emergency plans.
6) Suggest Guidelines for on-site and off - site emergency plan.

7.5 METHODOLOGY

A] Identify hazards based on

- Processes description received based.
- Identify Hazardous Chemicals handled and stored.
- Inventory of Hazardous chemicals
- Proposed storage facilities for hazardous chemicals
- Plant layout
- Safety measures to be adopted by the company

B] Hazard Assessment

- By Qualitative Risk Assessment
- By Quantitative Risk Assessment by Hazard index calculations and estimate threat zones by using ALOHA.

C] Recommendations

- Recommend mitigation measures based upon the above
- Recommending guidelines for the preparation of On-site Emergency plan.

7.6 HAZARD IDENTIFICATION

7.6.1 Risk Prone Areas

Based on classification of chemicals the hazard prone areas have been identified as follows-

- Reaction and separation Sections of production unit
- Storage of chemicals in tanks or respective vessels

A) QUALITATIVE RISK ANALYSIS

7.7 REACTION AND SEPARATION SECTIONS OF PRODUCTION UNIT

The reactions like condensation carried out in batch reactor, separation and recovery of solvents (used as reaction media), un-reacted component, neutralization, followed by separation and purification of the product. In the production plant, major hazards observed in the reaction section and separation sections. Major hazard in this section is of fire, explosion leading to toxic release.

1. Fire, and explosion
2. Toxic release
3. Exposure to hazardous chemicals

- **Mitigation measure**

1. It is imperative that all the safety instrumentations, alarms and interlocks will be installed and all safety precautions in handling the flammable and explosive gases, class 'A' flammable solvents will be taken care off at the design and basic engineering and detailed equipment design stages.
2. The first and the foremost recommendation is carryout HAZOP studies for all the processes right from the storage of Raw materials to the product storage by the experts from the process and basic engineering supplier with active involvement from the production and maintenance staff from the company. This study should form an important part of basic engineering supply and process know- how.
3. There are number of catalysts used in the manufacture of the processes and the quantities are also on higher side. So it is important to have catalyst re-generation processes if available and also either buy-back arrangement with the catalyst supplier and or safe disposal procedure.
4. All processes will be fully automated and will be PLC based controlled.

- **Major Hazard in Reactions**

It is known that highly exothermic reactions and even mildly exothermic reactions can lead to the uncontrollable rise in temperatures and pressures in the reactors and ultimately to the conditions of run-away reaction, (mostly in highly exothermic reactions and which use solvents as reaction media or and flammable and explosive chemicals) and this results in catastrophic explosion and fire. The major reason for occurrence of uncontrollable rise in temperature is accumulation of un- reacted reactants. This accumulation of un-reacted reactant has to be avoided at any cost.

- **Mitigation Measures**

For controlling exothermic reactions and to eliminate the possibility of uncontrolled reaction following safety measures will be adopted-

1. Setting up a Standard Operating Procedure (SOP) for all critical operations, reactions and separations.
2. Once the SOP and operating parameters have been finalized, strictly following it, 24X7, particularly for batch operations without any change of procedure.
3. Must have in built system to check that the procedures (SOP) are not violated at any time, and no short cuts are taken in batch processes. Manufacturing and production of APIs are in majority batch processes.
4. Provision of following alarm and interlock system (essential for highly exothermic reactions and alarms recommended for all exothermic reactions)
   - Utility failure alarm
   - Agitator failure alarm
   - High temperature alarm
   - Alarm for High rate of addition of limiting reactant which is added at controlled rate.
   - Raw material (limiting reactant) addition rate should be controlled by flow control loop. (FT, FIC, FCV). Controlling parameter being reactor temperature.
   - FCV and/or On-Off valve should be interlocked with the reaction mass temperature and agitator tripping.

7.8 STORAGE AND HANDLING OF HAZARDOUS RAW MATERIALS

7.8.1. Hazard Identification

There are number of Class A flammable solvents stored in form of Raw materials and also final products. Hence the major hazard will be fire and explosion which will have serious impact on environment damage, loss of property, life and injuries to personnel, in certain cases the impact may be felt outside the factory premises. Details of hazardous properties of Class A solvents stored as Products and Raw materials are given in Table 7.1.

Table No. 7.1 List of Products with Hazardous properties

Sr. No	CHEMICAL	NH	NF	NR	FLASH POINT DEG C	BP DEG C	CLASS	TWA	IDLH	ODOUR
1	Mono Iso Propyl Amine (MIPA)	2	3	0	MINUS 18	31 TO 35	A	5 PPM	750 PPM	
2	MIBK	2	3	1	14	115	A	50 PPM		0.1 PPM
3	Di Phynel Amine (DPA)	3	1	0	153	320/ mp 53		10PPM		
4	Iso Propyl Alcohol (IPA)	2	3	0	11	82	A			22 PPM
5	Di-isopropyl ether (By-product)	1	3	1	MINUS 28	69	A			
6	Propane By-product GAS	STORED UNDER PRESSURE 1435 KPA AT 37 DEG C FLAMMABLE								
7	N Butyl Thiophosphoric Triamide (NBPT)									
8	Methyl Amine Plant	3	4	0	37.8	100 deg c	B	5 PPM		
9	Ethyl Amine Plant	3	4	0	MINUS 18 DEG C	100 DEG C				
10	(DMC)Di Metyal Carbonate	2	3	0	18	90	A			
11	Propylene Carbonate	0	1	0	99	188	241			
12	**Propylene Glycol**	1	1	0	132					
13	Choline Chloride 75 %					solid		Hygroscopic		
14	Choline Chloride 60%									
15	Choline Chloride 98%									
16	Hydrogen	1	3	2						
	Propylene Glycol Storage: Hygroscopic. Keep container tightly closed. Keep container in a cool, well-ventilated area. Do not store above 23°C (73.4°F).									

7.8.2 The aim for RH analysis is

1. To identify the hazardous materials handled and stored at the plant site. Based on the hazardous properties, conditions of storage.
2. Quantify the hazards in case of major fire, explosion or toxic release by visualization of Maximum Credible Accident Scenarios.
3. Incorporate the results of QRA for safe layout of hazardous chemicals storage in tank farm as well as in the warehouse and factory layout, in addition to the requirements of statutory rules and regulations.
4. Suggest mitigation measures to reduce the risk/possibility of the accident to the minimum.
5. Incorporate all these measures to arrive at Safe Disaster Management Plan, On-site and Off-site Emergency preparedness plan, if there is any possibility of off-site emergency. For storage and handling of the potentially hazardous material also.

7.8.3 Storage of Hazardous Chemicals

Hazard Analysis and Risk Assessment

Hazard analysis is the process of determining the release probabilities and quantities, emission or release rates, the routes/pathways by which the released substances could reach the receptors, the fate of the substances in environmental media through which they are transported or moved and the characteristics of the receptors at risk.

Characterization of Hazardous Raw Materials

For the manufacture of above products number of organic/inorganic chemicals are used. Out of these, hazardous raw chemicals have been characterized into

A. Flammable solvents
B. Toxic and hazardous chemicals
C. Other non-hazardous materials chemicals

The following solvents will be stored on site:

Table 7.2 List of Flammable solvents Stored in Warehouse

SR NO	CHEMICAL	Description	STORAGE			
			CLASS	NO OF TANKS	CAPACITY CU M	TOTAL Cu M
1	ACETONE	SOLVENT	A	3	500	1500
2	METHANOL	SOLVENT	A	6	500	3000
3	ETHANOL	SOLVENT	A	6	500	300
4	N -BUTANOL	SOLVENT	A	2	300	600

7.8.4 Main Hazards in Storage of Chemicals

The main hazards from the storage of flammable liquids are fire and explosion, involving either the liquid or the vapour given off from it. Fires or explosions are likely to occur when liquid or vapour is released and comes into contact with a suitable ignition source, or alternatively, when a heat or fire source comes into contact with the container.

A. Common causes or contributory factors of such incidents include

1. Lack of awareness of the properties of flammable liquids.
2. Operator error, due to lack of training.
3. Inadequate or poor storage facilities.
4. Hot work on or close to flammable liquid containers.
5. Inadequate design, installation or maintenance of equipment.
6. Decanting flammable liquids in unsuitable storage areas.
7. Exposure to heat from a nearby fire.
8. Dismantling or disposing of containers containing flammable liquids.

B. Combustion of liquids

Combustion of liquids occurs when flammable vapours released from the surface of the liquid ignite. The extent of a fire or explosion hazard depends on the amount of flammable vapour given off from a liquid which is determined by: A) temperature of the liquid. B) The volatility of the liquid. C) How long the liquid is exposed for; and the air movement over the surface. Other physical properties of the liquid give additional information on how vapour/air mixtures may develop and also on the potential hazards. These physical properties include: flashpoint; auto-ignition temperature; viscosity; Lower explosion limit; and upper explosion limit.

C. Effect of Flash Point

Generally, a liquid with a flashpoint below the ambient temperature of the surroundings will give off sufficient vapour to mix with the air and be ignited. The lower the flashpoint of a liquid, the higher the risk.

- **Mitigation Measures**

1. Based on standard recommendations for moderate hazard is it is recommended to have Alcohol storage tanks should be in open in dyke walls and must have spill collection and control (recycle) arrangement to pump into another tank.
2. The storage tank will be in open with dyke walls.
3. Dyke wall dimensions should be such that clear volume is at least 1.2 times the tank capacity.
4. Clear distance between tanks will be provided as per the requirement of Petroleum Rules.
5. Location of pumps, location of tank farm in the factory should be as per the requirements of Petroleum rules.
6. Necessary approval from Chief Controller of Explosives will be obtained for the alcohol storage and factory lay out.

D. Maintenance and modifications:

Many incidents involving flammable liquids occur during maintenance and repairs. The likelihood is increased if the work is done by staff or outside contractors who have little knowledge of the hazards associated with flammable liquids. You should only employ experienced contractors. A guide which gives sound practical advice for selecting and managing contractors should be used while employing a contractor.

- **Mitigation Measures:**

1. Hot work Permit:

It is absolutely essential to establish hot work permit system for any hot work to be carried out in the factory, especially in the areas which store flammable solvents of Class A. And this should be strictly followed for any hot work carried out. It is essential that no maintenance work is done until the potential hazards of the work have been clearly identified and assessed; the precautions needed have been specified in detail; the necessary safety equipment has been provided; and adequate and clear instruction has been given to all those concerned.

In most cases, a permit-to-work (PTW) system should be used to control maintenance operations 20 in areas where flammable liquids are stored or used. PTWs are formal management documents. They should only be issued by those with clearly assigned authority to do so, and the requirements stated in them must be complied with before the permit is issued and the work covered by it is undertaken. Individual PTWs need to relate to clearly defined individual pieces of work. PTWs should normally include: the location and nature of the work intended; identification of the hazards, including the residual hazards and those introduced by the work itself; the precautions necessary, for example, isolations; the personal protective equipment required; the proposed time and duration of the work; the limits of time for which the permit is valid; and the person in direct control of the work.

2. Information and training:

Adequate training and knowledge of the properties of flammable liquids are essential for their safe storage. You need to inform all staff on the site about the hazards of storing flammable liquids, and about the need to exclude sources of ignition and heat from the designated storage areas. Those responsible for the operation of the store also need to receive specific training in how to deal with spillages and leaks, and emergency procedures.
Periodic retraining will normally be required. The training should include the following aspects:

1. The types of flammable liquid stored, their properties and hazards.
2. Use of protective clothing.
3. Housekeeping.
4. Reporting of faults and incidents, including minor leaks and spills.
5. Emergency procedures, including raising the alarm, calling the fire brigade and the use of appropriate fire-fighting equipment.

- **Major Mitigations Measures**

1. Good Ventilation in the storage area.
2. No ignition source. To be stored in good containers. No spillage. Control of spillage.
3. Adequate separation from each other and other storage areas and process areas.

7.8.5 Storage of Toxic Chemicals

7.8.5.1 Storage of Ammonia under pressure:

Hazards and impact of Ammonia leak can be wide spread and likely to affect people outside the factory area.

- **PROPERTIES OF AMMONIA**

"Ammonia is a natural constituent of the atmosphere but exists in concentrations below the level which is hazardous to humans, animals, plants or materials.

High concentrations of ammonia gas are corrosive to mucous membranes; can cause damage to the eye, throat and upper respiratory tract; and can produce residual damage and even death to humans and animals.

High concentrations are also toxic to most plant life and have corrosive effects on materials.

