

QUANTITATIVE RISK ASSESSMENT (QRA) REPORT

Prepared For

M/s. CHALLA CHLORIDE PVT. LTD.

MAHARASHTRA, INDIA

Conducted & Prepared By



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ACKNOWLEDGEMENT

We express our sincere thanks to management & employees of **M/s. Challa Chloride** for their co-operation & unstinted help without which the **QRA (Quantitative Risk Assessment)** could not have been possible. The courtesy extended to our team is highly appreciated.

For: GREEN CIRCLE, INC.

AUTHORISED SIGNATORY

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ABBREVIATIONS

API	American Petroleum Institute
BLEVE	Boiling Liquid Expanding Vapor Explosion
DALR	Dry Adiabatic Lapse Rate
dB	Decibel
ELR	Environmental Lapse Rate
FO	Fuel oil
GO	Gas Oil
HCRD	Database for Hydrocarbon Contaminate Release
KW	Kilo Watt
LEL	Lower Explosive Limit
LFL	Lower Flammable Limit
LPG	Liquefied Petroleum Gas
MCLS	Maximum Credible Loss Scenario
MSDS	Material Safety Data Sheet
QRA	Quantitative Risk Assessment
UEL	Upper Explosive Limit
UFL	Upper Flammable Limit
VCE	Vapor Cloud Explosion



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1. PROJECT DESCRIPTION

M/s. Challa Chloride Pvt. Ltd. proposed project is named as - Bulk Drug & Intermediates and Chemical Manufacturing Unit. The expected cost of the proposed project will be around **Rs. 4.5 Crores**. Out of which about Rs. 100 Lakhs would be invested towards installation of Multiple Effect Evaporation System, Rs. 15 Lakhs would be spent on Air Pollution Control (APC) Equipment in the form of Bag Filter and Stack, Rs. 5 Lakhs towards the Green Belt Development Plan and Rs. 19.5 Lakhs would be spent annually towards O & M of ETP and APC as well as EMP.

2. SCOPE OF THE STUDY

This QRA study is to be conducted for the following facility:

- Acetic acid tank
- Acetone tank
- Acetyl Chloride drum
- Ammonia tonner
- Chlorine tonner
- Ethylene Dichloride drum
- Isopropyl Alcohol drum
- Methanol tank
- N-hexane drum
- Toluene drum



3. EXECUTIVE SUMMARY

M/s. Challa Chloride Pvt. Ltd. has engaged the services of **GREEN CIRCLE, INC, VADODARA**, for carrying out Quantitative Risk Analysis study of their facility consisting of Acetic acid tanks, Acetone tank, Acetic acid tank, Acetyl Chloride drum, Ammonia tonner, Chlorine tonner, Ethylene Dichloride drum, Isopropyl Alcohol drum, Methanol tank, N-hexane drum, and Toluene drum. Green Circle, Inc. Ltd. has the requisite software and specialist manpower resources for this purpose. The renowned PHAST software package of DNV has been used by Green Circle, Inc. Ltd. for carrying out this study.

QRA study for the said facility has been carried out based on the verification of information from the plant personnel.

Based on the operations to be carried out and hazardous storages at the tank farm, the Risk Analysis study analyses the affected distances and the damage to PEAR (People, Environment, Assets and Reputation of the company) from the identified scenarios considering the Maximum credible loss scenario (MCLS) & Worst case scenario. Maximum credible loss scenarios have been worked based on the inbuilt safety systems and protection measures to be provided for the operation of the facility & the Worst case scenario i.e. Catastrophic Rupture has been worked out based on failure of the inbuilt safety system.

Following are the damage distances computed for specific scenarios and the recommendations based thereon

- Jet fire effect in Acetone due to a leak scenario of 100 mm for the heat load of 4.0 kW/m² is 34.55 m at 1.5 F Condition. These damage distances are considerable but proper extinguishing system must be installed to counter if any incident occurs.
- Flash fire effect in Methanol due to a catastrophic rupture scenario is 161.08 m at 1.5 F Condition. Late Pool fire effect in Acetone due to a catastrophic rupture scenario is 158.88 m at 1.5 F Condition. The damage will extend beyond company premises hence; off site emergency plan should be activated.
- Maximum effect of explosion in Acetone tank due to leak scenario at overpressure 0.02 bar and 1.5 F condition is up to 242.65 m creating pain to the people exposed and



damage the nearby units. It is recommended that the fire fighting facilities should be provided as per OISD, NFPA guidelines.

- The structural strength provided for building is such that the above overpressure could not affect the buildings and nearby units. Also toughen glass should be provided in office areas to withstand the shock wave.
- In this Risk Assessment Study various assumptions for process conditions, equipment layout have been considered to carry out consequence analysis due to partial and full rupture scenarios.
- Fire extinguishers available at the manifold should be kept in proper conditions and fire hydrant lines and monitoring at the jetties should be maintained properly.

