RISK ASSESMENT

7.1 PUBLIC CONSULTATION

Public hearing minutes are attached as **Annexure.** The public hearing held on Dec2014.

7.2 RISK ASSESSMENT

As per the Manufacture, storage and import of Hazardous Chemical rules, 1989, the flammable chemicals are categorized into the following three categories.

Class I A: Liquids having flash point below 23°C and boiling point below 38 °C

Class I B: Liquids having flash point at or above 60 °C and below 93 °C

Class I C: Liquids having flash point at or above 23 °C and below 38 °C.

Ethanol based on the above classification and properties fall under Class I B flammable liquid.

- To ensure safe operation of the plant, Purti has proposed to carry out the Risk Assessment study with the following objectives.
- To identify the major hazards relating to fire explosion and toxicity due to hazardous chemicals storage and handling
- To visualize maximum credible accident scenarios
- To analyze and quantify primary and secondary effects and damage potentials of the identified Maximum credible accident scenarios using mathematical and analytical models.
- To study the nature of exposures, pathways and consequences of maximum credible accident scenarios and characteristics of risk levels on onsite and offsite population and environment.
- To provide guidelines for disaster management plan for onsite and Emergency preparedness plan for offsite emergency based on the above study

Risk assessment studies have been carried out to assess the worst-case scenarios of the plant operations and to formulate a Disaster Management Plan.

Ethanol

Ethanol is colorless volatile liquid with alcohol odour. The main characteristics are furnished below:

Parameters	**Characteristics**
Physical State	Liquid
Appearance	Clear
Color	Colorless
Physical form	Volatile Liquid
Odour	Alcohol Odour
Taste	Burning Taste
Molecular Weight	46.07
Molecular Formula	CH_3CH_2OH
Boiling Point	78°C
Freezing Point	-117°C
Vapour Pressure	40 mm Hg @ 19C
Vapour Density	1.59
Specific Gravity	0.789
Water Solubility	Soluble
Volatility	100 %
Odour Threshold	5 – 10 ppm
Viscosity	1.22 – 1.41 cp@20°C
Solvent Solubility	Benzene, Ether, Acetone, Chloroform, Methanol, Organic Solvents

Details of storage conditions and hazardous nature of the Ethanol is given below:

Storage Condition and Hazardous nature

Hazardous Chemicals	**Physical State**	**Material of Construction**	**Storage Pressure**	**Hazardous Nature**
Ethanol	Liquid	MS	Atmospheric	Flammable & Toxic

The rating of large number of chemical based on flammability, reactivity and toxicity have been given in National Fire Protection Association codes 49 and 345 M. The main hazardous material in the plant is storage of ethanol. The NFPA rating for the Ethanol is given below:

NFPA Hazard Rating

Chemical	**Nh (Health Factor)**	**Nf (Fire Factor)**	**Nr (Reactivity)**
Ethanol	2	3	0

(Least-0, Slight-1, Moderate-2, High-3, Extreme-4).

Based on the above, Ethanol and other products falls under flammable category of high intensity. PURTI management will exert close control over the storage and handling of the ethanol. This is best done by proper training of personnel, confinement of the liquids and associated vapors to selected areas, ventilation to prevent vapor build up, control of potential ignition sources, and protection of the area with an extinguishing system.

The probable fire hazard in the Plant is in the areas of ethanol and storage and handling. Incase of leaks, invisible vapours spread easily and be set on fire by ignition sources. Therefore it is important to control or eliminate all potential ignition sources in areas that might lead to ignition of vapour. All forms and types of energy can be considered a potential ignition source. The potential ignition sources are:

- Open flames
- Electrical wiring I devices
- Smoking
- Heat sources I Hot surfaces
- Welding and cutting
- Friction
- Sparks and Arcs
- Static sparks
- Gas Compression

Following are some of the precautions that will be taken to minimize the probability of ignition:

- Electrical equipment and wiring should be suitable for the hazard.
- If a heating operation is necessary, use only indirect heating methods.
- Do not allow any open flames, hot surfaces, radiant heat sources or friction- and spark-producing equipment in flammable liquid areas.
- Provide grounding and bonding for all equipment handling using these liquids.

Establish a maintenance program to assure that all equipment and safety controls are functioning satisfactorily.

7.2.1 Identification of Possible Hazards

In order to identify Hazardous units and segregation of plant and storage units, the following two methods for hazard identification have been followed

1. Identification based on Manufacture, Storage and Import of Hazardous Chemical rules, 1989 of Government of India (GOI rules 1989)

2. Identification involving relative rating technique through Fire Explosion and Toxicity Index.

Identification based on Manufacture, Storage and Import of Hazardous Chemical Rules, 1989 of Government of India (GOI Rules 1989)

In order to determine applicability of GOI Rules 1989 to the notified threshold quantities, analysis of products and quantities of storage in the plant has been carried out.

Product	Listed in Schedule	Threshold Quantity		Application Rule
		Rule 5,7-9 And 13-15	Rule 10-12	
Ethanol	1(2)	1000 T	50000 T	Rule 5,7-9 and 13-15

Based on the above, it is noted that RS as ethanol produced and stored in the plant attract the rules of GOI 1989.

Identification involving Relative Rating Technique through Fire Explosion and Toxicity Index

Fire, Explosion & Toxicity Indexing (FETI) is a rapid ranking method for identifying the degree of hazard.

The basic objectives that characterize Fire Explosion and Toxicity Index are:

- Identification of equipment within the plant that would contribute to the initiation or escalation of accidents.
- Quantification and classification of the expected damage potential of fire explosion and toxicity index in relative terms.
- Determination of area of exposure.
- In preliminary hazard analysis, Ethanol is considered to have Toxic & Fire hazards. The application of FETI would help to make a quick assessment of the nature and quantification of the hazard in these areas.
- Before hazard indexing is applied, the installation in question is subdivided into logical, independent elements or units. The unit is logically characterized by the nature of the process that takes place in it.
- Fire Explosion and Toxicity Index is a product of Material Factor MF and Hazard Factor. Material factor represents the flammability and reactivity of the chemicals. The hazard factor itself is a product of General Process and Special Process Hazard.
- Respective Material Factor (MF), General Hazard Factors (GHF), Special Process Hazard Factors (SPH) are computed using standard procedure of awarding penalties based on storage, handling and reaction parameters.
- Material factor is a measure of intrinsic rate of potential energy release from fire and explosion produced by combustion or other chemical reaction.

a. General Process Hazard

Plant activities which contribute to a significant enhancement of potential for Fire and Explosion have been identified and the measured values of penalties have been added to obtain the value 0 General Process Hazard as given in DOWs Fire & Explosion Index Hazard classification guide.

b. Special Process Hazard

The Special Process Hazard includes the factor that contributes the probability and occurrences of accident are as follows.

Process temperature

Low pressure

Operation in or near flammable range

Operating pressure

Low temperature

Quantity of flammable and toxic material

Corrosion and erosion

Leakage, Joints

FEI (Fire Explosion Index) = MF x (1 + GPH) x (1 + SPH)

7.2.2 Classification of Hazards in Categories

By comparing the indices Fire and/or Toxicity to the criteria in the following table the unit in the question classified in one of the three categories established for this purpose.

Dows Fire & Explosion Index Hazard Classification

Degree of Hazard for F & E I

F & EI Range	Degree of Hazard
01-60	Light
61-96	Moderate
97-127	Intermediate
128-158	Heavy
159 and more	Severe

Based on the above, the degree of potential hazard based on DOWs classification for Ethanol is given below

Section	Material Factor	General Process Hazard	Special Process Hazard	Fire & Explosion Index	Radius Of Exposure M	Category Of Potential Hazard
Ethanol	16	2.85	2.6	118.56	30	Intermediate

7.3 Toxicity Index

Toxicity index is primarily based on the index figures for health hazards established by the NFPA in codes NFPA 704, NFPA 4 n and NFPA 325 m.

NFPA Index figures of toxicity factor for Health Hazard index Nh are given below:

NFPA Index	Toxicity Factor
1	50
2	125
3	250
4	325

NFPA Health hazard index of ethanol is 2, which gives toxicity factor a 125. In addition, the toxicity factor has to be corrected for the Maximum Allowable Concentration (MAC) values of the toxic substance by adding a penalty Ts. Ts values are arranged according to the following criteria.

MAC (ppm)	Penalty Ts
<5	125
5 – 50	75
<50	50

MAC value for Alcohol is 1000 ppm. Toxicity Index is evaluated using the following equation

Toxicity Index = Th + Ts (1 + GPH + SPH) 100

Comparing the indices FEI and Toxicity index classify the unit under consideration classified into one of the following three categories:

Classification of FEI and Toxicity Index

Category	Fire Explosion Index	Toxicity Index
Light	<65	<6
Moderate	65-95	6-10
Severe	>95	>10

Fire Explosion and Toxicity Index – PURTI Storage Facility

Section	Quantity Processed	Material Factor	Fire Explosion Index	Toxicity Index
Ethanol	200 m3	16	118.56	3.6

Degree of hazard based on Fire explosion and Toxicity indices computed for the storage units is categorized as below:

Degree of Hazard Storage Units

Section	**Fire Explosion**	**Toxicity**
Ethanol	Intermediate	Light

Minimum Preventive and Protective Measures for Fire and Explosion Hazard Units

Based on the categorization of degree of hazard, the following minimum preventive and protective measures are recommended.

Features	**Light**	**Moderate**	**FE&I Rating Intermediate Heavy**		**Severe**
Fire proofing	2	2	3	4	4
Water spray					
Directional	2	3	3	4	4
Area	2	3	3	4	4
Curtain	1	2	2	2	4
Special Instr.					
Temperature	2	3	3	4	4
Pressure	2	3	3	4	4
Flow control	2	3	4	4	4
Blowdown- spills	1	2	3	3	4
Internal explosion	2	3	3	4	4
Combustible gas					
Moniters	1	2	3	3	4
Remote operations	1	2	2	3	4
Dyking	4	4	4	4	4
Blast and barrier					
Wall separation	1	2	3	4	4
1 = Optional , 2 = Suggested, 3 = Recommended, 4 = Required					

7.4 Preliminary Hazard Analysis

Preliminary Hazard analysis is used to identify typical and often relatively apparent risk sources and damage events in a system. Based on the preliminary hazard identification, the storage and handling facilities of ethanol has been recognized as distinctive and relative evidential risk sources.

Hazards of significant nature whose consequence potential is of worth consideration and wherein a specified area or where more number no of personnel likely to be present etc., are considered in identifying the hazards. Considering the PURTI plant, the significant hazards could be hazards related to storage and handling of ethanol.

Preliminary Hazard Analysis – Storage

Loading and unloading from storage and forwarding of ethanol may lead to containment failure for various reasons. Such situations can cause fires or explosions depending upon the situation.

Inventory Hazard Analysis

Inventory analysis involves the assessing of Ethanol in detail with reference to the characteristic. Ethanol properties are similar in properties except for ethanol content. Hazards considered below for Ethanol.

Ethanol is a clear colorless liquid with strong odour and bitter taste. Ethanol is on the Hazardous substance list because it is regulated by OSHA and cited by ACGIH, DOT, NEPA, and NIOSH.

It has an explosion limit of 3.3% - 19% by volume-I ambient air. It has an ignition temperature of 363 °C and flash point of more than 13°C and boiling point of 78°C. in view of these properties, it is highly flammable.

The vapor is heavier than air and may ignite at distant ignition sources. Ethyl alcohol must be stored to avoid contact with oxidizers. The product is stored in tightly closed container in a cool, well-ventilated area away from heat or flame.