Table 7.3 Health Hazards of Ammonia

Concentration in Air	**Effect**
20 µg/m (0.027 ppm)3	Average atmospheric background concentration.
30 - 36,000 µg/m3 (.04 - 50 ppm)	odour threshold.
1.44 mg/m3 (2.0 ppm) Max one hour conc. limit	A limit of 0.50 ppm may be desirable if a surrounding buffer is not possible.
18 mg/m3 (25 ppm)	Threshold limit value to which it is believed workers may be exposed continuously for 8 hours without adverse effects3
280 - 490 mg/m3 (390 - 680 ppm)	Concentration range where NH_3 gas produces eye, nose and throat irritation and may injure respiratory mucous.
360 mg/m3 (500 ppm)	Suggested maximum short-term atmospheric concentration due to uncontrolled release of ammonia resulting from equipment failure, safety valves discharging or any other single release.
1,700 - 4,500 mg/m3 (2,360 - 6,250 ppm)	Concentration range in which NH_3 acts as an asphyxiant. above 4,500 mg/m3 - fatal.

The flammable limits of ammonia are from 15% to 25% by volume in air; however, ammonia is difficult to ignite in spite of this. Gaseous ammonia will dissolve readily in water at a rate of approximately 700 volumes/volume of water.

Melting point: -77.4°C Boiling point: -33.4°C Density: 0.677 g per c.c.

* Due to the chilling effect of evaporation, ammonia vapour resulting from a large spill may move down-wind as a visible cloud some distance before dissipating or rising.

- **RECOMMENDATIONS:**

1. The following separations should be maintained:

Table 7.4 Capacity of Tanks & Its Distances from Residential Buildings

Nominal Capacity of Tank		**Min. Distance From Tank to Residential Buildings***	**Feet**
Liters	Gallons	Meters	Feet
over 2770 to 9090	500 to 2,000	75	250
over 9,090 to 90,900	2,000 to 20,000)	150	500
over 90,900 to 136,400	(20,000 to 30,000	230	750
over 454,600	Over 100,000	380	1250

* Isolated residences where occupant has an influence over the location of the tank (i.e. from whom land is bought or leased) are excluded. Two or more tanks - use capacity of largest tank.
2. If the recommended distances cannot be met, provisions for a high pressure water spray, which may be directed on any possible point of ammonia emissions to the atmosphere, should be included in the design.
3. Provisions should be included in the design such that displaced vapors from tanks are not emitted to the atmosphere during loading or unloading operations.
Design operating details should be submitted.
4. Any hose used for loading or unloading should have a shut-off valve as close to the discharge point as possible. Any ammonia remaining in the liquid ammonia hose after transfer operations should be absorbed in water such that it is not discharged to the ground or atmosphere in an uncontrolled manner
5. The manner in which unauthorized personnel will be prevented from causing vandalistic emissions of ammonia; for example, fencing and locked gate.

- **PROHIBITIONS:**

1. Purging of any tank which has contained or contains liquid ammonia such that ammonia-containing gases are vented directly to the atmosphere is prohibited.
   Purging on-site may be approved if appropriate facilities are available.

Table 7.5 Vapour Concentration & Its General Effect

Vapour Concentration(ppm)	**General Effect**	**Exposure Period**
(1)	(2)	(3)
1-5	Odour detectable by most person	Prolonged repeated exposure produces no injury
25	No adverse effect for average worker	Maximum allowable concentration for 8 hour working exposure
35	No adverse effect for erage worker	Exposure should not be longer than 15 minutes and should not occur more than four times per day

Vapour Concentration(ppm)	General Effect	Exposure Period
(1)	(2)	(3)
400 to 700	Nose and throat irritation Eye irritation with tearing	Infrequent short (1/2 hour) exposure ordinarily produces no serious effect
2 000 to 3 000	Conculsive coughing Severe eye irritation	No permissible exposure. May be fatal after short exposure
5 000 to 10 000	Respirator spasm. Rapid asphyxia	No permissible exposure. Rapidly fatal

Liquid anhydrous ammonia produces skin burn on contact.

i. ACGIH Short Term Exposure Limit (STEL) – 35 ppm

NOTES:

1. ACGIH (TLV-TWA) – The TWA concentration for a conventional 8 h work day and 40 h work week, to which it is believed that nearly all workers may be repeatedly exposed, day after day for lifetime without adverse effect.
2. ACGIH (TLV-STEL) indicates Short Term Exposure Limit. A 15 minutes TWA exposure that should not be exceeded at any time during a work day, even if the 8 h TWA is within the TLV-TWA. Exposures above the TLV-TWA up to the TLV-STEL should be less than four times per day, and there should be at least 60 minutes between successive exposures in this range.'

(2) Additionally, it is recommended to refer to the wide range of literature available on the bulk storage of Ammonia and precautions to be taken while storing Ammonia in bulk storages under pressure.

7.8.5.2 Ethylene Oxide Storage:

Following are the hazards and mitigation measures to be taken for the storage of Ethylene Oxide:

- **Hazardous properties:**

NFPA RATINGS (SCALE 0-4): HEALTH=3 FIRE=4 REACTIVITY=3
MAJOR HEALTH HAZARDS: harmful if inhaled or swallowed, skin burns, eye burns, respiratory tract irritation, central nervous system depression, allergic reactions, cancer hazard (in humans) PHYSICAL HAZARDS: May explode when heated. Flammable gas. May cause flash fire

POTENTIAL HEALTH EFFECTS:
INHALATION:

1. SHORT TERM EXPOSURE: irritation, lack of sense of smell, tearing, nausea, vomiting, diarrhea, difficulty breathing, irregular heartbeat, headache, drowsiness, symptoms of drunkenness, disorientation, bluish skin color, lung congestion, lung damage, kidney damage, paralysis, reproductive effects, convulsions
2. LONG TERM EXPOSURE: cancer

- **Mitigation Measures:**

1. Precautions and measures to be taken with respect to instrumentations on storage tanks, loading and unloading of Ethylene Oxide

2. The following minimum instrumentation should be provided on storage tanks:
   1. Temperature monitoring and alarms.
   2. Pressure monitoring and alarms.
   3. Level monitoring and alarms.

3. Temperature monitoring and alarms

Each EO storage tank should be provided with at least two independent temperature measuring devices. One should be used for temperature indicating or recording and the other should provide a high temperature alarm. It is important that both devices are situated in the bottom of the tank so as to be always immersed in the liquid. In larger storage tanks, and particularly in vertical tanks, where mixing is difficult, temperature indicators and alarms may be installed at several levels so that stratification of the ethylene oxide can be detected.

In addition to the provision of absolute temperature indications and alarms, consideration should be given to the provision of rate of temperature rise indication and alarms. These, together with the absolute temperature indications and alarms, will give early warning of possible polymerisation due to contamination.

4. Pressure monitoring and alarms

Two independent pressure measuring devices should be provided. One for pressure indicating and recording, and the other to provide both high and low pressure alarms. High and low pressure alarms will give a warning of problems associated with the inserting nitrogen supply system or pressure venting system.

Condensation of EO vapour in DP cells, with the possibility of polymerisation of the condensed liquid, can be prevented by the use of double diaphragm type DP cells.

5. Level monitoring and alarms

Level measurement with high and low alarms should be provided. The high alarm serves to prevent overfilling and the low alarm to prevent damage to pumps which are used for pumping out tank contents.

In general, level measurement devices should be of the float, displacer or differential pressure cell type and should be fitted internally to the tank. Other types, such as ultrasonic or radar echo sounders, are also possible, as are load cells; the latter should be selected to avoid or minimise flexible connections.

Remote seals or double diaphragm types are recommended for DP cells to minimise the possibility of back-flow in the event of diaphragm failure. Stagnation of ethyleneoxide in dip legs should be avoided by filling the legs with an inert liquid or purging with nitrogen.

It is recommended that the switches used to initiate level alarms and trips are of the point contact type, such as float or capacitance switches; it may be difficult to zero or span other types without a reference level.

6. Glass level gauges and sight glasses are not recommended.

7. Relief and vent systems

Storage vessels which contain EO must be fitted with an adequate relief valve. If a spare relief valve is fitted, to allow maintenance of relief valves whilst the vessel remains on line, then interlocking facilities must be provided to ensure that one valve always protects the vessel. Fire relief valves should be fitted in accordance with the recommendations made in the codes of practice relating to Liquified Petroleum Gases.

Relief valves and vent systems should discharge to a safe location at a high point and at a high velocity to ensure good dispersion. If several vents are joined in a manifold together, before discharge through the common system to prevent diffusion of air back into the system. Piping arrangements between relief valves and vents and vent stacks should be such that liquid cannot accumulate at low points and continuous drainage facilities should be provided at vent stacks to prevent the accumulation of liquid.

Relief valves should be fitted as close as possible to the vessel on to nozzles which allow free draining of any condensed liquid back into the storage vessel; this arrangement should prevent polymer build-up in the inlet to the relief valve.

Bursting discs should not be used as the primary form of pressure relief because they could lead to an uncontrolled loss emission until the vessel is empty. They may, however, be used as a safeguard against polymerisation blockage in a relief valve or to prevent minor leakage through the valve, which creates an environmental problem, or could ignite in an electrical storm. If bursting discs are fitted, a pressure indicator should be fitted between the bursting disc and relief valve to indicate whether or not the bursting disc is intact. Care should be taken in the selection of bursting discs which are fitted below relief valves, since fragments from a failed bursting disc may prevent reseating of the relief valve.

Venting of vapour from storage should be kept to a minimum. This may be achieved by split range control of the pressure with dead bands in the EO storage vessels and by pumped transfer with vapour balance between delivery vehicles and storage vessels. Any vapours that have to be vented may be scrubbed in a vent scrubber to remove EO. This operational vent should be quite separate from emergency vents.

The fitting of flame arresters to EO vents is not recommended due to the risk of blockage by polymer. Fitting bursting discs below relief valves and inerting process vents is the preferred way of avoiding ignition in the vent.

8. Back Flow Protection

Many bulk storage installations are associated with plants which use catalysts to polymerise EO; this polymerisation can be extremely rapid with some catalytic materials, e.g. amines, and every effort must be made at the design stage to minimise the possibility of contaminating the bulk of the storage with catalysts. In addition, the consequences of such contamination occurring should be carefully considered and emergency procedures developed to deal with the consequences.

9. Unloading Systems

EO may be unloaded in two ways:

a) By pressurisation of the transportation vehicle with an inert gas, e.g. nitrogen.

b) By pumping from the transportation vehicle.

The first option entails the venting of ethylene oxide containing nitrogen from the receiving vessel and thus has environmental consequences. The second option overcomes this drawback if a balance line is used to connect delivery and receiving vessels but requires the safeguarding systems.

When using nitrogen to displace the EO, it should be ensured that the pressure of the nitrogen supply cannot exceed the set pressure of the relief device on the transportation vehicle.
Separation distances from the offloading point to storage, boundary fence or other facilities, should ideally be at least 15 metres.

10. Gas detection and fixed fire fighting facilities

Since EO is susceptible to explosive decomposition when heated by a external fire, special precautions are necessary.
Gas and fire detection in the neighbourhood of sources of possible leakage, such as pumps, unloading system and drainage points, should be considered.
The gas detection network and fire detection system may sound an alarm but more rapid knock-down of vapours, dilution of leakage and control of fire will result if automatic operation of a water spray and deluge system is triggered by the gas detection system. Early application of water sprays also means that the water spray system itself is less likely to become damaged by the fire.
Water spray systems should be provided with non-clogging nozzles and be designed to apply water at a density of 8-10 l/m2/min to storage vessels and associated pipe work, and at a density of 40 l/m2/min to pump areas. Supply of water should be sufficient to allow other mitigating actions to be taken before supplies are exhausted.
The drainage in the EO handling area should be checked to ensure that it has the capacity to remove the large amount of water required to control a major leak or fire; insufficient capacity could result in the flooding of the area with flammable EO solutions which could hinder the control of the incident.

11. FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARDS: Severe fire hazard. The vapor is heavier than air. Vapors or gases may ignite at distant ignition sources and flash back. Vapor/air mixtures are explosive.
EXTINGUISHING MEDIA: Alcohol-resistant foam, carbon dioxide, regular dry chemical, water
Large fires: Use alcohol-resistant foam or flood with fine water spray.
FIRE FIGHTING: Let burn unless leak can be stopped immediately. Move container from fire area if it can be done without risk. Fight large fires from a protected location or safe distance. Stay away from the ends of tanks. For fires in cargo or storage area: Cool containers with water from unmanned hose holder or monitor nozzles until well after fire is out. If this is impossible then take the following precautions: Keep unnecessary people away, isolate hazard area and deny entry. Let the fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of tanks due to fire.
For tank, rail car or tank truck, evacuation radius: 1600 meters (1 mile). Do not attempt to extinguish fire unless flow of material can be stopped first. Flood with fine water spray. Do not scatter spilled material with high-pressure water streams.
Apply water from a protected location or from a safe distance. Cool containers with water spray until well after the fire is out. Avoid inhalation of material or combustion by-products. Stay upwind and keep out of low areas. Evacuate if fire gets out of control or containers are directly exposed to fire. Evacuation radius: 1600 meters (1 mile). Water may be ineffective.

7.8.6 Storage of flammable gases under pressure:

Following gases which are highly flammable and explosive are to be stored at the factory site

1. **Propylene**
2. **Propylene Oxide**
3. **Propane**
4. **Hydrogen**

- **Hazards:**

In case of leakage and in presence of ignition source, there will be fire and which may lead to explosion of BELVE type causing impact on large areas inside as well as may be outside the factory limits.

- **Mitigation measures:**

Design, installation, operation, design of safety systems, fire fighting system and hydrant layout etc and maintenance of the entire storage loading/unloading and transfer facility for storage will be in line with and as per the details given in PETROLEUM AND NATURAL GAS REGULATORY BOARD NOTIFICATION New Delhi, the 12th February 2016**.**
Approval for the storage of for all these gases will be obtained as per the requirement of Petroleum and Explosive Act 2002
Important Safety Instrumented system as detailed of the above act is illustrated below:

1. Emergency Shutdown (ESD)
   - ii. Surge Relief
   - iii. Alarm for hydrocarbon level in the tank
   - iv. Thermal Safety Valve (TSV) or Thermal Relief Valve (TRV)
   - v. Hydrocarbon detectors
   - vi. High level and High-High level alarms for storage tanks and line balancing tank to be integrated with SCADA of pipeline control room.

2. Operation system interlock checking shall be carried out once in a year. Calibration, Maintenance and Inspection of Safety Instrumentation shall be carried out as per industry practice or recommendations of OEM or Statutory Authority requirements.

3. Testing of Pressure or Thermal Safety valves or Surge relief system shall be carried out once in a year and proper authenticated document shall be maintained.

4. Emergency Shut Down (ESD) systems shall be checked with actuation once in a year.

5. Fire Protection System

A. Ultra Violet or Infra Red or Other Flame detectors or Heat detectors or a combination of flame and heat detectors shall be installed in the pump shed to give automatic alarm and/ or shut down of the unit, isolation of the facilities in the event of occurrence of fire. The same may be coupled with suitable extinguishing system such as foam system for extinguishing the fire.

B. Smoke or multi sensor detectors shall be provided in control room, Motor Control Center (MCC) room and utility rooms, cable trenches etc. with provision of indication, alarm and annunciation.

C. Break glass type fire alarm system shall be installed at all strategic locations of the stations and shall be integrated to the Fire Alarm Panel in the control room and the same shall be extended to the marketing control room in delivery or terminal stations. Manual call point with talk back facilities shall be installed in the strategic locations of large size tank farm and to be hooked up with station fire alarm pane

D. Environmental friendly fire extinguishing system shall be considered for control rooms, switch gear and battery room, computer rooms of pump station, terminal station, delivery or tap off stations.

E. Fire water network with fire hydrants, long range monitors and fire water storage shall be provided at all stations except scrapper stations and sectionalizing valve stations.

F. **Back Up Power for CP System**

G. Wherever the availability of power supply from State Electricity Board to the CP system is not reliable suitable back up power (battery bank or Inverter or DG or Solar or TEG or Any other suitable) shall be provided so as to provide minimum 90% time power to CP system.

H. **Safety Appliances**

I. Safety appliances provided against lightning, stray current interference from foreign objects at pipeline crossings etc shall be maintained once in six months and updated records shall be maintained.

6. Identification:

1) Suitable signs shall be posted to serve as warnings in hazardous areas, high noise area preferably with area segregation.
2) Classified and high voltage areas shall be adequately marked and isolated.
3) Caution signs shall be displayed indicating name of the operating company and, where possible an emergency telephone contact.

7. Prevention of Accidental Ignition:

A. Smoking shall be prohibited in all areas of a pump station, terminal, or tank farm in which the possible leakage or presence of vapor constitutes a hazard of fire or explosion.

B. Flashlights or hand lanterns, when used, shall be of the approved type.

C. Welding shall commence only after compliance of the safety precautions taken as listed in the work

D. Consideration should be given to the prevention of other means of accidental ignition.

8. Display of Operating Instructions

The gist of operating instructions, emergency shutdown (ESD) procedure, ESD trip and pressure shall be displayed or made readily available in the respective control room and also near all important operating equipments. If a piping system is de-rated to a lower operating pressure in lieu of repair or replacement, the new MAOP shall be determined and displayed prominently at an appropriate place in the control rooms.

9. Training of Personnel

For the operation of the facility in a safe and appropriate manner, it is required that the operating and maintenance personnel shall suitably be trained every year on the following aspects:

i. Up-gradation of operating and maintenance skills
ii. Up-dation of safety methods and procedures
iii. Technical Up-gradation in the field of operation or maintenance.

Table 7.6 List of Toxic Chemicals (In drums and Warehouse)

Sr. No	Name of the Chemical	NH Value	Max Qty stored T/Month	Capacity of Container	Number of Containers
1.	Di PhynelAmine	3	1050	200	2
2.	N Butyl ThiophosphoricTriamide (NBPT)	2	300	40	2
3.	Choline Chloride 75 %	2	2100	200	2
4.	Choline Chloride 60%	2	1500	25 Kg	--
5.	Choline Chloride 98%	2	300	25 Kg	--

Mitigation measures for storage of chemicals in warehouse

- **Warehouse Design**

Warehouse for the storage of chemicals in drums of the area will be constructed. This will be constructed as per the **IS code 3594** and other relevant standards
Major points are from the code are given below:

1. Roadways around warehouse should be min 5 meters wide and compound gates min 4.5 m wide
2. Floor areas: WH should be divided to have max 750 sq m area by separating walls. Dimensions LXW not exceeding 40 meter
3. Floors should have 2 hrs fire resistance
4. Buildings used for storage of hazardous and extra-hazardous goods should be preferably of single storied structure and in no case should exceed 2 stories in height
5. In no case should a storage building exceed 1S m in height
6. Floor Drainage The floors should be of watertight construction and Scuppersof not less than 20 cm sq cross sectional area should be provided at no more than 6·0 m intervals or as required to take care of maximum water discharge from hydrant/sprinkler system.
7. External Drainage External drains of not less than 25 CM width and 30 Cm depth should be provided along the side of each building and so constructed that any flow of water from the building be directed to a suitable ground tank or reservoir or public drainage system in the vicinity not leading to a natural water source. No external drainage of warehouses storing hazardous goods should be connected to public drainage system which leads directly to a natural water source.
8. Every storage/warehouse building should have a minimum of two exit doorways, and at the rate of one exit doorway per every 30 m length of the external walls of the building
9. The means of exit as well as the exit ways, travel distances, etc, should be as per the guidelines given in IS 1641 : 1988 If used for storage of hazardous goods, it should conform to Type I of IS 1642 : 1989.

- **Additional measures for improving Warehouse Safety**

Measures for improvement in the design of warehouse:

1. Dividing warehouse into fire compartments, by suitably designed firewalls, to limit the spread of fire.

2. Limiting the quantity of hazardous chemicals stored.
3. It is safe practice to store explosive, self igniting, oxidizing and organic peroxides separately, preferably in different compartments.
4. Storage of chemicals should be planned by categorizing these based on their hazardous properties, like toxicity, flammability, explosibility, for which MSDS needs to be critically studied.
5. Based on the above, proper segregation of materials should be achieved.
6. Installation of smoke, fire and toxic gas leak detectors.
7. It should be easily possible to reach and attend toxic chemical leakage.
8. There should be enough space, and pathways for easy approach and escape.
9. Having all flameproof fittings inside the warehouse.

7.8.7 Storage of other Hazardous Chemicals in tanks

Table 7.7 List of Flammable Chemicals in tanks

Sr. No	**Chemical**	**Max. Storage At a Time at Site (T/M)**	**No. of tanks**	**Storage In tanks**	**Size Capacity** (KL)
1	Mono Iso Propyl Amine (MIPA)	1500	1	Over Ground	300
2	MIBK	3000	4	Over ground	800
3	IPA	4968	5	Overground	3000
4	Di-isopropyl ether	198	2	Over ground	40
5	Propane	966	3	Overground	276
6	Methyl amine plant	3600	3	Over ground	240
7	Ethyl amine plant	3000	2	Overground	200
8	Di methyl Carbonate (DMC)	1656	4	Over ground	1200
9	Propylene Carbonate	432	2	Over ground	184
10	Propylene Glycol	1656	3	Over ground	900
11	Hydrogen	450	1	Over ground	25
12	Hydrochloric acid	191.1	4	Over ground	200
13	Acetone	5430	3	Over ground	1500
14	Ammonia	4448.4	4	Over ground	368
15	Aniline	1260	2	Over ground	100
16	Propylene	4800	2	Over ground	300
17	n-Butanol	360	2	Over ground	100
18	Methanol	7020	6	Over ground	3000
19	Ethanol	8430	6	Over ground	300
20	PO	1620	4	Over ground	368
21	CO2	1260	4	Over ground	200

7.8.8 Storage of Coal

It is proposed to install and operate reeboilers of capacity 60 TPH each and two TFH of capacity 30LK/H eachusing imported coal

7.8.9 Mitigation Measures for Coal storage

1) Fire hydrant lines (self auto-mode fire fighting) will be laid around these areas.
2) No hot work will be permitted in this area without safety permit.
3) There will be no high voltage (H.T.) transmission lines over & near briquette and coal storage.
4) All useful material will be stored far away from storage of coal area.
5) Proper supervision staff with necessary communication facility will be deployed.
6) Training will be arranged for all the staff in normal & emergency operating system.
7) Proper training will be imparted for creating awareness among workers about sudden coal fire as an emergency action plan. This will be part of On-site-emergency plan.

7.8.10 Quantification of Hazards due to Storage of Hazardous Materials

Worst case scenarios for leakage / spillage of hazardous raw materials using ALOHA software are done. This is summarized in following table:

Table 7.8 Risk Assessment - Worst Case Scenarios and Mitigation Measures

No.	Raw Material	Scenario of Spillage/Leakage	Area of Spread	Mitigation Measures
1	**Methyl Butyl Ketone**	Leak from hole in horizontal cylindrical tank	**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: 17 yards --- (2.0 kW/(sq m) = pain within 60 sec)	**Small Spill:** Absorb with an inert material and put the spilled material in an appropriate waste disposal. **Large Spill:** Flammable liquid. Poisonous liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

2	**Propane**	Leak from hole in vertical cylindrical tank	**Threat Modeled: Flammable Area of Vapor Cloud** Model Run: Heavy Gas Red : 11 meters --- (12600 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: 19 meters --- (2100 ppm = 10% LEL)	**Small Spill:** Absorb with an inert material and put the spilled material in an appropriate waste disposal. **Large Spill:** Toxic flammable liquid, insoluble or very slightly soluble in water. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.
3	**Chemical-Di Methyl Carbonate**	Leak from hole in horizontal cylindrical tank	**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)	**Small Spill:** Absorb with an inert material and put the spilled material in an appropriate waste disposal. **Large Spill:** Corrosive liquid. Poisonous liquid. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray curtain to divert vapor drift. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.
4	**Methyl Amine**	Leak from hole in horizontal cylindrical tank	**Threat Modeled: Thermal radiation from jet fire** Red : 10 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec) Orange: 10 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec) Yellow: 17 meters --- (2.0 kW/(sq m) = pain within 60 sec)	**Small Spill:** Absorb with an inert material and put the spilled material in an appropriate waste disposal. **Large Spill:** Absorb with an inert material and put the spilled material in an appropriate waste disposal. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Appendix G may be referred for severity mapping done for hazardous chemicals.

➢ **Conclusions and Recommendations from QRA results**

Many of the following mitigation/safety measures would be installed and are in place as plant is operational, the rest will be adopted –

1. QRA results of pool fire in case of both the cases, i.e. in the case of flammable solvents stored in the tank and flammable solvents stored in drums, The threat zones estimated

for the radiation effects are within or less than 10 meters in all the scenarios considered. Because of less quantity stored.