Health Hazards

The following acute health effects may occur:

- Can affect when breathed in and by passing through skin
- May cause mutations
- Can irritate he skin repeated contact can dry the skin with cracking, peeling and itching

- Exposure can cause headache, nausea, a feeling if heat and drowsiness. Higher exposure can cause unconsciousness
- Exposure can irritate the eyes, nose, mouth and throat
- Breathing of ethanol can irritate the lungs causing coughing and/or shortness of breath.

Workplace Exposure Limits

	OSHA	**NIOSH**	**ACGIH**
8-hours exposure	1000 ppm	1000 ppm	1000 ppm

Maximum Credible Accident Analysis

Maximum Credible Accident Analysis (MCA Analysis) is one of methodologies evolved to identify worst credible accident with maximum damage distance, which is still believed to be probable. The analysis does not include quantification of probability. The following is an attempt in that direction.

Hazardous substance may be released as a result of failures or catastrophes, causing damage to the surrounding area. The physical effects resulting from the release of hazardous substances can be calculated by means of models. The results thus obtained through modeling are used to exposed population and environment.

The probable fire hazard in the Plant is in the area of ethanol storage and handling. It is proposed to store about 40 days production of both the products within a common dyke of 40 x 55 m. As a worst case it is assumed that the entire contents are leaked out. In the event of spilling its contents through a small leakage or due to rupture of the pipeline connecting the tank and on ignition fire will eventuate forming pool fire. In order to assess the radiation levels, Heat Radiation Model has been used; the algorithm of the models is based on the formulae published in the yellow book by the TNO, Netherlands. Details of the model are given below:

Heat Radiation Model – Pool Fire

The heat load on objects outside the burning pool of liquid can be calculated with the heat radiation model. This model uses average radiation intensity, which is dependent on the liquid. Account is also taken of the diameter to height ratio of the fire, which depends on the burning liquid. In addition, the heat load is also influences by the following factors:

Distance from the fire

The relative humidity of the air (water vapor has a relatively high heat absorbing capacity)

Visualization and Simulation of Maximum Accidental Scenarios

The worst-case scenario, which is considered for MCA analysis, is Pool fire due to failure of storage of Alcohol storage tanks in the farm area.

PURTI will provide 40 days storage of the final product within the plant premises. The following table provides the storage details of Alcohol.

Storage Details

Tank Code	Height ,m	Diameter, m	Capacity m^3	Chemical
T-702A	10.31	13.2	1416.283	RS
T-702 B	10.31	13.2	1415.963	RS
T-722 A	10.90	11.8	1191.507	ENA
T-722 B	10.87	11.8	1188.135	AA
T-722 C	10.87	11.8	1188.015	AA
T-7736	7.22	7.14	287.820	TA
T-732	6.22	4.5	99.430	IS

As a worst case it is assumed that the entire contents are leaked out. In the event of spilling its contents through a small leakage or due to rupture of the pipeline connecting the tank and on ignition fire will eventuate forming pool fire. As the tanks are provided within the dyke the fire will be confined within the dyke wall.

Fires affect surroundings primarily through radiated heat, which is emitted. If the level of heat radiation is sufficiently high, other objects, which are inflammable, can be ignited. In addition, any living organism may be burned by heat radiation. The damage caused by heat radiation can be calculated from the dose of radiation received, a measure of dose is the energy per unit area of surface exposed to radiation over the duration of exposure.

Effects of Pool Fire

Pool fire may result when bulk storage tanks will leak/burst, and the material released is ignited. As these tanks are provided with dyke walls to contain the leak and avoid spreading of flammable material, the pool fire will be confined to the dyke area only. However, the effect of radiation may be felt to larger area depending upon the size of the pool and quantity of material involved.

Thermal radiation due to pool fire may cause various degrees of burns on human bodies. Moreover, their effects on objects like piping, equipment are severe depending upon the intensity. The heat radiation intensities due to the pool fire of the above tank farms are computed using the pool fire model. The results obtained are presented in the following table.

The following table indicates likely damage level for different levels of heat radiation:

Damage Criteria for Heat Radiation

Incident Radiation Intensity (kW/ m^2)	**Type of Damage**
37.5	Sufficient to cause damage to process equipment
25	Minimum energy required to ignite wood at infinitely long exposure (non piloted)
12.5	Minimum energy required for piloted ignition of wood, melting plastic tubing etc.
4.5	Sufficient to cause pain to personnel if unable to reach cover within 20 seconds; however blistering of skin (1st degree burns) is likely
1.6	Will cause no discomfort to long exposure
0.7	Equivalent to solar radiation

Critical Radiations of Interest on Human Body

1	Un protected skin continuous	1.5 kW/m^2
2	Blisters in skin at 30 sec	5 kW/m^2
3	Protected skin	5 kW/m^2
4	Special Protection	8 kW/m^2

For continuous presence of persons, thermal radiation intensity levels of 4.5 kW/m2 for plant operators for outside population are usually assumed. These criteria are followed where peak load conditions may occur for a short time but mostly without warning. If the operators are properly trained and clothed, they are expected to run to shelter very quickly. For the secondary fires, a thermal incident radiation of 12.5 kW/m2 is adopted as minimum criteria.

Consequences in respect of containment failure related to ethanol storage tank, is a modeled assuming relevant atmospheric condition, using certain mathematical models presented in Scenarios.

7.5 Consequence Analysis of Ethanol due to Storage Facility.

Scenario of Ethanol in different forms

SCENARIO:
TANK CODE: T-702A & T-702B
CHEMCIAL NAME : RECTIFIED SPIRIT
SITE DATA:
Location: NAGPUR, INDIA
Building Air Exchanges Per Hour: 0.38 (unsheltered double storied)
Time: September 1, 2013 1639 hours ST (using computer's clock)

CHEMICAL DATA:
Chemical Name: ETHANOL Molecular Weight: 46.07 g/mol
ERPG-1: 1800 ppm ERPG-2: 3300 ppm ERPG-3: N/A
IDLH: 3300 ppm LEL: 33000 ppm UEL: 190000 ppm
Ambient Boiling Point: 77.5° C
Vapor Pressure at Ambient Temperature: 0.12 atm
Ambient Saturation Concentration: 123,566 ppm or 12.4%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 2.4 meters/second from S at 3 meters
Ground Roughness: open country Cloud Cover: 5 tenths
Air Temperature: 32.6° C Stability Class: C
No Inversion Height Relative Humidity: 50%

SOURCE STRENGTH:
Leak from short pipe or valve in vertical cylindrical tank
Flammable chemical escaping from tank (not burning)
Tank Diameter: 13.2 meters Tank Length: 10.3 meters
Tank Volume: 1416.283 cubic meters
Tank contains liquid Internal Temperature: 32.6° C
Chemical Mass in Tank: 859 tons Tank is 71% full
Circular Opening Diameter: 2.5 inches
Opening is 10 centimeters from tank bottom
Ground Type: Concrete
Ground Temperature: equal to ambient
Max Puddle Diameter: Unknown
Release Duration: MODEL limited the duration to 1 hour
Max Average Sustained Release Rate: 64.7 kilograms/min
(averaged over a minute or more)
Total Amount Released: 2,515 kilograms
Note: The chemical escaped as a liquid and formed an evaporating puddle.
The puddle spread to a diameter of 45 meters.

SCENARIO: When Tank containing an unpressurised flammable liquid

1. **Type of Tank Failure:** Leaking tank, chemical is not burning and forms an evaporating puddle.

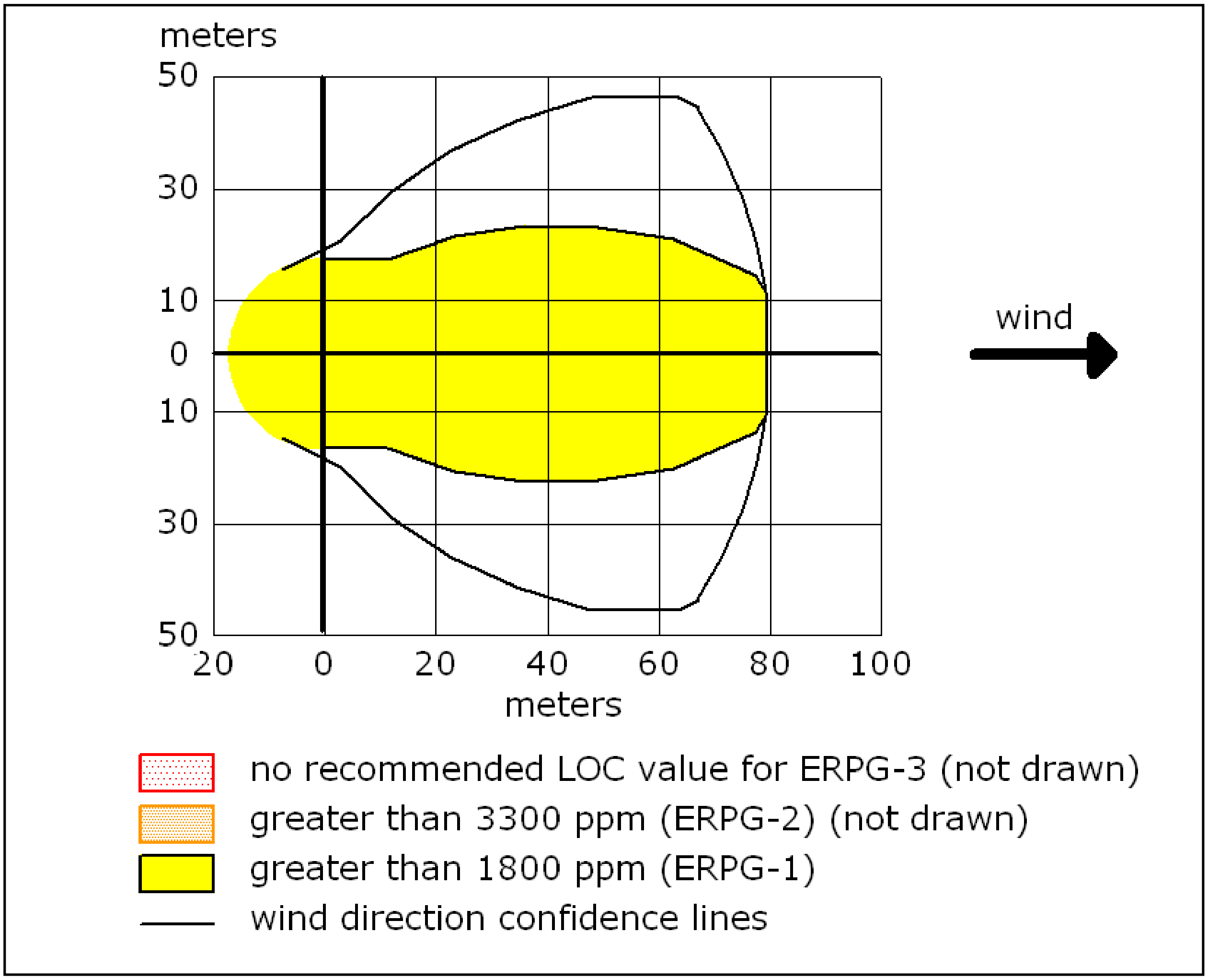
Potential hazards from flammable chemical which is not burning as it leaks from tank.

- Downwind toxic effects
- Vapour cloud flash fire
- Over pressure (blast force) from vapour cloud explosion

When,
Flammable chemical escaping from tank chemical is **NOT** on fire
Choose Hazard to Analyze: **Toxic Area of Vapour Cloud**

THREAT ZONE:
Model Run: Heavy Gas
Red : Not recommended LOC value --- (N/A = ERPG-3)

Orange: 49 meters --- (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: 80 meters --- (1800 ppm = ERPG-1)



When,
Flammable chemical escaping from tank chemical is **NOT** on fire
Choose Hazard to Analyze: **Flammable Area of Vapour Cloud**
Local areas of flame can occur even though the average concentration is below the LEL. Model finds the flammable area by using 60% of LEL.