2. However flame lengths estimated are in the range of 1.5 to 3 meters, which can cause escalate the fire situations because of heating of the nearest tank.
3. Automatic Sprinkler system will be provided to counter this effect.
4. Tanks will be placed within the well designed dyke wall of 6 m by 12 meters to contain and recover the spillage.
5. QRA results for toxic chemicals indicate that the threat zones as estimated based on PAC values and other recommended values, workers inside the warehouse and factory will be affected and on-site emergency plan will have to be put in action and if necessary also Off site emergency plan will have to be activated, if the leakage gets unnoticed for a long period of time like 30 to 45 minutes.
6. It is recommended to provide close watch on all the toxic chemicals stored for leak detection by the alert staff.
7. Adequate training and retraining needs to be provided for the workers, including contract workers.
8. Along with smoke detectors, adequate number of toxic gas leak detectors should be installed inside the warehouse.
9. All manual handling of drums should be avoided.
10. Special and all recommended PPEs should be used while handling of toxic chemicals, particularly suspect and confirmed carcinogenic chemicals.
11. Adequate spill kits in adequate quantities must be readily available inside the warehouse and plant to deal effectively with spillages.

7.8.11 Electrical Hazard

Electrocution incidents can be fatal, while non-fatal shocks can result in serious and permanent burn injuries to skin, internal tissues and damage to the heart depending on the length and severity of the shock.

1) Electric shocks from faulty electrical equipment may also lead to related injuries, including falls from ladders, scaffolding or other elevated work platforms. Other injuries or illnesses may include muscle spasms, palpitations, nausea, vomiting, collapse and unconsciousness.
2) Those working with electricity may not be the only ones at risk. Poor electrical installation and faulty electrical appliances can lead to electric shock to others at or near the workplace.
3) Although we speak mainly of dynamic electricity (i.e. an electric current), static electricity, the accumulation of charge on a surface as a result of two surfaces rubbing together can also cause a static electric shock which can be painful but normally non-life threatening. The trouble with static electricity is if there is flammable or combustible liquids or gases that (depending on their flash point) ignite causing explosion or fire.

- Mitigation Measures:

1) Ensure only appropriately licensed or registered electricians carry out electrical work.
2) Switch off electricity where possible before working on equipment.
3) Ensure electrical equipment is in good working order (testing and tagging).
4) Use battery operated tools rather than mains power tools where possible.
5) Remove damaged, unsafe electrical equipment or cords from the workplace.
6) Ensure tag out and isolation procedures are in place and used.

7) Use residual current devices (or safety switches) with portable equipment (as per the WHS Regulations)
8) Don't overload power sockets. Use power boards not double adaptors.
9) Meet electrical safety standards.

7.9 FIRE FIGHTING

This will be designed and installed as per the international standard NFPA or OISD standards and or as the guidelines given in the Guidelines are also given in 7.8, 7.9, 7.10 to 7.14 of **PETROLEUM AND NATURAL GAS REGULATORY BOARD NOTIFICATION New Delhi, the 12th February 2016**.

1. Fire fighting system will be designed and fire hydrant system will be laid all over the plant as per international /NFPA standards.
2. Factory layout showing the hydrant piping, location hydrant points etc will be prepared during detailed engineering.
3. Adequate water storage facility exclusively reserved for fire fighting will be constructed as required.
4. There are more detailed guidelines for the safe storage, loading and unloading of flammable gases under pressure for example HSG 176 publication of Health and Safety Executive 1998. Complete book is also available.
5. It is recommended to use these and other standard references for design, layout, installation of safety instrumentation, distances to be maintained in tank layout, distances of other facilities from the storage tank farm, fire fighting system design, hydrant piping layout etc.

Case Study:
Propylene Oxide:

There is standard reference (**Booklet by Dow International company**) available for safe storage and handling, fire fighting giving complete details, this should be used in design and storage and handling of Propylene oxide.

7.10 OCCUPATIONAL HEALTH CENTER (OHC)

The company will establish OHC as per the Factory act, Rule 73 clearly states the requirements, rules for pre-employment and regular medical check-up, trained man-power required to be employed in OHC, need for 24X7 Ambulance availability.

Since the workers will be dealing with hazardous and toxic chemicals following is suggested

1. It is clear that the parameters for periodic health check up for workers has to be based on and decided on the hazardous chemicals handled in the process (Raw material, intermediates, solvents, products), their toxic properties and the extent to which shop floor workers, including contract labours, operators, officers are exposed to these chemicals. Detailed information on the groups of hazardous chemicals, chemicals included in the group, their use, target organs, (organs which are affected by the exposure to these chemicals) and corresponding medical tests to be carried out is available.

2. It is expected that the parameters based on such or similar tables, hazardous properties of chemicals (available in MSDS) have to be finalized by the OHC doctor in consultations with the safety officials of the company.
3. Frequency of periodic examinations will depend upon the exposure, TLV values, extent of these chemicals in air, based upon air monitoring.
4. Periodic medical examination, in comparison with pre medicalcheckup results will reveal the ill effects on the worker's health. This will help early detection of the disease and the effect on organs tec. This will be used for suitable corrective action to prevent further deterioration. Suitable medical treatment will be initiated for the worker.
5. If air monitoring shows presence of hazardous chemicals more than TLV values, suitable action needs to be initiated immediately to improve process conditions/ pollution measures.

For less hazardous industries, same health parameters as per pre employment check up will be included in periodic medical checkup.

7.11 EHS Policy:

Company shall have clearly defined EHS policy and it will be known to all employees and will be properly displayed. The Company's EHS policy, if needed will be modified and displayed and known to the employees must inform district officials and hospitals.

7.12 ONSITE EMERGENCY PLAN

BAL will prepare On-site Emergency Plan based on the following guidelines, before the plant start-up.

This can be made as per the following guidelines suggested below:
On-site and Offsite emergency plan will be prepared as per the factory act and will be prepared as per Rule no. 12 of factory act (control of Industrial Major Accident Hazard Rules, 2003) as per the guidelines given in Schedule 6.
Objectives of Onsite Emergency Plan will be:

a) To control emergency situation arising out of possible hazards identified in the factory fire, explosion, and toxic leakage.
b) To identify all possible hazards, its consequence, areas affected.
c) To estimate areas affected.
d) Define actions to be taken in case of emergency.
e) Identify persons responsible to take necessary actions to deal with situation.
f) To localize emergency and if possible eliminate it.
g) To avoid confusion, panic and handle the emergency in a planed manner.
h) To minimize loss of life and property to the plant as well as to the neighborhood.
i) To carry out rescue operations
j) To treat injured persons and transfer to the nearest hospital for treatment.
k) To restore normalcy.

- It will specify names of key personnel as

1. Chief Controller (Generally he is Factory Chief)
2. Incidence Controller (Generally he is plant in charge where emergency has occurred or shift in charge after General Shift)
3. Under Chief Controller, three teams are formed
    a. Rescue team

   b. Service team
   c. Welfare team
4. Liaison Officer

The nature of responsibilities of these Key personal & Teams are clearly defined. Reporting chain of command will be clearly defined. Following documents will be required and will form essential part of the Onsite and offsite Emergency Plan

1. Factory layout showing location of all plants, location of hazardous storage, location of Emergency control center.
2. Factory layout showing designated assembly areas
3. Block diagram of manufacturing processes.
4. List of hazardous chemicals stored.
5. MSDS of all hazardous chemicals
6. List of Anti dots
7. List of Key Factory personnel with contact numbers and addresses.
8. List of employees trained in fire fighting with contact numbers
9. List of employees trained in first-aid and rescue operations
10. List of Telephone numbers and addresses of outside government and other agencies mainly
    - Nearest Police station
    - Nearest Fire Brigade Station
    - Ambulance services
    - Nearest Government and other Hospitals
    - Blood Bank
    - MSEB
    - MPCB

1. Emergency Action Plan in case of all possible hazards identified.
2. Procedure for reporting emergency will be clearly defined.
3. Actions to be taken by personnel where emergency has occurred and
4. Actions to be taken by personnel at other location will be clearly defined.
5. Precautions/Actions to be taken after emergency will be clearly defined.

7.12.1 Training and Mock Drill

It is absolutely necessary to train & carryout mock drills for success of emergency plan during actual emergency. Emergency procedures should be laid down clearly and convincingly to everyone on site, particularly the key personnel & essential workers.

7.13 DISASTER MANAGEMENT PLAN

This will be prepared after the preparation of On-site emergency Plan in co-ordination with industries round and local Government authorities.

WORST CASE SCENARIO

1. Chemical - METHYL BUTYL KETONE

a. SITE DATA:

Location: BALAJI AMINES LTD. IV UNIT, INDIA

Building Air Exchanges Per Hour: 0.37 (unsheltered single storied)

Time: September 25, 2018 1725 hours ST (using computer's clock)

b. CHEMICAL DATA:

Chemical Name: METHYL BUTYL KETONE Molecular Weight: 100.16 g/mol

PAC-1: 10 ppm PAC-2: 51 ppm PAC-3: 5000 ppm

IDLH: 1600 ppm LEL: 12200 ppm UEL: 80000 ppm

Ambient Boiling Point: 258.0° F

Vapor Pressure at Ambient Temperature: 0.020 atm

Ambient Saturation Concentration: 21,586 ppm or 2.16%

c. ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 1 meters/second from NW at 10 meters

Ground Roughness: open country Cloud Cover: 0 tenths

Air Temperature: 30° C Stability Class: B

No Inversion Height Relative Humidity: 5%

d. SOURCE STRENGTH:

Leak from hole in horizontal cylindrical tank

Flammable chemical is burning as it escapes from tank

Tank Diameter: 30 meters   Tank Length: 70 meters

Tank Volume: 49,480 cubic meters

Tank contains liquid   Internal Temperature: 30° C

Chemical Mass in Tank: 30,640 tons   Tank is 70% full

Circular Opening Diameter: 3 centimeters

Opening is 10.5 meters from tank bottom

Max Flame Length: 9 yards

Burn Dura tion: ALOHA limited the duration to 1 hour

Max Burn Rate: 72.7 pounds/min

Total Amount Burned: 4,297 pounds

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

The puddle spread to a diameter of 3.7 yards.

e. 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: 17 yards --- (2.0 kW/(sq m) = pain within 60 sec)

f. THREAT AT POINT:

Thermal Radiation Estimates at the point:

Downwind: 14.0 yards   Off Centerline: 0.25 yards

Max Thermal Radiation: 2.7 kW/(sq m)