THREAT ZONE:
Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : LOC was never exceeded --- (19800 ppm = 60% LEL = Flame Pockets)
Yellow: 49 meters --- (3300 ppm = 10% LEL)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions

less reliable for short distances.

When,
Flammable chemical escaping from tank chemical is **NOT** on fire
Choose Hazard to Analyze: **Blast Area of Vapour Cloud Explosion**

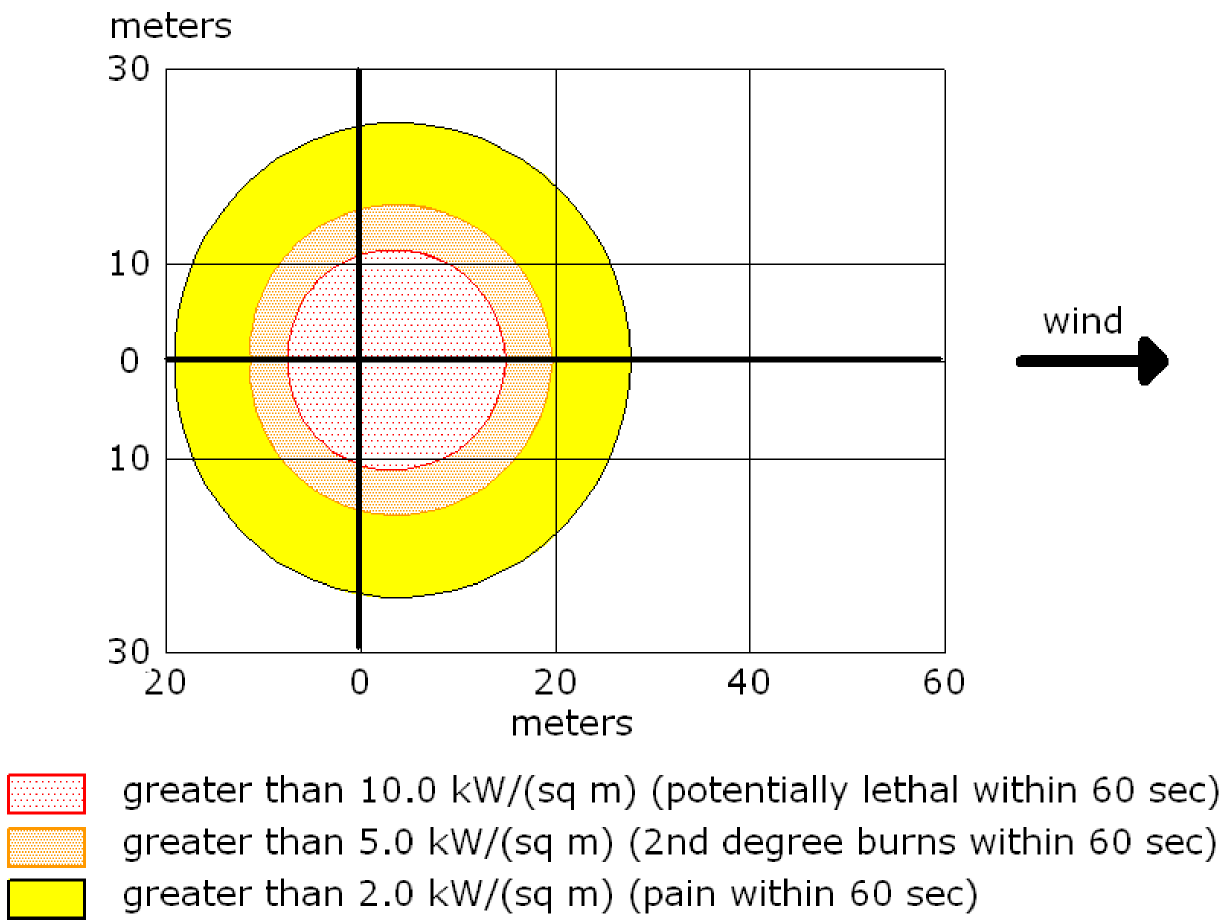
THREAT ZONE:
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Heavy Gas
No explosion: No part of the cloud is above the LEL at any time

2. **Type of Tank Failure: Leaking tank, chemical is burning and forms a pool fire**

Potential hazards from chemical which is burning as it leaks from tank:
- Thermal radiation from pool fire
- BLEVE (if heat rises the internal tank temperature and causes the tank to fail)
- Downwind toxic effects of fire byproducts

SOURCE STRENGTH:
Leak from short pipe or valve in vertical cylindrical tank
Flammable chemical is burning as it escapes from tank
Tank Diameter: 13.2 meters Tank Length: 10.3 meters
Tank Volume: 1416.283 cubic meters
Tank contains liquid Internal Temperature: 32.6° C
Chemical Mass in Tank: 859 tons Tank is 71% full
Circular Opening Diameter: 2.5 inches
Opening is 10 centimeters from tank bottom
Max Puddle Diameter: Unknown
Max Flame Length: 9 meters
Burn Duration: MODEL limited the duration to 1 hour
Max Burn Rate: 146 kilograms/min
Total Amount Burned: 8,422 kilograms
Note: The chemical escaped as a liquid and formed a burning puddle.
The puddle spread to a diameter of 10.5 meters.

THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : 15 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 20 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 28 meters --- (2.0 kW/(sq m) = pain within 60 sec)



3. Type of Tank Failure: BLEVE tank explodes and chemical burns in a fireball

Potential hazards from BLEVE:

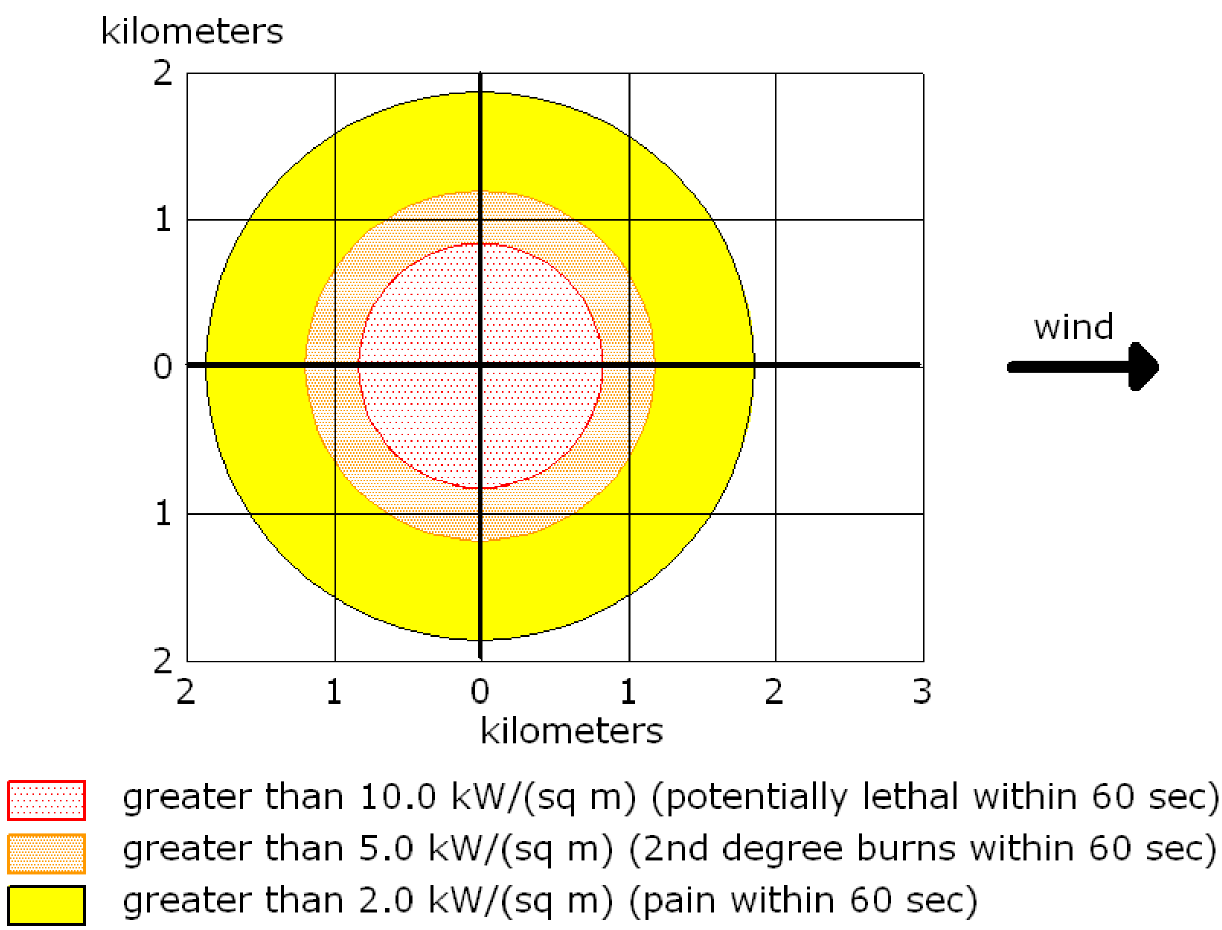
- Thermal radiation from fireball and pool fire
- Hazards fragments and blast force from explosion
- Downwind toxic effects of fire byproducts

BLEVE/Fire ball Scenario: The higher the internal tank pressure/temperature at the time of tank failure, the larger the fire ball. Any liquid not consumed by the fire ball will form a pool fire.

SOURCE STRENGTH:
BLEVE of flammable liquid in vertical cylindrical tank
Tank Diameter: 13.2 meters Tank Length: 10.3 meters
Tank Volume: 1416.283 cubic meters
Tank contains liquid
Internal Storage Temperature: 32.6° C

Chemical Mass in Tank: 859 tons Tank is 71% full
Percentage of Tank Mass in Fireball: 100%
Fireball Diameter: 534 meters Burn Duration: 27 seconds

THREAT ZONE:
Threat Modeled: Thermal radiation from fireball
Red : 832 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 1.2 kilometers --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 1.9 kilometers --- (2.0 kW/(sq m) = pain within 60 sec)



SCENARIO:
TANK CODE: T-722A & T-722B & T-722C
CHEMICAL NAME : EXTRA NEUTRAL ALCOHOL/ABSOLUTE ALCOHOL

SITE DATA:
Location: NAGPUR, INDIA

Building Air Exchanges Per Hour: 0.35 (unsheltered double storied)
Time: September 4, 2013 2143 hours ST

CHEMICAL DATA:
Chemical Name: ETHANOL Molecular Weight: 46.07 g/mol
ERPG-1: 1800 ppm ERPG-2: 3300 ppm ERPG-3: N/A
IDLH: 3300 ppm LEL: 33000 ppm UEL: 190000 ppm
Ambient Boiling Point: 77.5° C
Vapor Pressure at Ambient Temperature: 0.016 atm
Ambient Saturation Concentration: 16,627 ppm or 1.66%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 2.4 miles/hour from S at 3 meters
Ground Roughness: open country Cloud Cover: 5 tenths
Air Temperature: 32.6° F Stability Class: F
No Inversion Height Relative Humidity: 50%

SOURCE STRENGTH:
Leak from short pipe or valve in vertical cylindrical tank
Flammable chemical escaping from tank (not burning)
Tank Diameter: 11.8 meters Tank Length: 10.9 meters
Tank Volume: 1191.507 cubic meters
Tank contains liquid Internal Temperature: 32.6° F
Chemical Mass in Tank: 890 tons Tank is 84% full
Circular Opening Diameter: 2.5 inches
Opening is 10 centimeters from tank bottom
Ground Type: Default soil
Ground Temperature: equal to ambient
Max Puddle Diameter: Unknown
Release Duration: MODEL limited the duration to 1 hour
Max Average Sustained Release Rate: 8.82 kilograms/min
(averaged over a minute or more)
Total Amount Released: 307 kilograms
Note: The chemical escaped as a liquid and formed an evaporating puddle.
The puddle spread to a diameter of 52 meters.

SCENARIO: When Tank containing an unpressurised flammable liquid

1. **Type of Tank Failure:** Leaking tank, chemical is not burning and forms an evaporating puddle.

Potential hazards from flammable chemical which is not burning as it leaks from tank.

- Downwind toxic effects
- Vapour cloud flash fire
- Over pressure (blast force) from vapour cloud explosion

When,
Flammable chemical escaping from tank chemical is **NOT** on fire
Choose Hazard to Analyze: **Toxic Area of Vapour Cloud**

THREAT ZONE:
Model Run: Heavy Gas
Red : Not recommended LOC value --- (N/A = ERPG-3)
Orange: LOC was never exceeded --- (3300 ppm = ERPG-2)
Yellow: 33 meters --- (1800 ppm = ERPG-1)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

When,
Flammable chemical escaping from tank chemical is **NOT** on fire
Choose Hazard to Analyze: **Flammable Area of Vapour Cloud**
Local areas of flame can occur even though the average concentration is below the LEL. Model finds the flammable area by using 60% of LEL.

THREAT ZONE:
Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : LOC was never exceeded --- (19800 ppm = 60% LEL = Flame Pockets)
Yellow: LOC was never exceeded --- (3300 ppm = 10% LEL)

When,
Flammable chemical escaping from tank chemical is **NOT** on fire
Choose Hazard to Analyze: **Blast Area of Vapour Cloud Explosion**

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

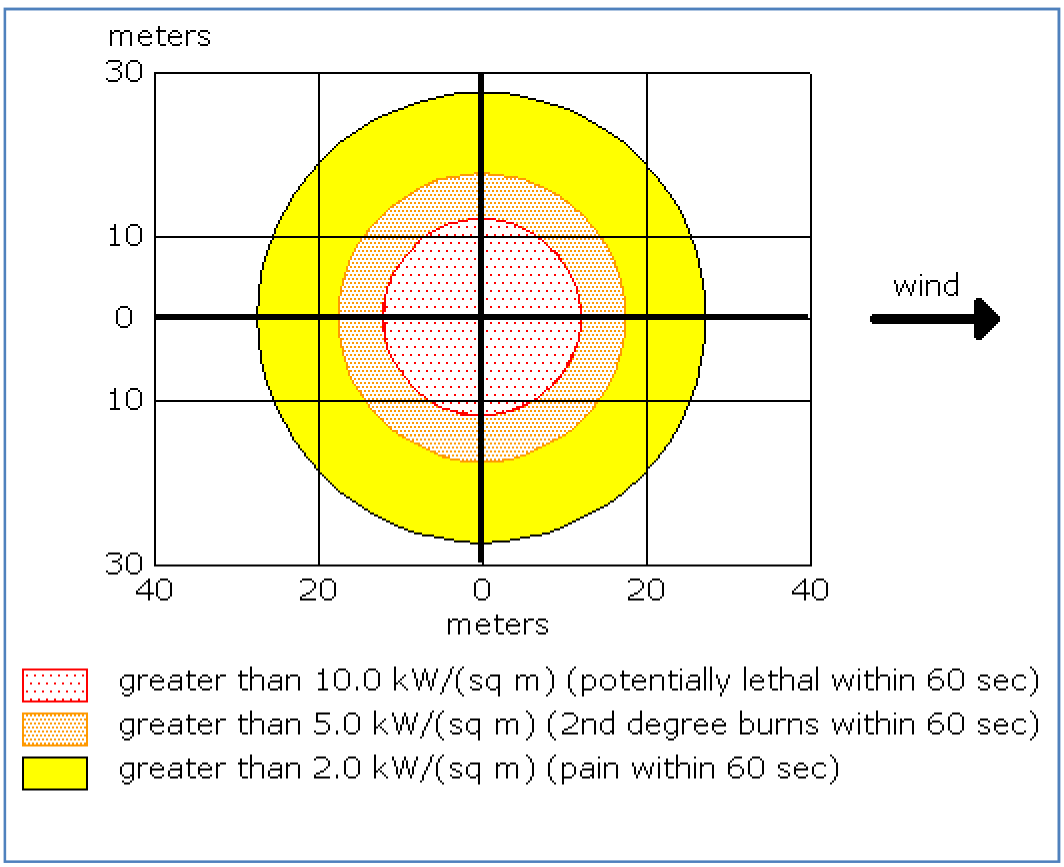
2. **Type of Tank Failure: Leaking tank, chemical is burning and forms a pool fire**

Potential hazards from chemical which is burning as it leaks from tank:
- Thermal radiation from pool fire
- BLEVE (if heat rises the internal tank temperature and causes the tank to fail)
- Downwind toxic effects of fire byproducts

SOURCE STRENGTH:
Leak from short pipe or valve in vertical cylindrical tank
Flammable chemical is burning as it escapes from tank

Tank Diameter: 11.8 meters Tank Length: 10.9 meters
Tank Volume: 1191.507 cubic meters
Tank contains liquid Internal Temperature: 32.6° F
Chemical Mass in Tank: 890 tons Tank is 84% full
Circular Opening Diameter: 2.5 inches
Opening is 10 centimeters from tank bottom
Max Puddle Diameter: Unknown
Max Flame Length: 9 meters
Burn Duration: MODEL limited the duration to 1 hour
Max Burn Rate: 148 kilograms/min
Total Amount Burned: 8,538 kilograms
Note: The chemical escaped as a liquid and formed a burning puddle.
The puddle spread to a diameter of 11.0 meters.

THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : 12 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 18 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 27 meters --- (2.0 kW/(sq m) = pain within 60 sec)



3. Type of Tank Failure: BLEVE tank explodes and chemical burns in a fireball

Potential hazards from BLEVE:

- Thermal radiation from fireball and pool fire
- Hazards fragments and blast force from explosion
- Downwind toxic effects of fire byproducts

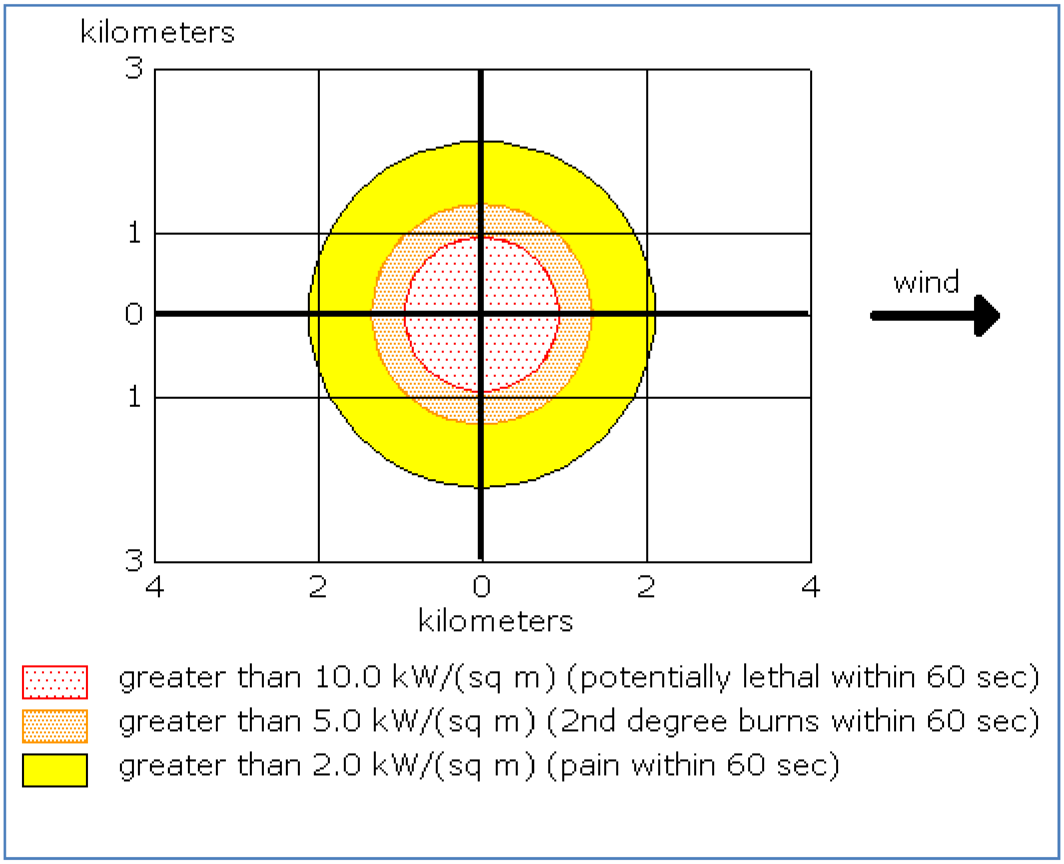
BLEVE/Fire ball Scenario: The higher the internal tank pressure/temperature at the time of tank failure, the larger the fire ball. Any liquid not consumed by the fire ball will form a pool fire.

SOURCE STRENGTH:

BLEVE of flammable liquid in vertical cylindrical tank
Tank Diameter: 11.8 meters   Tank Length: 10.9 meters
Tank Volume: 1191.507 cubic meters
Tank contains liquid
Internal Storage Temperature: 32.6° F
Chemical Mass in Tank: 890 tons   Tank is 84% full
Percentage of Tank Mass in Fireball: 100%
Fireball Diameter: 540 meters   Burn Duration: 27 seconds

THREAT ZONE:

Threat Modeled: Thermal radiation from fireball
Red : 937 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 1.3 kilometers --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 2.1 kilometers --- (2.0 kW/(sq m) = pain within 60 sec)



SCENARIO:
TANK CODE: T-736
CHEMICAL NAME : TECHNICAL ALCOHOL

SITE DATA:
Location: NAGPUR, INDIA
Building Air Exchanges Per Hour: 0.35 (unsheltered double storied)
Time: September 4, 2013 2143 hours ST

CHEMICAL DATA:
Chemical Name: ETHANOL Molecular Weight: 46.07 g/mol
ERPG-1: 1800 ppm ERPG-2: 3300 ppm ERPG-3: N/A
IDLH: 3300 ppm LEL: 33000 ppm UEL: 190000 ppm
Ambient Boiling Point: 77.5° C
Vapor Pressure at Ambient Temperature: 0.016 atm
Ambient Saturation Concentration: 16,627 ppm or 1.66%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 2.4 miles/hour from S at 3 meters
Ground Roughness: open country Cloud Cover: 5 tenths
Air Temperature: 32.6° F Stability Class: F

No Inversion Height Relative Humidity: 50%

SOURCE STRENGTH:
Leak from short pipe or valve in vertical cylindrical tank
Flammable chemical escaping from tank (not burning)
Tank Diameter: 7.14 meters Tank Length: 7.19 meters
Tank Volume: 287.820 cubic meters
Tank contains liquid Internal Temperature: 32.6° F
Chemical Mass in Tank: 222 tons Tank is 87% full
Circular Opening Diameter: 2.5 inches
Opening is 10 centimeters from tank bottom
Ground Type: Default soil
Ground Temperature: equal to ambient
Max Puddle Diameter: Unknown
Release Duration: MODEL limited the duration to 1 hour
Max Average Sustained Release Rate: 8.82 kilograms/min
(averaged over a minute or more)
Total Amount Released: 307 kilograms
Note: The chemical escaped as a liquid and formed an evaporating puddle.
The puddle spread to a diameter of 52 meters.