Figure 1 Threat zone of pool fire

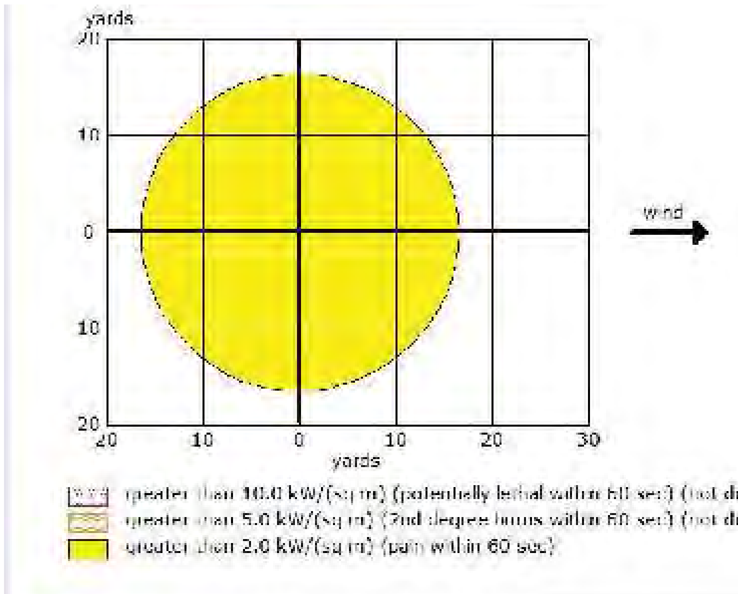


Figure 2 Threat at point 1

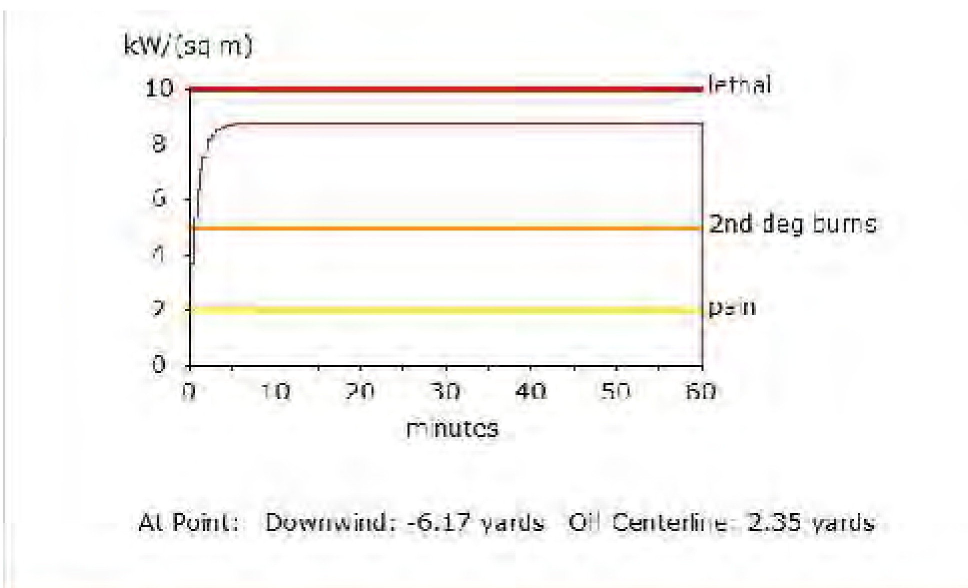


Figure 3 Source Strength

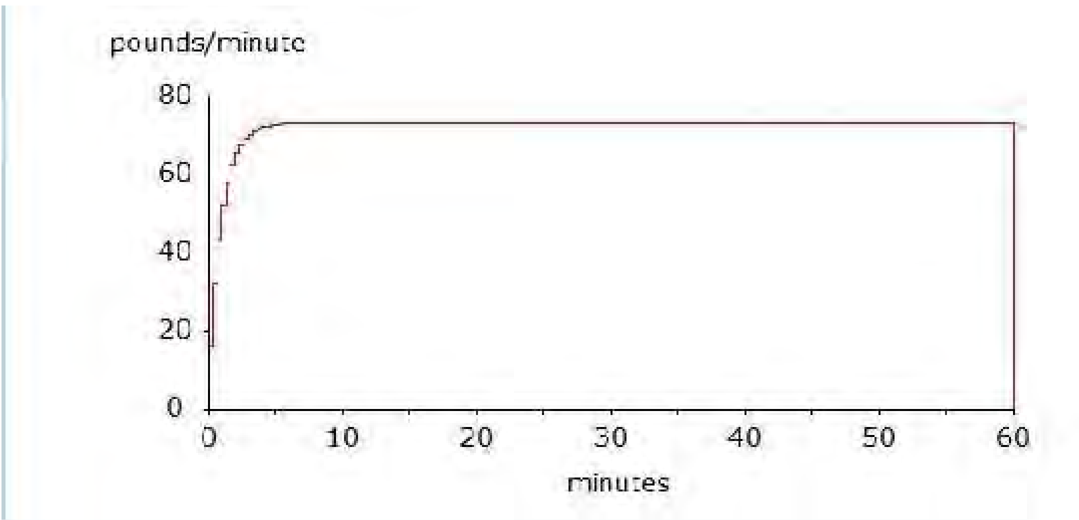


Figure 4 Google Image

2. Chemical – ISO PROPYL AMINE

a. SITE DATA:

Location: BALAJI AMINES LTD. IV UNIT, INDIA

Building Air Exchanges Per Hour: 0.37 (unsheltered single storied)

Time: September 25, 2018 1725 hours ST (user specified)

b. CHEMICAL DATA:

Chemical Name: ISOPROPYLAMINE

CAS Number: 75-31-0 Molecular Weight: 59.11 g/mol

PAC-1: 10 ppm PAC-2: 670 ppm PAC-3: 4000 ppm

IDLH: 750 ppm LEL: 20000 ppm UEL: 104000 ppm

Ambient Boiling Point: 30.3° C

Vapor Pressure at Ambient Temperature: 0.93 atm

Ambient Saturation Concentration: 988,617 ppm or 98.9%

c. ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 1 meters/second from NW at 10 meters

Ground Roughness: open country Cloud Cover: 0 tenths

Air Temperature: 30° C Stability Class: B

No Inversion Height Relative Humidity: 5%

d. SOURCE STRENGTH:

Leak from hole in horizontal cylindrical tank

Flammable chemical is burning as it escapes from tank

Tank Diameter: 30 meters Tank Length: 70 meters

Tank Volume: 49,480 cubic meters

Tank contains liquid Internal Temperature: 30° C

Chemical Mass in Tank: 25,938 tons Tank is 70% full

Circular Opening Diameter: 1.5 centimeters

Opening is 9.00 meters from tank bottom

Max Flame Length: 11 meters

Burn Duration: ALOHA limited the duration to 1 hour

Max Burn Rate: 63.4 kilograms/min

Total Amount Burned: 3,769 kilograms

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

The puddle spread to a diameter of 4.2 meters.

Figure 5 Threat zone

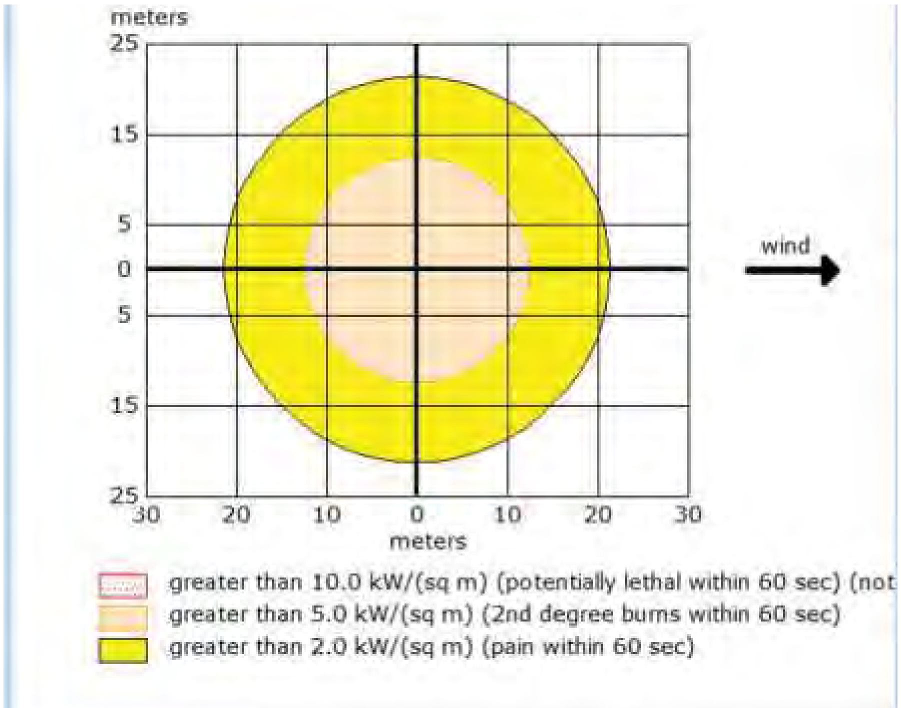


Figure 6 Threat at point

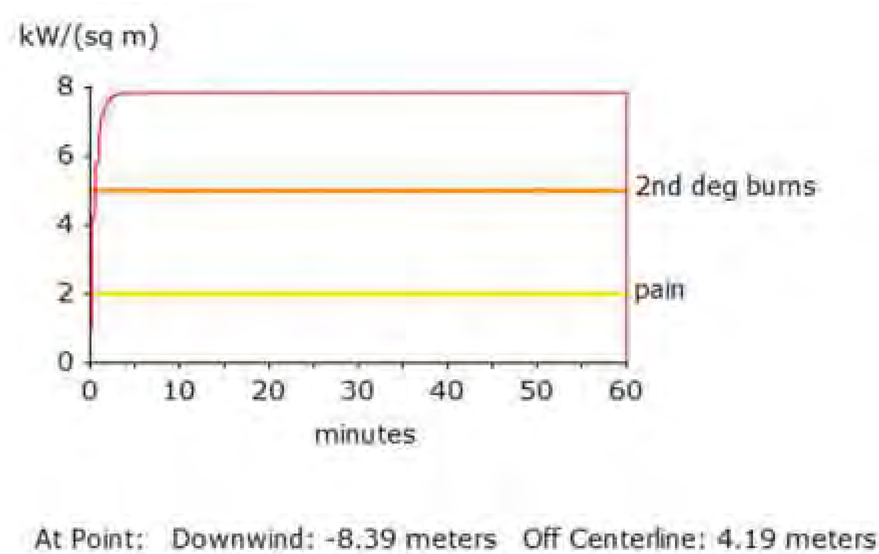


Figure 7 Source Strength

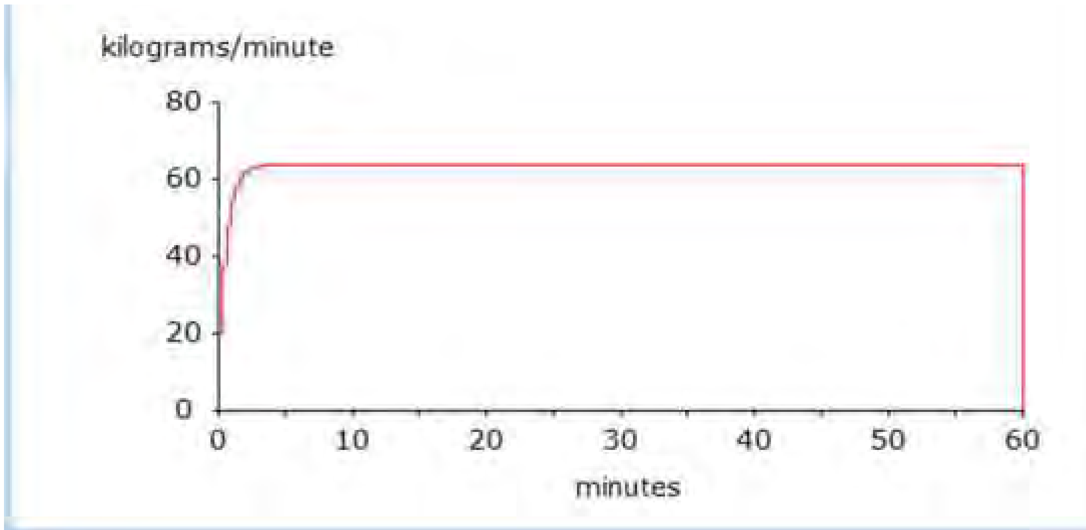


Figure 8 Google Image

3. Chemical – Propane

a. SITE DATA:

Location: BALAJI AMINES LTD. IV UNIT, INDIA

Building Air Exchanges Per Hour: 0.37 (unsheltered single storied)

Time: September 25, 2018 1725 hours ST (user specified)

b. CHEMICAL DATA:

Chemical Name: PROPANE

CAS Number: 74-98-6 Molecular Weight: 44.10 g/mol

AEGL-1 (60 min): 5500 ppm AEGL-2 (60 min): 17000 ppm AEGL-3 (60 min): 33000 ppm

IDLH: 2100 ppm LEL: 21000 ppm UEL: 95000 ppm

Ambient Boiling Point: -43.3° C

Vapor Pressure at Ambient Temperature: greater than 1 atm

Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

c. ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 1 meters/second from NW at 10 meters

Ground Roughness: open country Cloud Cover: 0 tenths

Air Temperature: 30° C Stability Class: B

No Inversion Height Relative Humidity: 5%

d. SOURCE STRENGTH:

Leak from hole in vertical cylindrical tank

Flammable chemical escaping from tank (not burning)

Tank Diameter: 30 meters Tank Length: 70 meters

Tank Volume: 49,480 cubic meters

Tank contains gas only Internal Temperature: 30° C

Amount of Chemical in Tank: 53,399 cubic meters

Internal Press: 1.2 atmospheres

Circular Opening Diameter: 1.2 centimeters

Release Duration: ALOHA limited the duration to 1 hour

Max Average Sustained Release Rate: 1.18 kilograms/min

(averaged over a minute or more)

Total Amount Released: 70.7 kilograms

e. THREAT ZONE:

Threat Modeled: Flammable Area of Vapor Cloud

Model Run: Heavy Gas

Red : 11 meters --- (12600 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.