SCENARIO: When Tank containing an unpressurised flammable liquid

1. **Type of Tank Failure:** Leaking tank, chemical is not burning and forms an evaporating puddle.

Potential hazards from flammable chemical which is not burning as it leaks from tank.

- Downwind toxic effects
- Vapour cloud flash fire
- Over pressure (blast force) from vapour cloud explosion

When,
Flammable chemical escaping from tank chemical is **NOT** on fire
Choose Hazard to Analyze: **Toxic Area of Vapour Cloud**

THREAT ZONE:
Model Run: Heavy Gas
Red : no recommended LOC value --- (N/A = ERPG-3)
Orange: LOC was never exceeded --- (3300 ppm = ERPG-2)
Yellow: 33 meters --- (1800 ppm = ERPG-1)
Note: Threat zone was not drawn because effects of near-field patchiness
make dispersion predictions less reliable for short distances.

When,
Flammable chemical escaping from tank chemical is **NOT** on fire
Choose Hazard to Analyze: **Flammable Area of Vapour Cloud**

Local areas of flame can occur even though the average concentration is below the LEL. Model finds the flammable area by using 60% of LEL.

THREAT ZONE:
Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : LOC was never exceeded --- (19800 ppm = 60% LEL = Flame Pockets)
Yellow: LOC was never exceeded --- (3300 ppm = 10% LEL)

When,
Flammable chemical escaping from tank chemical is **NOT** on fire
Choose Hazard to Analyze: **Blast Area of Vapour Cloud Explosion**

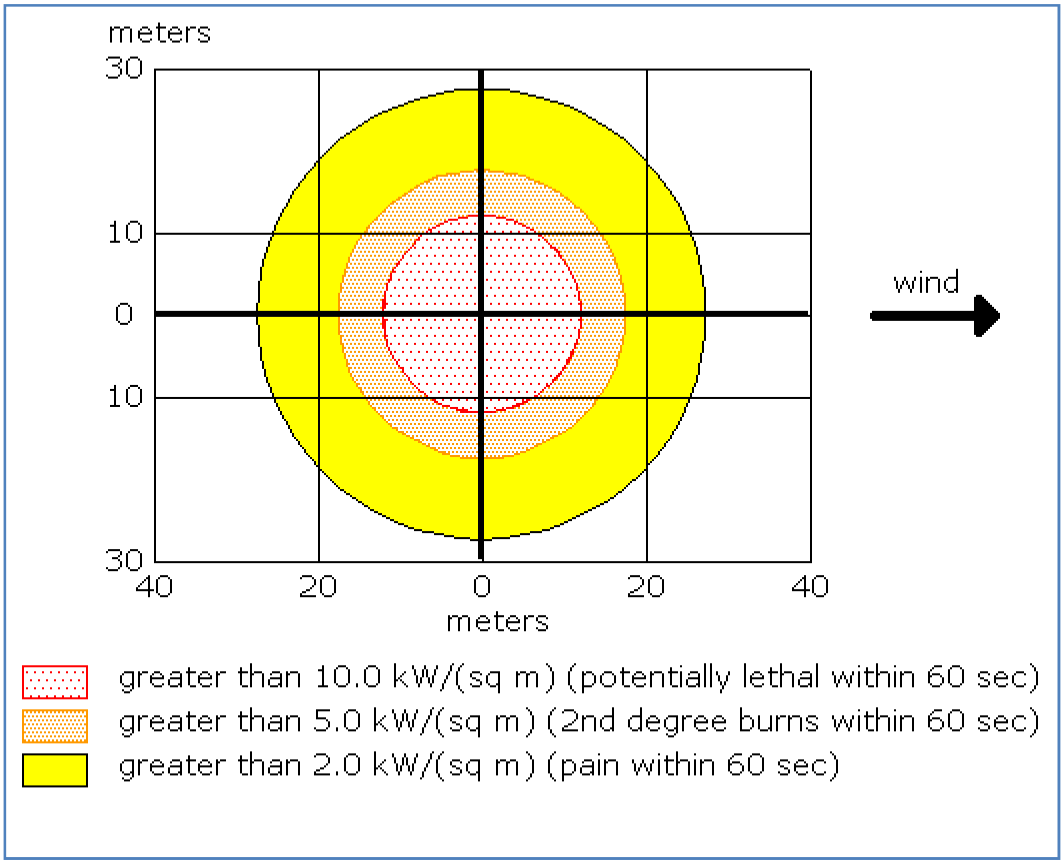
THREAT ZONE:
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Heavy Gas
No explosion: no part of the cloud is above the LEL at any time

2. **Type of Tank Failure: Leaking tank, chemical is burning and forms a pool fire**

Potential hazards from chemical which is burning as it leaks from tank:

- Thermal radiation from pool fire
- BLEVE (if heat rises the internal tank temperature and causes the tank to fail)
- Downwind toxic effects of fire byproducts

SOURCE STRENGTH:
Leak from short pipe or valve in vertical cylindrical tank
Flammable chemical is burning as it escapes from tank
Tank Diameter: 7.14 meters Tank Length: 7.19 meters
Tank Volume: 287.820 cubic meters
Tank contains liquid Internal Temperature: 32.6° F
Chemical Mass in Tank: 222 tons Tank is 87% full
Circular Opening Diameter: 2.5 inches
Opening is 10 centimeters from tank bottom
Max Puddle Diameter: Unknown
Max Flame Length: 9 meters
Burn Duration: MODEL limited the duration to 1 hour
Max Burn Rate: 148 kilograms/min
Total Amount Burned: 8,538 kilograms
Note: The chemical escaped as a liquid and formed a burning puddle.
The puddle spread to a diameter of 11.0 meters.



THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : 12 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 18 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 27 meters --- (2.0 kW/(sq m) = pain within 60 sec)

3. Type of Tank Failure: BLEVE tank explodes and chemical burns in a fireball

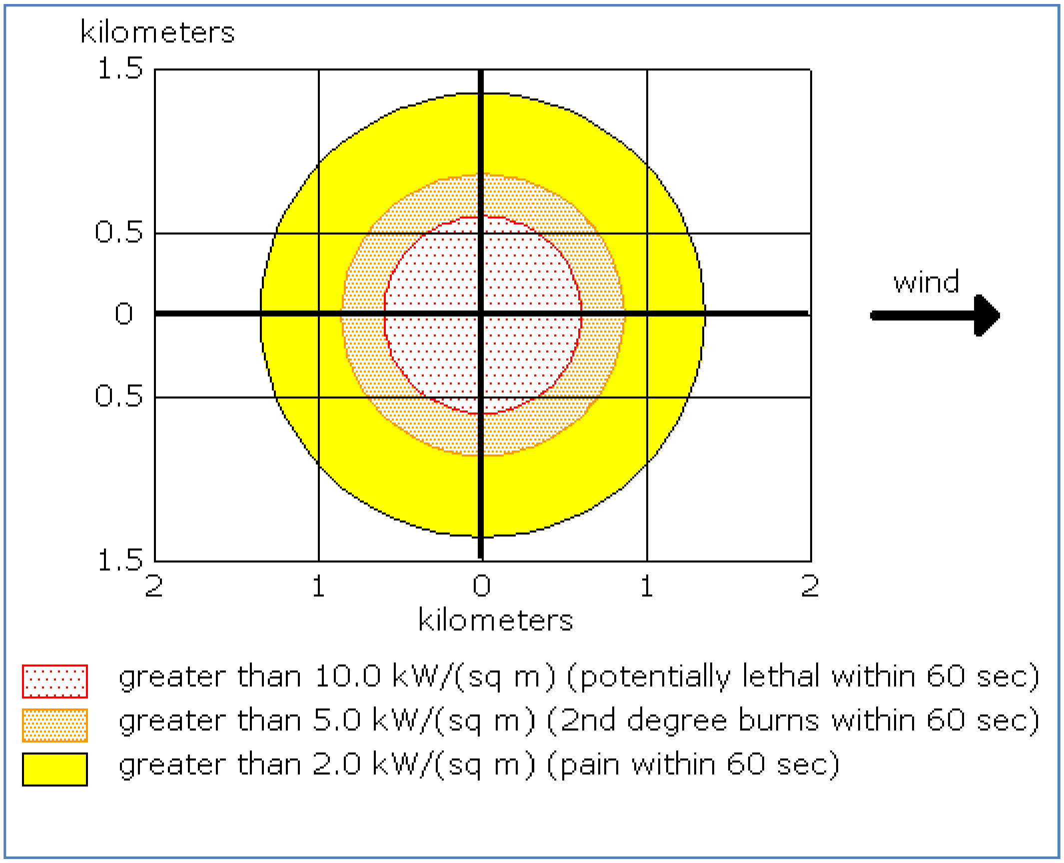
Potential hazards from BLEVE:

- Thermal radiation from fireball and pool fire
- Hazards fragments and blast force from explosion
- Downwind toxic effects of fire byproducts

BLEVE/Fire ball Scenario: The higher the internal tank pressure/temperature at the time of tank failure, the larger the fire ball. Any liquid not consumed by the fire ball will form a pool fire.

SOURCE STRENGTH:
BLEVE of flammable liquid in vertical cylindrical tank

Tank Diameter: 7.14 meters Tank Length: 7.19 meters
Tank Volume: 287.820 cubic meters
Tank contains liquid
Internal Storage Temperature: 32.6° F
Chemical Mass in Tank: 222 tons Tank is 87% full
Percentage of Tank Mass in Fireball: 100%
Fireball Diameter: 340 meters Burn Duration: 19 seconds



THREAT ZONE:
Threat Modeled: Thermal radiation from fireball
Red : 602 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 860 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 1.4 kilometers --- (2.0 kW/(sq m) = pain within 60 sec)

SCENARIO:
TANK CODE: T-732
CHEMICAL NAME : IMPURE ALCOHOL
SITE DATA:
Location: NAGPUR, INDIA
Building Air Exchanges Per Hour: 0.35 (unsheltered double storied)
Time: September 4, 2013 2143 hours ST
CHEMICAL DATA:
Chemical Name: ETHANOL Molecular Weight: 46.07 g/mol
ERPG-1: 1800 ppm ERPG-2: 3300 ppm ERPG-3: N/A
IDLH: 3300 ppm LEL: 33000 ppm UEL: 190000 ppm
Ambient Boiling Point: 77.5° C
Vapor Pressure at Ambient Temperature: 0.016 atm
Ambient Saturation Concentration: 16,627 ppm or 1.66%
ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 2.4 miles/hour from S at 3 meters
Ground Roughness: open country Cloud Cover: 5 tenths
Air Temperature: 32.6° F Stability Class: F
No Inversion Height Relative Humidity: 50%
SOURCE STRENGTH:
Leak from short pipe or valve in vertical cylindrical tank
Flammable chemical escaping from tank (not burning)
Tank Diameter: 4.5 meters Tank Length: 6.22 meters
Tank Volume: 98.9 cubic meters
Tank contains liquid Internal Temperature: 32.6° F
Chemical Mass in Tank: 80.1 tons Tank is 91% full
Circular Opening Diameter: 2.5 inches
Opening is 10 centimeters from tank bottom
Ground Type: Default soil
Ground Temperature: equal to ambient
Max Puddle Diameter: Unknown
Release Duration: MODEL limited the duration to 1 hour
Max Average Sustained Release Rate: 8.82 kilograms/min
(averaged over a minute or more)
Total Amount Released: 307 kilograms
Note: The chemical escaped as a liquid and formed an evaporating puddle.
The puddle spread to a diameter of 52 meters.