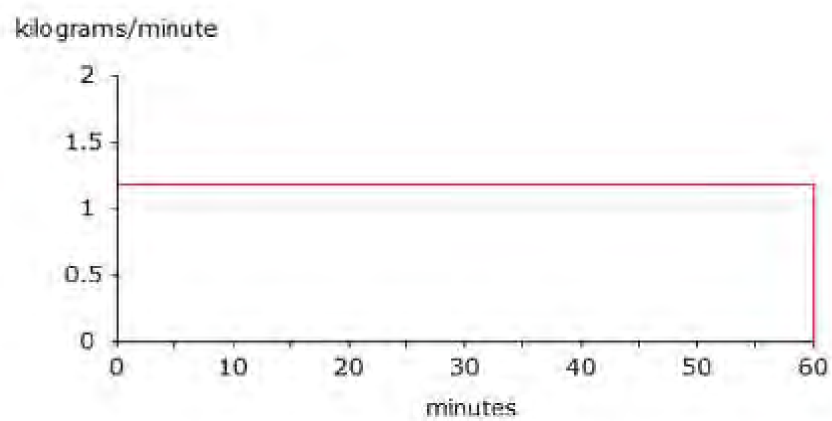
Yellow: 19 meters --- (2100 ppm = 10% LEL)

Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

Figure 9 Threat Zone

Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : 11 meters --- (12600 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: 19 meters --- (2100 ppm = 10% LEL)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

Figure 10 source Strength



4. Chemical- Di Methyl Carbonate

a. SITE DATA:

Location: BALAJI AMINES LTD. IV UNIT, INDIA

Building Air Exchanges Per Hour: 0.37 (unsheltered single storied)

Time: September 25, 2018 1725 hours ST (user specified)

b. CHEMICAL DATA:

Chemical Name: DIMETHYL CARBONATE

CAS Number: 616-38-6 Molecular Weight: 90.08 g/mol

PAC-1: 11 ppm PAC-2: 120 ppm PAC-3: 700 ppm

LEL: 31000 ppm UEL: 205000 ppm

Ambient Boiling Point: 88.4° C

Vapor Pressure at Ambient Temperature: 0.093 atm

Ambient Saturation Concentration: 98,730 ppm or 9.87%

c. ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 1 meters/second from NW at 10 meters

Ground Roughness: open country Cloud Cover: 0 tenths

Air Temperature: 30° C Stability Class: B

No Inversion Height Relative Humidity: 5%

d. SOURCE STRENGTH:

Leak from hole in horizontal cylindrical tank

Flammable chemical is burning as it escapes from tank

Tank Diameter: 10 meters Tank Length: 15.3 meters

Tank Volume: 1200 cubic meters

Tank contains liquid Internal Temperature: 30° C

Chemical Mass in Tank: 887,830 kilograms

Tank is 70% full

Circular Opening Diameter: 1.2 centimeters

Opening is 4.00 meters from tank bottom

Max Flame Length: 4 meters

Burn Duration: ALOHA limited the duration to 1 hour

Max Burn Rate: 6.06 kilograms/min

Total Amount Burned: 346 kilograms

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

The puddle spread to a diameter of 2.1 meters.

e. 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

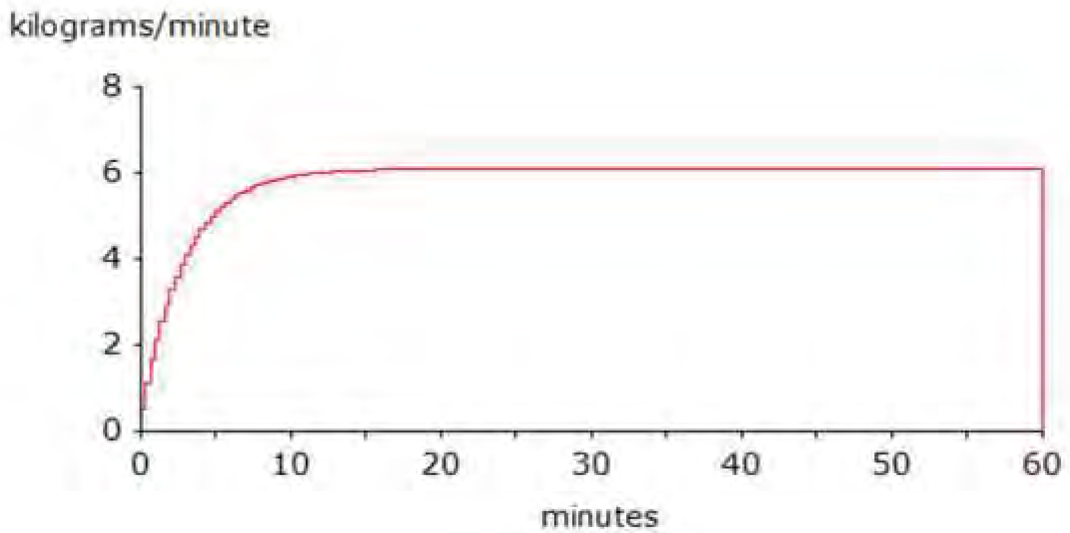
Orange: less than 10 meters(10.9 yards) --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)

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

Figure 11 Threat Zone

Threat Modeled: Thermal radiation from pool fire
Red   : less than 10 meters(10.9 yards) --- (10.0 kW/(sq m) = potentially le
Orange: less than 10 meters(10.9 yards) --- (5.0 kW/(sq m) = 2nd degree
Yellow: less than 10 meters(10.9 yards) --- (2.0 kW/(sq m) = pain within 6(

Figure 12 Source Strength



5. Chemical- Methyl Amine

a. SITE DATA:

Location: BALAJI AMINES LTD. IV UNIT, INDIA

Building Air Exchanges Per Hour: 0.37 (unsheltered single storied)

Time: September 25, 2018 1725 hours ST (user specified)

b. CHEMICAL DATA:

Chemical Name: METHYLAMINE

CAS Number: 74-89-5 Molecular Weight: 31.06 g/mol

AEGL-1 (60 min): 15 ppm AEGL-2 (60 min): 64 ppm AEGL-3 (60 min): 350 ppm

IDLH: 100 ppm LEL: 49000 ppm UEL: 207000 ppm

Ambient Boiling Point: -7.6° C

Vapor Pressure at Ambient Temperature: greater than 1 atm

Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

c. ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 1 meters/second from NW at 10 meters

Ground Roughness: open country Cloud Cover: 0 tenths

Air Temperature: 30° C Stability Class: B

No Inversion Height Relative Humidity: 5%

d. SOURCE STRENGTH:

Leak from hole in horizontal cylindrical tank

Flammable chemical is burning as it escapes from tank

Tank Diameter: 3 meters Tank Length: 7.07 meters

Tank Volume: 50 cubic meters

Tank contains liquid Internal Temperature: 30° C

Chemical Mass in Tank: 22,775 kilograms

Tank is 70% full

Circular Opening Diameter: 1.2 centimeters

Opening is 1.05 meters from tank bottom

Max Flame Length: 7 meters

Burn Duration: ALOHA limited the duration to 1 hour

Max Burn Rate: 85.5 kilograms/min

Total Amount Burned: 5,100 kilograms

Note: The chemical escaped from the tank and burned as a jet fire.

e. THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

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

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

Yellow: 17 meters --- (2.0 kW/(sq m) = pain within 60 sec)

f. THREAT AT POINT:

Thermal Radiation Estimates at the point:

Downwind: 10.0 meters Off Centerline: 5.38 meters

Max Thermal Radiation: 4.31 kW/(sq m)

Figure 13 Threat Zone

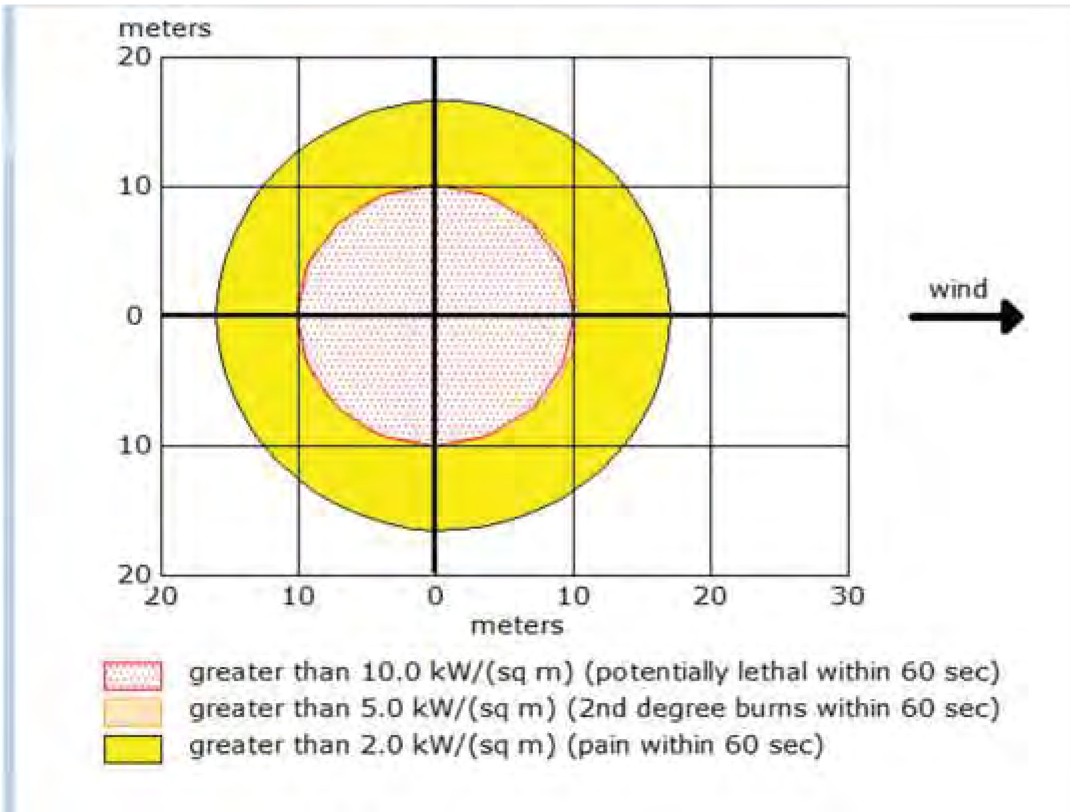


Figure 14 Threat at point 1

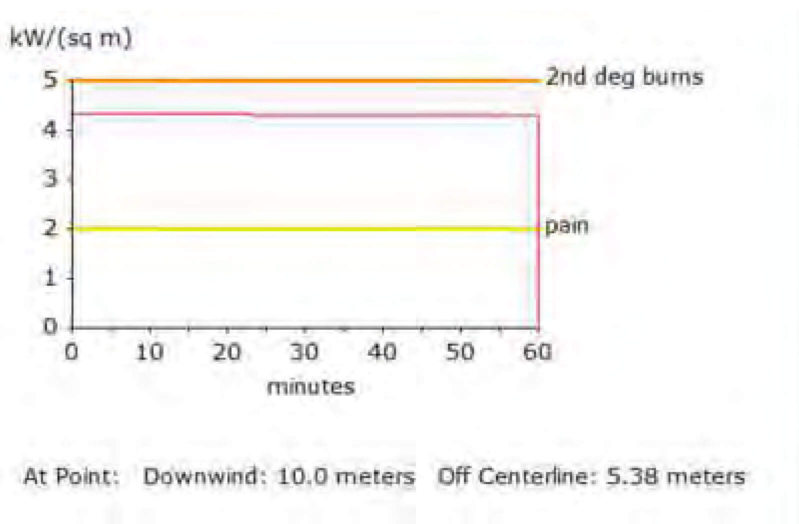


Figure 15 Source Strength

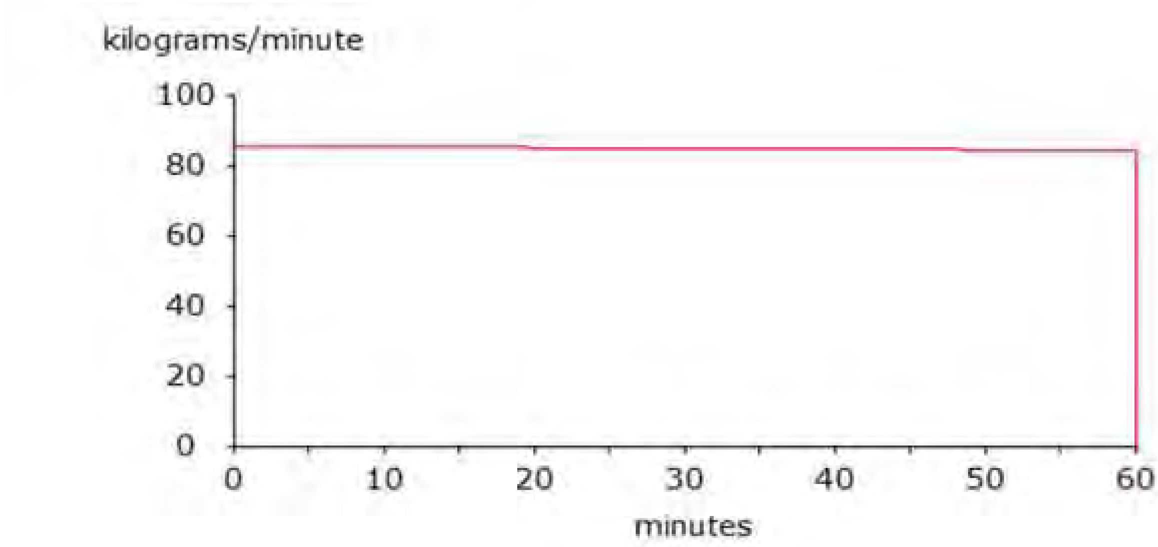


Figure 16 Google Image

6. Chemical – Ethyl amine

a. SITE DATA:

Location: BALAJI AMINES LTD. IV UNIT, INDIA

Building Air Exchanges Per Hour: 0.37 (unsheltered single storied)

Time: September 25, 2018 1725 hours ST (user specified)

b. CHEMICAL DATA:

Chemical Name: ETHYLAMINE

CAS Number: 75-4-7 Molecular Weight: 45.08 g/mol

AEGL-1 (60 min): 7.5 ppm AEGL-2 (60 min): 49 ppm AEGL-3 (60 min): 270 ppm

IDLH: 600 ppm LEL: 27000 ppm UEL: 140000 ppm

Ambient Boiling Point: 15.4° C

Vapor Pressure at Ambient Temperature: greater than 1 atm

Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

c. ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 1 meters/second from NW at 10 meters

Ground Roughness: open country Cloud Cover: 0 tenths

Air Temperature: 30° C Stability Class: B

No Inversion Height Relative Humidity: 5%

d. SOURCE STRENGTH:

Leak from hole in horizontal cylindrical tank

Flammable chemical is burning as it escapes from tank

Tank Diameter: 5 meters Tank Length: 5.09 meters

Tank Volume: 100 cubic meters

Tank contains liquid Internal Temperature: 30° C

Chemical Mass in Tank: 47,017 kilograms

Tank is 70% full

Circular Opening Diameter: 1.2 centimeters

Opening is 1.50 meters from tank bottom

Max Flame Length: 7 meters

Burn Duration: ALOHA limited the duration to 1 hour

Max Burn Rate: 44 kilograms/min

Total Amount Burned: 2,630 kilograms

Note: The chemical escaped from the tank and burned as a jet fire.

e. THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

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

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

Yellow: 15 meters --- (2.0 kW/(sq m) = pain within 60 sec)

f. THREAT AT POINT:

Thermal Radiation Estimates at the point:

Downwind: 7.69 meters Off Centerline: 6.73 meters

Max Thermal Radiation: 3.89 kW/(sq m)

Figure 17 Threat zone

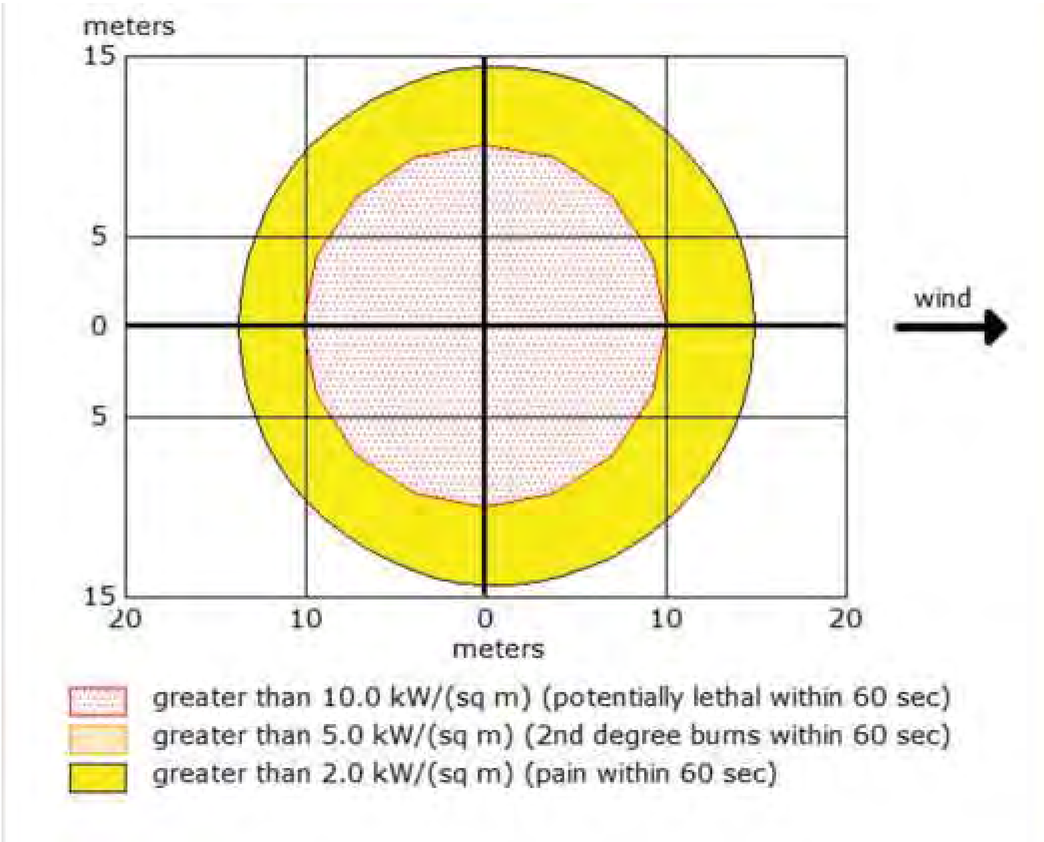


Figure 18 Threat at point 1

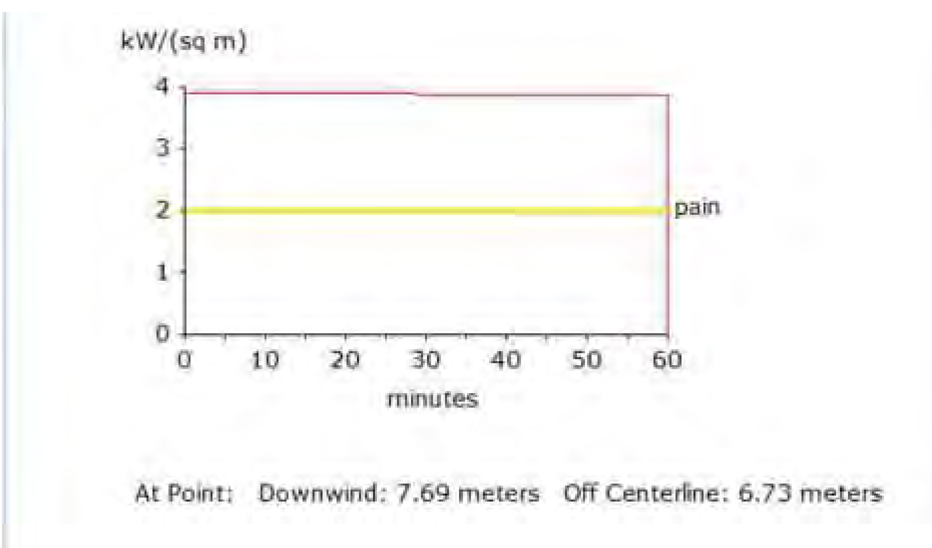


Figure 19 Source Strength

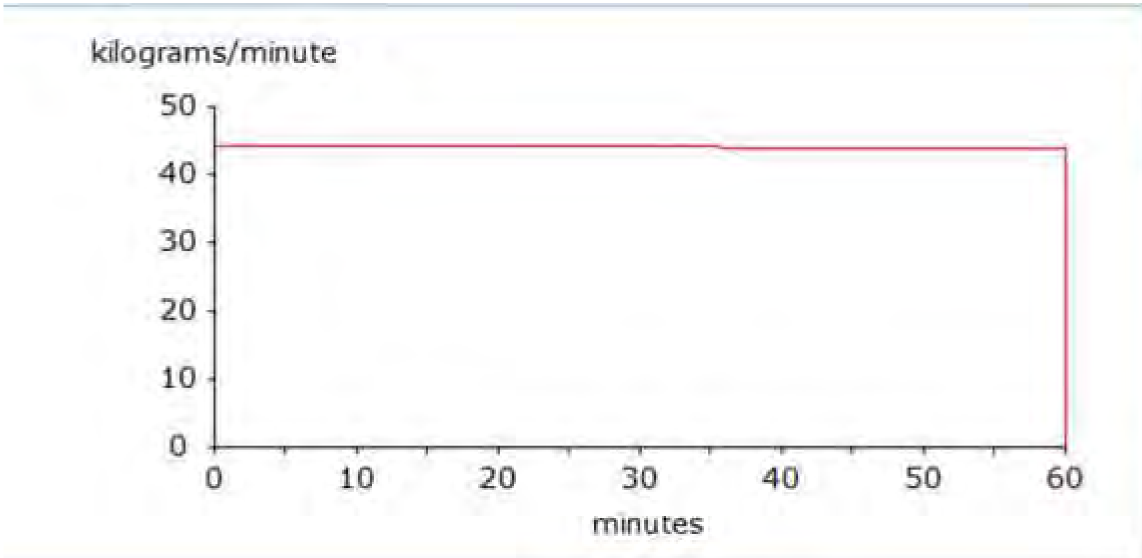


Figure 20 Google Image

7. Chemical-Hydrogen

a. SITE DATA:

Location: BALAJI AMINES LTD. IV UNIT, INDIA

Building Air Exchanges Per Hour: 0.37 (unsheltered single storied)

Time: September 25, 2018 1725 hours ST (user specified)

b. **CHEMICAL DATA**:

Chemical Name: HYDROGEN

CAS Number: 1333-74-0 Molecular Weight: 2.02 g/mol

PAC-1: 65000 ppm PAC-2: 230000 ppm PAC-3: 400000 ppm

LEL: 40000 ppm UEL: 750000 ppm

Ambient Boiling Point: -253.0° C

Vapor Pressure at Ambient Temperature: greater than 1 atm

Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

c. ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 1 meters/second from NW at 10 meters

Ground Roughness: open country Cloud Cover: 0 tenths

Air Temperature: 30° C Stability Class: B

No Inversion Height Relative Humidity: 5%

d. SOURCE STRENGTH:

Leak from hole in horizontal cylindrical tank

Flammable chemical is burning as it escapes from tank

Tank Diameter: 3 meters Tank Length: 3.54 meters

Tank Volume: 25 cubic meters

Tank contains gas only Internal Temperature: 30° C

Chemical Mass in Tank: 3.04 kilograms

Internal Press: 1.5 atmospheres

Circular Opening Diameter: 1.2 centimeters

Max Flame Length: 0 meters Burn Duration: 5 minutes

Max Burn Rate: 377 grams/min

Total Amount Burned: 932 grams

e. THREAT ZONE:

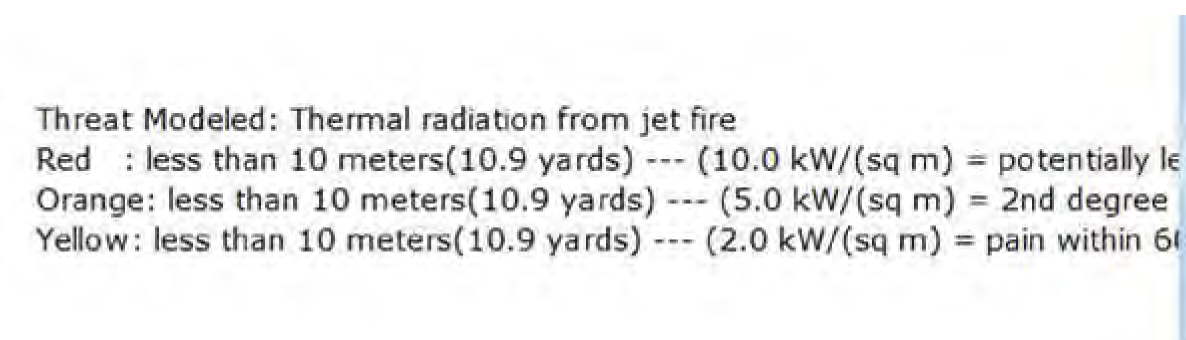
Threat Modeled: Thermal radiation from jet fire

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)

Figure 21 Threat Zone



Threat Modeled: Thermal radiation from jet fire
Red : less than 10 meters(10.9 yards) --- (10.0 kW/(sq m) = potentially le
Orange: less than 10 meters(10.9 yards) --- (5.0 kW/(sq m) = 2nd degree
Yellow: less than 10 meters(10.9 yards) --- (2.0 kW/(sq m) = pain within 6