SCENARIO: When Tank containing an unpressurised flammable liquid

1. **Type of Tank Failure:** Leaking tank, chemical is not burning and forms an evaporating puddle.

Potential hazards from flammable chemical which is not burning as it leaks from tank.

- Downwind toxic effects
- Vapour cloud flash fire

- Over pressure (blast force) from vapour cloud explosion

When,
Flammable chemical escaping from tank chemical is **NOT** on fire
Choose Hazard to Analyze: **Toxic Area of Vapour Cloud**

THREAT ZONE:
Model Run: Heavy Gas
Red : no recommended LOC value --- (N/A = ERPG-3)
Orange: LOC was never exceeded --- (3300 ppm = ERPG-2)
Yellow: 33 meters --- (1800 ppm = ERPG-1)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
When,
Flammable chemical escaping from tank chemical is **NOT** on fire
Choose Hazard to Analyze: **Flammable Area of Vapour Cloud**
Local areas of flame can occur even though the average concentration is below the LEL. Model finds the flammable area by using 60% of LEL.

THREAT ZONE:
Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : LOC was never exceeded --- (19800 ppm = 60% LEL = Flame Pockets)
Yellow: LOC was never exceeded --- (3300 ppm = 10% LEL)

When,
Flammable chemical escaping from tank chemical is **NOT** on fire
Choose Hazard to Analyze: **Blast Area of Vapour Cloud Explosion**

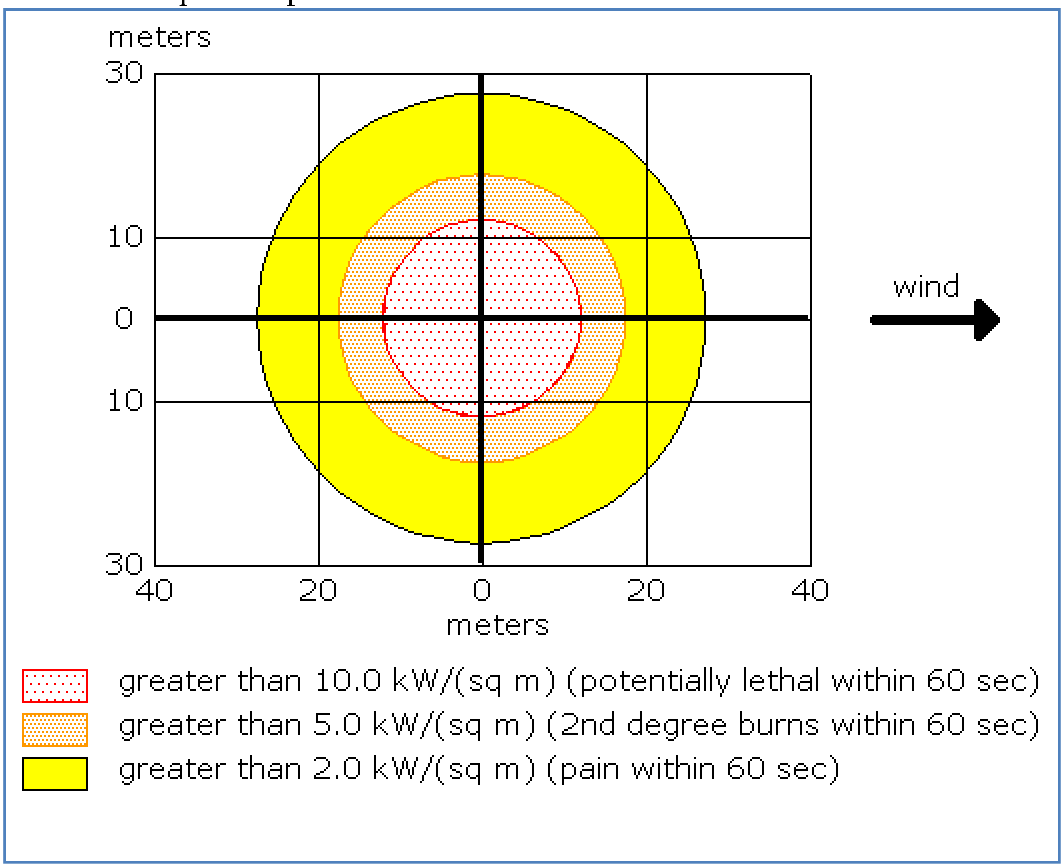
THREAT ZONE:
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Heavy Gas
No explosion: no part of the cloud is above the LEL at any time

2. Type of Tank Failure: Leaking tank, chemical is burning and forms a pool fire

Potential hazards from chemical which is burning as it leaks from tank:
- Thermal radiation from pool fire
- BLEVE (if heat rises the internal tank temperature and causes the tank to fail)
- Downwind toxic effects of fire byproducts

SOURCE STRENGTH:
Leak from short pipe or valve in vertical cylindrical tank

Flammable chemical is burning as it escapes from tank
Tank Diameter: 4.5 meters Tank Length: 6.22 meters
Tank Volume: 98.9 cubic meters
Tank contains liquid Internal Temperature: 32.6° F
Chemical Mass in Tank: 80.1 tons Tank is 91% full
Circular Opening Diameter: 2.5 inches
Opening is 10 centimeters from tank bottom
Max Puddle Diameter: Unknown
Max Flame Length: 9 meters
Burn Duration: MODEL limited the duration to 1 hour
Max Burn Rate: 148 kilograms/min
Total Amount Burned: 8,538 kilograms
Note: The chemical escaped as a liquid and formed a burning puddle.
The puddle spread to a diameter of 11.0 meters.



THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : 12 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 18 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 27 meters --- (2.0 kW/(sq m) = pain within 60 sec)

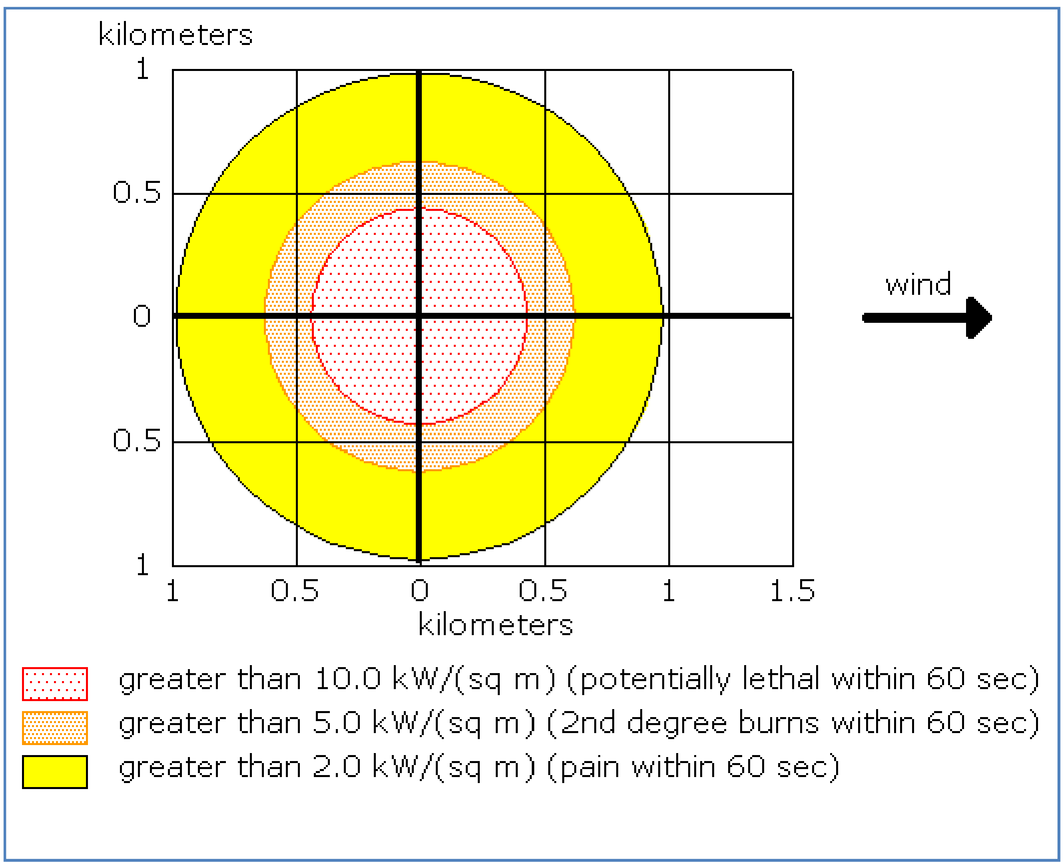
3. Type of Tank Failure: BLEVE tank explodes and chemical burns in a fireball

Potential hazards from BLEVE:

- Thermal radiation from fireball and pool fire
- Hazards fragments and blast force from explosion
- Downwind toxic effects of fire byproducts

BLEVE/Fire ball Scenario: The higher the internal tank pressure/temperature at the time of tank failure, the larger the fire ball. Any liquid not consumed by the fire ball will form a pool fire.

SOURCE STRENGTH:
BLEVE of flammable liquid in vertical cylindrical tank
Tank Diameter: 4.5 meters Tank Length: 6.22 meters
Tank Volume: 98.9 cubic meters
Tank contains liquid
Internal Storage Temperature: 32.6° F
Chemical Mass in Tank: 80.1 tons Tank is 91% full
Percentage of Tank Mass in Fireball: 100%
Fireball Diameter: 242 meters Burn Duration: 15 seconds



THREAT ZONE:
Threat Modeled: Thermal radiation from fireball

Red   : 435 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 621 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 976 meters --- (2.0 kW/(sq m) = pain within 60 sec)

7.5.1 Conclusions

Scenario-1

When ethanol is leaking from tank and is NOT burning, forms an evaporating puddle;

The threat zone for the Ethanol tanks T-702A & T-702B not recommended the LOC value as per the maximum Emergency Response Planning Guidelines ERPG-3 which predicts severe impact on health. Hence the Red coloured level of concern is not recommended. Similarly, the remaining threat zones ERPG-2 and ERPG-1 are subjected to within the unit at 49 and 80 meters with lower concentrations 3300 ppm and 1800 ppm respectively.

The threat zone for the Ethanol tanks T-722A, T-722B & T-&722C not recommended the LOC value as per the maximum Emergency Response Planning Guidelines ERPG-3 which predicts severe impact on health. Hence the Red coloured level of concern is not recommended. Similarly, the LOC was never exceeded for the threat zones ERPG-2. The ERPG-1 is subjected to within the unit at 33 meters with lower concentrations 1800 ppm.

The threat zone for the Ethanol tank T-736 not recommended the LOC value as per the maximum Emergency Response Planning Guidelines ERPG-3, ERPG-2 and ERPG-1.

The threat zone for the Ethanol tank T-732 not recommended the LOC value as per the maximum Emergency Response Planning Guidelines ERPG-3, ERPG-2 and ERPG-1.

Scenario –2

When ethanol is leaking from tank and is burning forms a pool fire;

The thermal radiation for the Ethanol tanks T-702A & T-702B confined to the maximum at 15 meters only that means the thermal radiation intensity of 10kW/m^2 is potentially lethal within 60 seconds. Hence the Red coloured level of concern is within plant premises only. Similarly, the other threat zone of 5.0 kW/m^2 causes 2nd degree burns within 60 seconds at 20m and the rest is 2.0 kW/m^2 subjected to within the unit at 28m which causes pain within 60 seconds.