8. Chemical- HCL 30%

a. SITE DATA:

Location: BALAJI AMINES LTD. IV UNIT, INDIA

Building Air Exchanges Per Hour: 0.37 (unsheltered single storied)

Time: September 25, 2018 1725 hours ST (user specified)

b. CHEMICAL DATA:

Chemical Name: HYDROCHLORIC ACID

Solution Strength: 30% (by weight)

Ambient Boiling Point: 89.0° C

Partial Pressure at Ambient Temperature: 0.028 atm

Ambient Saturation Concentration: 29,246 ppm or 2.92%

Hazardous Component: HYDROGEN CHLORIDE

CAS Number: 7647-1-0 Molecular Weight: 36.46 g/mol

AEGL-1 (60 min): 1.8 ppm AEGL-2 (60 min): 22 ppm AEGL-3 (60 min): 100 ppm

IDLH: 50 ppm

c. ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 1 meters/second from NW at 10 meters

Ground Roughness: open country Cloud Cover: 0 tenths

Air Temperature: 30° C Stability Class: B

No Inversion Height Relative Humidity: 5%

d. SOURCE STRENGTH:

Evaporating Puddle

Puddle Diameter: 20 meters Puddle Volume: 50 cubic meters

Ground Type: Default soil Ground Temperature: 30° C

Initial Puddle Temperature: Ground temperature

Release Duration: ALOHA limited the duration to 1 hour

Max Average Sustained Release Rate: 1.65 kilograms/min

(averaged over a minute or more)

Total Amount Hazardous Component Released: 93.6 kilograms

e. THREAT ZONE:

Model Run: Gaussian

Red : 52 meters --- (100 ppm = AEGL-3 [60 min])

Orange: 125 meters --- (22 ppm = AEGL-2 [60 min])

Yellow: 431 meters --- (2 ppm)

f. THREAT AT POINT:

Concentration Estimates at the point:

Downwind: 268 meters Off Centerline: 74.2 meters

Max Concentration:

Outdoor: 1.14 ppm

Indoor: 0.309 ppm

Figure 22 Threat Zone

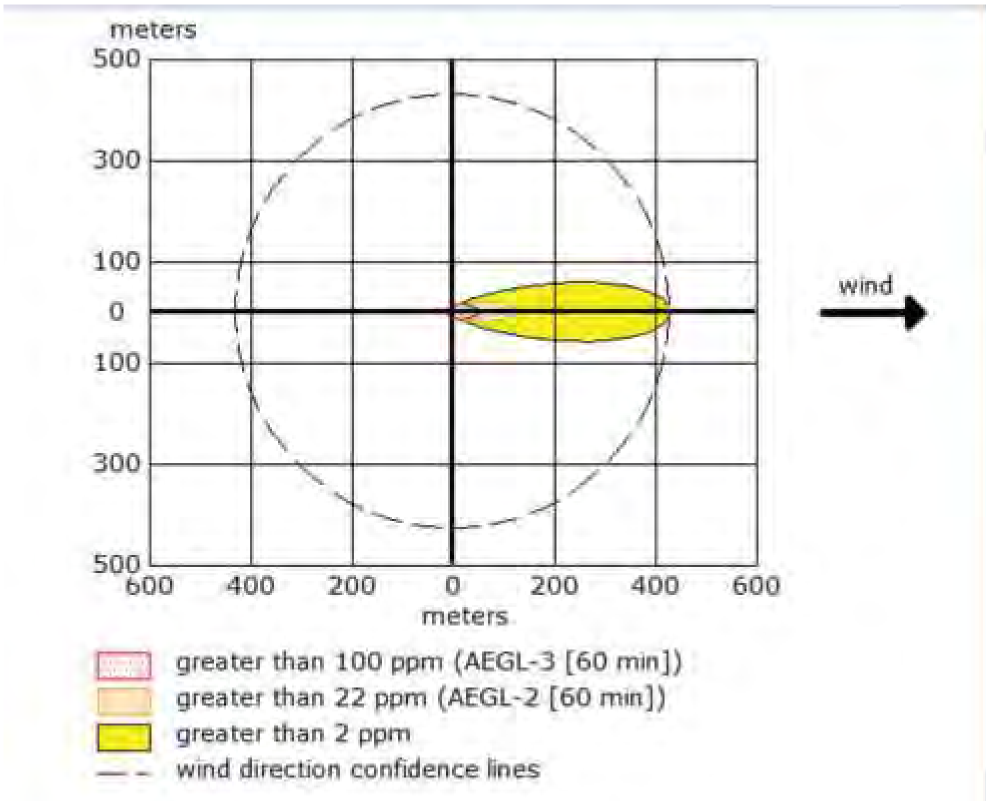


Figure 23 Threat at point 1

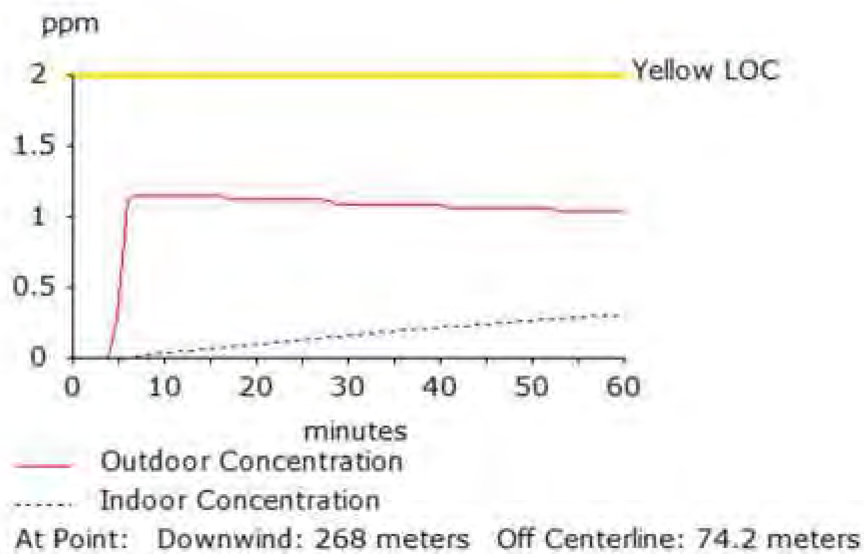


Figure 24 Source Strength

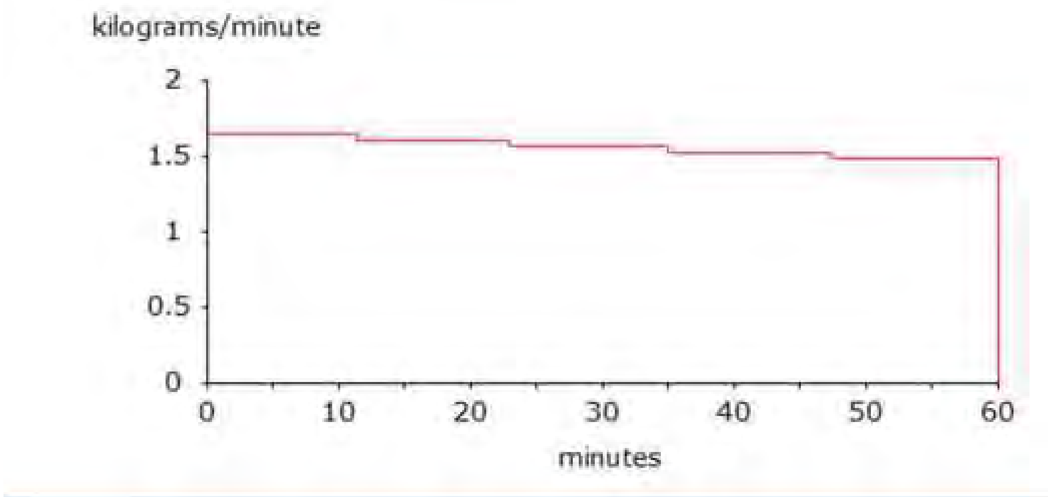


Figure 25 Google Image

9. Chemical –Acetone

a. SITE DATA:

Location: BALAJI AMINES LTD. IV UNIT, INDIA

Building Air Exchanges Per Hour: 0.37 (unsheltered single storied)

Time: September 25, 2018 1725 hours ST (user specified)

b. CHEMICAL DATA:

Chemical Name: ACETONE

CAS Number: 67-64-1 Molecular Weight: 58.08 g/mol

AEGL-1 (60 min): 200 ppm AEGL-2 (60 min): 3200 ppm AEGL-3 (60 min): 5700 ppm

LEL: 26000 ppm UEL: 130000 ppm

Ambient Boiling Point: 54.5° C

Vapor Pressure at Ambient Temperature: 0.37 atm

Ambient Saturation Concentration: 396,462 ppm or 39.6%

c. ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 1 meters/second from NW at 10 meters

Ground Roughness: open country Cloud Cover: 0 tenths

Air Temperature: 30° C Stability Class: B

No Inversion Height Relative Humidity: 5%

d. SOURCE STRENGTH:

Leak from hole in horizontal cylindrical tank

Flammable chemical is burning as it escapes from tank

Tank Diameter: 8 meters Tank Length: 9.95 meters

Tank Volume: 500 cubic meters

Tank contains liquid Internal Temperature: 30° C

Chemical Mass in Tank: 273,428 kilograms

Tank is 70% full

Circular Opening Diameter: 1.2 centimeters

Opening is 2.80 meters from tank bottom

Max Puddle Diameter: Unknown

Max Flame Length: 4 meters

Burn Duration: ALOHA limited the duration to 1 hour

Max Burn Rate: 5.21 kilograms/min

Total Amount Burned: 307 kilograms

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

The puddle spread to a diameter of 1.5 meters.

e. 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)

Figure 26 Threat Zone

Threat Modeled: Thermal radiation from pool fire
Red : less than 10 meters(10.9 yards) --- (10.0 kW/(sq m) = potentially le
Orange: less than 10 meters(10.9 yards) --- (5.0 kW/(sq m) = 2nd degree
Yellow: less than 10 meters(10.9 yards) --- (2.0 kW/(sq m) = pain within 6(

10. Chemical – Aniline

a. SITE DATA:

Location: BALAJI AMINES LTD. IV UNIT, INDIA

Building Air Exchanges Per Hour: 0.37 (unsheltered single storied)

Time: September 25, 2018 1725 hours ST (user specified)

b. CHEMICAL DATA:

Chemical Name: ANILINE

CAS Number: 62-53-3 Molecular Weight: 93.13 g/mol

AEGL-1 (60 min): 8 ppm AEGL-2 (60 min): 12 ppm AEGL-3 (60 min): 20 ppm

IDLH: 100 ppm LEL: 13000 ppm UEL: 110000 ppm

Carcinogenic risk - see CAMEO Chemicals

Ambient Boiling Point: 181.7° C

Vapor Pressure at Ambient Temperature: 0.0013 atm

Ambient Saturation Concentration: 1,342 ppm or 0.13%

c. ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 1 meters/second from NW at 10 meters

Ground Roughness: open country Cloud Cover: 0 tenths

Air Temperature: 30° C Stability Class: B

No Inversion Height Relative Humidity: 5%

d. SOURCE STRENGTH:

Leak from hole in horizontal cylindrical tank

Flammable chemical escaping from tank (not burning)

Tank Diameter: 3 meters Tank Length: 7.07 meters

Tank Volume: 50 cubic meters

Tank contains liquid Internal Temperature: 30° C

Chemical Mass in Tank: 35,432 kilograms

Tank is 70% full

Circular Opening Diameter: 1.2 centimeters

Opening is 0.90 meters from tank bottom

Ground Type: Concrete

Ground Temperature: equal to ambient

Max Puddle Diameter: Unknown

Release Duration: ALOHA limited the duration to 1 hour

Max Average Sustained Release Rate: 31.4 grams/min

(averaged over a minute or more)

Total Amount Released: 1.09 kilograms

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

The puddle spread to a diameter of 9.4 meters.

e. THREAT ZONE:

Model Run: Gaussian

Red : less than 10 meters(10.9 yards) --- (20 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: less than 10 meters(10.9 yards) --- (12 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: 12 meters --- (8 ppm = AEGL-1 [60 min])

Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

Figure 27 Threat Zone

Model Run: Gaussian
Red : less than 10 meters(10.9 yards) --- (20 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: less than 10 meters(10.9 yards) --- (12 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: 12 meters --- (8 ppm = AEGL-1 [60 min])
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.