The thermal radiation for the Ethanol tanks T-722A, T-722B & T-722C confined to the maximum at 12 meters only that means the thermal radiation intensity of $10kW/m^2$ is potentially lethal within 60 seconds. Hence the Red coloured level of concern is within plant premises only. Similarly, the other threat zone of 5.0 kW/m^2 causes 2nd degree burns within 60 seconds at 18m and the rest is 2.0 kW/m^2 subjected to within the unit at 27m which causes pain within 60 seconds.

The thermal radiation for the Ethanol tank T-736 confined to the maximum at 12 meters only that means the thermal radiation intensity of $10kW/m^2$ is potentially lethal within 60 seconds. Hence the Red coloured level of concern is within plant premises only. Similarly, the other threat zone of 5.0 kW/m^2 causes 2nd degree burns within 60 seconds at 18m and the rest is 2.0 kW/m^2 subjected to within the unit at 27m which causes pain within 60 seconds.

The thermal radiation for the Ethanol tank T-732 confined to the maximum at 12 meters only that means the thermal radiation intensity of $10kW/m^2$ is potentially lethal within 60 seconds. Hence the Red coloured level of concern is within plant premises only. Similarly, the other threat zone of 5.0 kW/m^2 causes 2nd degree burns within 60 seconds at 18m and the rest is 2.0 kW/m^2 subjected to within the unit at 27m which causes pain within 60 seconds.

Scenario-3

When tank explodes and ethanol in a fireball due to BLEVE;

The thermal radiation for the Ethanol tanks T-702A & T-702B confined to the maximum at 832m that means the thermal radiation intensity of $10kW/m^2$ is potentially lethal within 60 seconds. Similarly, the other threat zone of 5.0 kW/m^2 causes 2nd degree burns within 60 seconds at 1.2 km and the rest is 2.0 kW/m^2 subjected to within the unit at 1.9 km, which causes pain within 60 seconds.

The thermal radiation for the Ethanol tanks T-722A, T-722B & T-722C confined to the maximum at 937m that means the thermal radiation intensity of 10kW/m^2 is potentially lethal within 60 seconds. Similarly, the other threat zone of 5.0 kW/m^2 causes 2nd degree burns within 60 seconds at 1.3 km and the rest is 2.0 kW/m^2 subjected to within the unit at 2.1km, which causes pain within 60 seconds.

The thermal radiation for the Ethanol tank T-736 confined to the maximum at 602m that means the thermal radiation intensity of 10kW/m^2 is potentially lethal within 60 seconds. Similarly, the other threat zone of 5.0 kW/m^2 causes 2nd degree burns within 60 seconds at 860m and the rest is 2.0 kW/m^2 subjected to within the unit at 1.4km, which causes pain within 60 seconds.

The thermal radiation for the Ethanol tank T-732 confined to the maximum at 435m that means the thermal radiation intensity of 10kW/m^2 is potentially lethal within 60 seconds. Similarly, the other threat zone of 5.0 kW/m^2 causes 2nd degree burns within 60 seconds at 621m and the rest is 2.0 kW/m^2 subjected to within the unit at 976m, which causes pain within 60 seconds.

Emergency Response Planning Guidelines (ERPGs)

ERPGs estimate the concentrations at which most people will begin to experience health effects if they are exposed to a hazardous airborne chemical for 1 hour. (Sensitive members of the public—such as old, sick, or very young people—aren't covered by these guidelines and they may experience adverse effects at concentrations below the ERPG values.) A chemical may have up to three ERPG values, each of which corresponds to a specific tier of health effects.

The three ERPG tiers are defined as follows:

- **ERPG-3** is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.
- **ERPG-2** is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.
- **ERPG-1** is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient health effects or perceiving a clearly defined, objectionable odor.

7.6 Risk Mitigation Measures

The materials handled at the proposed installation are inflammable and reactive substances and based on the consequence analysis; the following measures are suggested as risk mitigation measures.

- It should be ensured that combustible materials such as oiled rags, wooden supports, oil buckets etc. are not kept in the storage and process areas as well as road tankers loading/unloading sites where there is maximum possibility of presence of flammable hydrocarbons in large quantities, to reduce the probability of secondary fires..
- Hydrocarbon, smoke and fire detectors should be suitably located and linked to fire fighting system to reduce the response time and ensure safe dispersal of vapours before ignition can occur.
- Tank fires result in little damage at ground levels. Damage at tank height is such as to damage adjacent tanks. Hence tank cooling provisions, particularly upper sections of the tank must be ensured to prevent explosion. Foam for arresting roof fires must be started immediately.
- Pool fires resulting from tanker/pump/pipeline leakage are dangerous since the liquid pool becomes unconfined. Training in fire fighting, escape action, operation of emergency switches etc. is vital.

- Pump loading line failures also have possibility of causing major damage. Strict inspection, maintenance and well laid down operation procedures are essential for preventing escalation of such incidents.
- Emergency procedures should be well rehearsed to achieve state of readiness.

Possibilities, Nature and Effects of Emergency

Leaving aside earthquake, cyclone, flood, arson and sabotage, the possible emergencies that can arise in the plant due to operations and storages and handling of the fuels and gases are:

- Heavy leakage and subsequent fire in the fuel oil handling area and storage tanks
- Large fires involving the coal stockyard and coal handling areas
- Accidental release of ash slurry
- Accidental fire due to some other reasons such as electrical short circuit.

7.7 Disaster Management Plan

This DMP has been designed based on the range, scales and effects of "Major Generic Hazards" described in the Risk Assessment and prediction of their typical behavior. The DMP addresses the range of thermal and mechanical impacts of these major hazards so that potential harm to people onsite and off-site, plant and environment can be reduced to a practicable minimum. The scenarios of loss of containment are credible worst cases to which this DMP is linked.

The project is in its formative stage and detail engineering is yet to be done, so the elements of the DMP are based on concepts.

Capabilities of DMP

The emergency plan envisaged will be designed to intercept full range of hazards specific 'to Rolling plant such as fire, explosion, major spill etc. In particular, the DMP will be designed and conducted to mitigate those losses of containment situations, which have potentials to escalate into major perils.

Another measure of the DMP's capability will be to combat small and large fires due to ignition, of flammable materials either from storage or from process streams and evacuate people from the affected areas speedily to safe locations to prevent irreversible injury.

Emergency medical aids to those who might be affected by incident heat radiation flux, shock wave overpressures and toxic exposure will be inherent in the basic capabilities.

The most important capability of this DMP will be the required speed of response to intercept a developing emergency in good time so that disasters such as explosion, major fire etc. are never allowed to happen.

Disaster Control Philosophy

The principal strategy of DMP is "Prevention" of identified major hazards. The "Identification" of the hazards will employ one or more of the techniques [e.g. Hazard and Operability Study (HAZOP), accident consequence analysis etc.]. Since these hazards can occur only in the event of loss of containment, one of the key objectives of technology selection, project engineering, construction, commissioning and operation is "Total and Consistent Quality Assurance". The Project Authority will be committed to this strategy right from the conceptual stage of the plant so that the objective of prevention can have ample opportunities to mature and be realised in practice.

The DMP or Emergency Preparedness Plan (EPP) will consist of:

- On-site Emergency Plan
- Off-site Emergency Plan

Disaster Management Plan preparation under the headlines of On-site Emergency Plan and Off-site Emergency Plan is in consonance with the guidelines laid by the Ministry of Environment and Forests (MOEF) which states that the "Occupier" of the facility is responsible for the development of the On-site Emergency Plan. The Off-site Emergency Plan should be developed by the Government (District Authorities).

7.7.1 On-Site Emergency Plan

Objectives

The objective of the On-site Emergency Plan should be to make maximum use of the combined resources of the plant and the outside services to

- Effect the rescue and treatment of casualties
- Safeguard other personnel in the premises
- Minimise damage to property and environment
- Initially contain and ultimately bring the incident under control
- Identify any dead
- Provide for the needs of relatives
- Provide authoritative information to the news media
- Secure the safe rehabilitation of affected areas
- Preserve relevant records and equipment for the subsequent enquiry into the cause and circumstances of emergency

Action Plans

The Action Plan should consist of:

- Identification of Key Personnel

- Defining Responsibilities of Key Personnel
- Designating Emergency Control Centres and Assembly Points
- Declaration of Emergency
- Sending All Clear Signal
- Defining actions to be taken by non-key personnel during emergency

Key Personnel

The actions necessary in an emergency will clearly depend upon the prevailing circumstances. Nevertheless, it is imperative that the required actions are initiated and directed by nominated people, each having specified responsibilities as part of co-ordinate plan. Such nominated personnel are known as Key Personnel.

The Key Personnel are:

- Site Controller (SC)
- Incidental Controller (IC)
- Liaison and Communication Officer (LCO)
- Fire and Security Officer (FSO)
- Team Leaders (TL)

Site Controller (SC)

In the emergency situation, decisions have to be taken which may affect the whole or a substantial part of the plant and even places outside. Many of these decisions will be taken in collaboration with the other officers at the plant and the staff. It is essential that the authority to make decision be invested in one individual. In this plan, he is referred to as the 'Site Controller'. The Plant Manager (however called) or his nominated deputy will assume responsibility as SC.

Incident Controller (IC)

In the emergency situation, someone has to direct the operations in the plant area and co-ordinate the actions of outside emergency services at the scene of incident. The one who will shoulder this responsibility is known as 'Incident Controller' in this plan.

A Senior Operations Officer or an officer of similar rank of the unit may be nominated to act as the IC.

Liaison and Communication Officer (LCO)

Operations Officer or any other officer of deputy rank will work as LCO and will be stationed at the main entrance during emergency to handle Police, Press and other enquiries. He will maintain communication with the IC

Fire and Safety officer (FSO)

The Fire and Safety Officer will be responsible for fire fighting. On hearing the fire alarm he shall contact the fire station immediately and advise the security staff in the plant and cancel the alarm. He will also announce on PAS (public Address System) or convey through telephones or messengers to the SC, IC and LCO about the incident zone. He will open the gates nearest to the incident and stand by to direct the emergency services. He will also be responsible for isolation of equipment from the affected zone.

Team Leaders (TL)

A number of special activities may have to be carried out by specified personnel to control as well as minimize the damage and loss. For this purpose designated teams would be available. Each team will be headed by a Team Leader (TL).

Following teams are suggested:

- Repair Team
- Fire Fighting Team
- Communication Team
- Security Team
- Safety Team
- Medical Team

- Responsibilities of Key Personnel
- Site Controller (SC)
- On getting information about emergency, proceed to Main Control Centre
- Call in outside emergency services
- Take control of areas outside the plant, which are affected
- Maintain continuous communication, review situation and assess possible course of events
- Direct evacuation of nearby settlements, if necessary
- Ensure that casualties are getting enough help
- Arrange for additional medical help and inform relatives
- Liaison with Fire and Police Services and Provide advice on possible effects on outside areas
- Arrange for chronological recording of the emergency
- Where emergency is prolonged, arrange for relieving personnel, their catering needs etc.
- Inform higher officials in head office
- Ensure preservation of evidence
- Direct rehabilitation work on termination of emergency
- Incident Controller (IC)
- On getting emergency information, proceed to Main Control Centre

Activate emergency procedure such as calling in various teams

Direct all operations within plant with following priorities:

a) Control and contain emergency

b) Secure safety of personnel

c) Minimise damage to plant, property and the environment

d) Minimise loss of material

- Direct rescue and repair activities
- Guide fire-fighting teams
- Arrange to search affected area and rescue trapped persons
- Arrange to evacuate non-essential personnel to safe area/assembly point
- Set up communications network and establish communication with SC
- Arrange for additional help/equipment to key personnel of various teams
- Consider need for preserving all records, information for subsequent enquiries
- Liaison and Communications Officer
- To ensure that casualties receive adequate attention, arrange additional help if required and inform relatives
- To control traffic movements into the plant and ensure that alternative transport is available when need arises
- When emergency is prolonged, arrange for the relief of personnel and organize refreshments/catering facility
- Advise the Site Controller of the situation, recommending (if necessary) evacuation of staff from assembly points
- Recruit suitable staff to act as runners between the Incident Controller and himself if the telephone and other system of communication fail. -Maintain contact with congregation points
- Maintain prior agreed inventory in the Control Room
- Maintain a log of the incident on tape
- In case of a prolonged emergency involving risk to outside areas by windblown materials - contact local meteorological office to receive early notification of changes in weather conditions

Fire and Safety Officer

Announce over the PAS in which zone the incident has occurred and on the advice of the Shift Officer informs the staff to evacuate the assembly

Inform the Shift Officer In-charge, if there is any large escape of products

Call out in the following order:

1) Incident Controller or his nominated deputy
2) Maintenance Officer
3) Personnel and Administrative Officer
4) Departmental Head in whose area the incident occurred
5) Team Leaders (TL)

Emergency Control Centre

The Emergency Control Centre will be the focal point in case of an emergency from where the operations to handle the emergency are directed and coordinated. It will control site activities.

Emergency management measures in this case have been proposed to be carried from single control Centre designated as Main Control Centre (MCC)

MCC is the place from which messages to outside agencies will be sent and mutual aids and other helps for the management of emergency will be arranged. It will be located in the safe area. It will be equipped with every facility for external and internal communication, with relevant data, personal protective equipments to assist hose manning the centre to enable them to co-ordinate emergency control activities. CC will be attended by SC.

Following facilities would be available in the MCC:

- P&T phones, mobile phones, intercoms, and wireless
- Fax and telex
- Emergency manuals

- Blown up area maps
- Internal telephone directories
- District telephone directories
- Emergency lights
- Wind direction and speed indicator
- Requisite sets of personal protective equipment such as gloves, gumboots and aprons

MCC will be furnished with call out list of key persons, fire, safety, first aid, medical, security, police and district administrative authorities. MCC will also contain safety data pertaining to all hazardous materials likely to cause emergency and well-defined procedures of fire fighting, rescue operations, first aid etc.

Assembly Point

In an emergency, it will certainly be necessary to evacuate personnel from affected areas and as precautionary measure, to further evacuate non-essential workers, in the first instance, from areas likely to be affected, should the emergency escalate. The evacuation will be effected on getting necessary message from i.e. On evacuation, employees would be directed to a predetermined safe place called Assembly Point.

Proposed Location: Area opposite to service building will be the Assembly Point where all non-key personnel would assemble on getting direction over Public-Address System.

Outdoor assembly points, predetermined and premarked, will also be provided to accommodate evacuees from affected plant area(s). Roll call of personnel collected at these assembly points, indoor and outdoor will be carried out by roll call crew of safety team to account for any missing person(s) and to initiate search and rescue operations if necessary.

Declaration of Emergency

An emergency may arise in the terminal due to major leakage of oil or major outbreak of fire/explosion. In case of major leak or major outbreak of fire the state of emergency has to be declared by the concerned by sounding Emergency Siren.

Upon manual or sensor detection of a major loss of containment of volatile hazardous substance, the DMP is activated by raising an audible and visual alarm through a network of geographically dispersed gas/vapour and heat detectors and also "break glass" type fire alarm call points with telephone hand sets to inform the Central Control Room.

A separate siren audible to a distance of 5 km range will be available for this purpose. The alarm is coded such that the nature of emergency can be distinguished as a leakage or major fire.

The Control Centre and Assembly point will be located at an area of the minimum risk or vulnerability in the premises concerned, taking into account the wind direction, areas which might be affected by fire/explosion, leakage etc.

After cessation of emergency, FSO will communicate to IC. After verification of status, IC will communicate with SC and then announce the "All Clear" by instructing the Time Office to sound the "All Clear Signal".

Alarms would be followed by an announcement over Public Address System (PAS).In case of failure of alarm system, communication would be' by telephone operator who will make announcement in the complex through PAS. Walkie-talkie system is very useful for communication during emergency with predetermined codes of communication. If everything fails, a messenger could be used for sending the information.

Two 5 km, range variable pitch electric sirens (one in service and the other standby)will generate the main alarm for the entire site as well as for the district fire brigade. The alarm is coded such that the nature of emergency can be distinguished as a leakage or major fire. Fire and Gas alarm matrices are provided at the Central Control room, security gate, on-site fire station and main administrative office corridor to indicate location of the site of emergency and its nature.

Mutual Aid

Procedure

All factories may not be equipped with an exhaustive stock of equipment/materials required during an emergency. Further, there may be a need to augment supplies if an emergency is prolonged.

It would be ideal to pool all resources available in the and nearby outside agencies especially factories during an emergency, for which a formal Mutual Aid scheme should be made among industries in the region.

Essential Elements

Essential elements of this scheme are given below:

- Mutual aid must be a written document, signed by Location In-charge of all the industries concerned
- It should specify available quantity of materials/ equipment that can be spared (not that which is in stock)
- Mode of requisition during an emergency.
- It should authorize the shift-in-charge to quickly deploy available material/equipment without waiting for formalities like gate pass etc.
- It should spell out mode of payment/replacement of material given during an emergency
- It should specify key personnel who are authorized to requisition materials from other industries or who can send materials to other industries
- It should state clearly mode of receipt of materials at the affected unit without waiting for quantity/quality verification etc.
- Revision number and validity of agreement should be mentioned
- This may be updated from time to time based on experience gained

Emergency Management Training

The Key Personnel would undergo special courses on disaster management. This may preferably be in-plant training. The Managers, Senior Officers and Staff would undergo a course on the use of personal protective equipment.

The Key Personnel belonging to various Teams would undergo special courses as per their expected nature of work at the time of emergency.

The plant management should conduct special courses to outside agencies like district fire services to make them familiar with the plant layout and other aspects, which will be helpful to them during an emergency.

Mock Drills

It is imperative that the procedures laid in this Plan are put to the test by conducting Mock Drills. To avoid any lethality, the emergency response time would be clocked below 2 minutes during the mock drill.

1st Step: Test the effectiveness of communication system

2nd Step: Test the speed of mobilization of the plant emergency teams

3rd Step: Test the effectiveness of search, rescue and treatment of casualties

4th Step: Test emergency isolation and shut down and remedial measures taken on the system

5th Step: Conduct a full rehearsal of all the actions to be taken during an emergency

The Disaster Management Plan would be periodically revised based on experiences gained from the mock drills.

Proposed Communication System

The instrument and control system will take care of the following operating philosophy of the plant:

- The project will be provided with a control system located in a central control room.
- The shift engineer will operate the plant from his console panel.

- All operations will be represented in a graphic panel on the console and every operation will be depicted as operating sequences.
- All operating parameters will be displayed in digital format.
- Alarms will be provided for all parameters, when they exceed set values.
- High-High/Low-Low alarms and trip functions will be provided to trip
- Pumps/compressors to bring the entire system to a safe shutdown.
- Proposed Fire Fighting System
- Elaborate fire fighting system will be available for fighting fires in any corner of the plant. A comprehensive fire detection and protection system is provided for the complete project.
- Fire water storage tanks of adequate capacity.
- Fire water pump house containing combination of diesel and electrically driven pumps.
- Hydrant system complete with suitable size piping, valves, instrumentation, hoses, nozzles, hose boxes/stations, monitors etc.
- Foam injection system for fuel oil/storage tanks consisting of foam concentrate tanks, foam pumps, in-line inductors, valves, piping and instrumentation etc.
- Automatic high velocity water spray system consisting of detectors, deluge valves projectors, valves, piping and instrumentation.
- Automatic medium velocity water spray system consisting of QB
- Detectors/smoke detectors, linear heat sensing cable detectors, deluge valves, isolation valves, nozzles, piping, instrumentation etc.
- Suitable "Halon Substitutes" such as INERGEN or FM..: 200 or AGGONITE for protection of control room, equipment room, computer room and other electric and electronic equipment rooms.

- Computerized analogue, addressable, early warning type fire detection and alarm system consisting various types of fire detection such as ionisation type smoke detection system, photo electric type smoke detection system, linear heat sensing cable detector, quartzoid bulb (QB)heat detection system, infrared heat detectors and spot type electrical heat detectors.
- Portable and mobile extinguishers, such as pressurized water type, carbondioxidetype, foam type, dry chemical powder (DCP) type located at strategic locations throughout the plant.
- Fire tenders/engines of water type, DCP type/foam type, trailer pump with fire jeep etc. provided in the fire station.
- Complete instrumentation and control system for the entire fire detection and protection system for safe operation of the complete system.

Other safety Measures

Considering that fire and explosion is the most likely hazard in such installations, the plant is being provided with systems to guard against such hazards. Salient among these are:

- A proper layout to prevent and minimize the effects of any hazardous situation
- Design of storage vessels and all components to codes and standards to withstand the rigorous duty
- Provision of operating systems to conduct the process through well established safe operating procedures
- A control system, which monitors all, plant parameters and give alarms
- Control system, which has trip provisions to prevent hazard conditions escalating
- A gas detection system which will provide early warning of any leaks
- Provision of a fire protection system to control fire
- Provision of flame-proof lighting system in the fire prone areas
- Proposed First Aid and Medical Facilities

- The First Aid Medical Centre has been proposed. It will be fully equipped with emergency facilities. It will be open round the clock. A Medical Officer with Compounder will always be available in the centre. Emergency cars will be available in all the shifts. Adequate number of first aid boxes will be kept at strategic locations. Required stock of first aid medicines will be maintained. Trained first aiders will be available in all departments.
- Facilities to be kept in the Medical Room along with others will include: Oxygen Cylinders, Injection Corarnine, Glucose Saline, LV. Sets, Syringes, Injection Needles, Stretchers and medicines.

Proposed Emergency Power Supply

Strategic areas will be provided with emergency lights fed through stationed battery system. Portable emergency lamps will be also available at required points. A Diesel Driven Generator of adequate capacity will be available to keep the operations running in case of power failure. Diesel Engine operated fire pumps will be available.

Off Site Emergency Plan

Objective

If the effects of the accident or disaster inside the plant are felt outside its premises, it calls for an off-site emergency plan, which should be prepared and documented in advance in consultation with the District Authorities.

Key Personnel

The ultimate responsibility for the management of the off-site emergencies rests on the Collector / District Magistrate / Deputy Commissioner. He will be assisted by representatives from all concerned organisations, departments and services at the District level. This core group of officers would be called the District Crisis Management Group (CMG). The members of the group will include:

1) Collector/District Magistrate Deputy Commissioner

2) Commissioner of Police

3) Municipal Commissioner, if municipalities are involved

4) Deputy Director, Health

5) Pollution Control Board Representative

An Operation Response Group (ORG) will then be constituted to implement the directives of the CMG.

The various government departments, some or all of which will be concerned, depending on the nature of the emergency, could include:

- Police
- Health & Family Welfare
- Medical
- Revenue
- Fire Service
- Transport
- Electricity
- Animal Husbandry
- Agriculture
- Civil Defense
- PWD
- Civil Supplies
- Panchayats

The SC and IC, of the on-site emergency team, will also be responsible for communications with the CMG during the off-site emergency.

Education to Public

People living within the influence zone should be educated on the emergency in a suitable manner. This can be achieved only through the Local and District Authorities. However, the Project Authority can extend necessary information to the Authorities.