References

Plot plant (Refer annexure)

4. LIST & DETAILS OF MATERIALS & TANKS

Table: 4.1 Physical Properties of Material

Sr. No.	Chemical Name	Flammability	Flash Point (°C)	LEL (%)	UEL (%)	Vapor Pressure, kPa	Boiling point (°C)	Physical state	Auto Ignition temp (°C)
1.	Acetic Acid	Flammable	40	4	19.9	1.5 (@ 20°C)	118.1	Liquid	463
2.	Acetone	Highly Flammable	-18.5	2.6	12.8	23.998 (@ 20°C)	45	Liquid	465
3.	Methanol	Highly Flammable	11.11	6	36.5	13.3322 (@21.22°C)	64.611	Liquid	464
4.	Acetyl Chloride	Highly Flammable	4.44	Not Available	5	18 (@7.5°C)	50.89	Liquid	390
5.	Ammonia	Not Available	Not Applicable	16	25	Not Available	-33.3	Gas	651.11
6.	Chlorine	Not flammable	Not Available	Not Available	Not Available	1013.2 (@ 30°C)	-34.61	Gas	Not Available
7.	Ethylene Dichloride	Highly Flammable	13.33	6.2	15.9	7.99 (@ 20°C)	83.5	Liquid	412.78
8.	Iso Propyl Alcohol	Flammable	11.66	2	12	4.4 (@ 20°C)	-88.5	Liquid	399.98
9.	N-Hexane	Flammable	-23	1.2	7.5	15.998 (@ 20°C)	68.89	Liquid	225
10.	Toluene	Highly Flammable	4.44	1.27	7.1	2.66 (@18.39°C)	110.61	Liquid	480

TANK DETAILS

The following are the detail that has been used while conducting the consequence analysis.

Chemical Stored	Storage Capacity of the tank (KL/m ³)		No. of tanks	Storage Conditions		Elevation Of the tank above ground (m)	Material of Construction	Tank Dimensions (mm/in.)	
	Designed Capacity	Actual Capacity		P (bar)	T (°C)			ID	H
Acetic acid	20 KL	15 KL	1	Ambient	Ambient	Above the ground	S.S.	3300	6600
Acetone	20 KL	15KL	2	Ambient	Ambient	Under ground	M.S.	3300	6600
Methanol	20 KL	15 KL	1	Ambient	Ambient	Above the ground	M.S.	2.3300	2.6600
Chlorine	900 kgs	900 kgs	3	Ambient	Ambient	Above the ground	M.S.	2500	740
Ethylene dichloride	200 liters	160 kgs	10	Ambient	Ambient	Above the ground	HDPE	1600	900
Acetyl chloride	200 liters	160 kgs	10	Ambient	Ambient	Above the ground	HDPE	1600	900
N-hexane	200 liters	180 liters	10	Ambient	Ambient	Above the ground	M.S	1600	900



Toluene	200 liters	180 liters	10	Ambient	Ambient	Above the ground	M.S	1600	900
Isopropyl Alcohol	200 liters	160 kgs	10	Ambient	Ambient	Above the ground	HDPE	1600	900
Ammonia	50 kg	50 kg	4	Ambient	Ambient	Above the ground	M.S.	960	1360



5. OBJECTIVE OF THE STUDY

The main objective for conducting this QRA (Quantitative Risk Analysis) Study is to determine the potential risks and their consequences to the facility due to storage and transferring of hazardous chemicals at various locations and other equipments. This is achieved by the following:

- Identification of hazards that could be realized from hazardous material.
- Identify the potential failure scenarios that could occur within the facility.
- To assess, the potential risks associated with identified hazards to which the plant and its personnel and community outside may be subjected. Consequence analysis of various hazards is carried out to determine the vulnerable zones for each probable accident scenario.
- Evaluate the process hazards emanating from the identified potential accident scenarios.
- Analyze the damage effects to the surroundings due to such accidents.
- Conclusion and Recommendations in order to mitigate the hazard.



6. USE OF QRA RESULTS

The techniques used for risk prediction within the QRA have inherent uncertainties associated with them due to the necessary simplifications required. In addition, QRA incorporates a certain amount of subjective engineering judgment and the results are object to levels of uncertainty. The results should be used as a tool to aid engineering judgment and, if used in this way, can provide valuable information during the decision making process.

The QRA results are dependent on the assumptions made in the calculations, which are clearly documented of this report. The results show the significant contributions to the overall risk and indicate where worthwhile gains may be achieved if further enhancement of safety is deemed necessary.

7. SOFTWARE USED

PHAST has been used for consequence analysis include discharge and dispersion calculations.

8. METHODOLOGY ADOPTED FOR QRA

The consequences of released toxic or flammable material are largely dependent on the prevailing weather conditions. Consequences of loss of containment can lead to hazardous situation in any industry handling potentially hazardous materials. Following factors govern the severity of consequence of the loss of containment.

- Intrinsic properties: flammability, toxicity and reactivity.
- Dispersive energy: pressure, temperature and state of matter.
- Quantity present
- Environmental factors: weather (wind speed, wind direction, atmospheric temperature & pressure).

Consequence analysis and calculations are effectively performed by computer software using models validated over a number of applications. Consequence modeling is carried out by PHAST of DNV Software, UK.

PHAST uses the Unified Dispersion Model (UDM) capable of describing a wide range of types of accidental releases. The Model uses a particularly flexible form, allowing for sharp-edged profiles, which become more diffuse downwind.

PHAST contains data for a large number of chemicals and allows definition of mixtures of any of these chemicals in the required proportion. The calculations by PHAST involve following steps for each modeled failure case:

- Run discharge calculations based on physical conditions and leak size.
- Model first stage of release (for each weather category).
- Determine vapor release rate by flashing of liquid and pool evaporation rate.
- Dispersion modeling taking into account weather conditions.
- In case of flammable release, calculate size of effect zone for fire and explosion.
- The hazardous materials considered in this study are mostly flammable liquids

Flow chart for consequence analysis is shown in the form of event tree for release of flammable liquid.

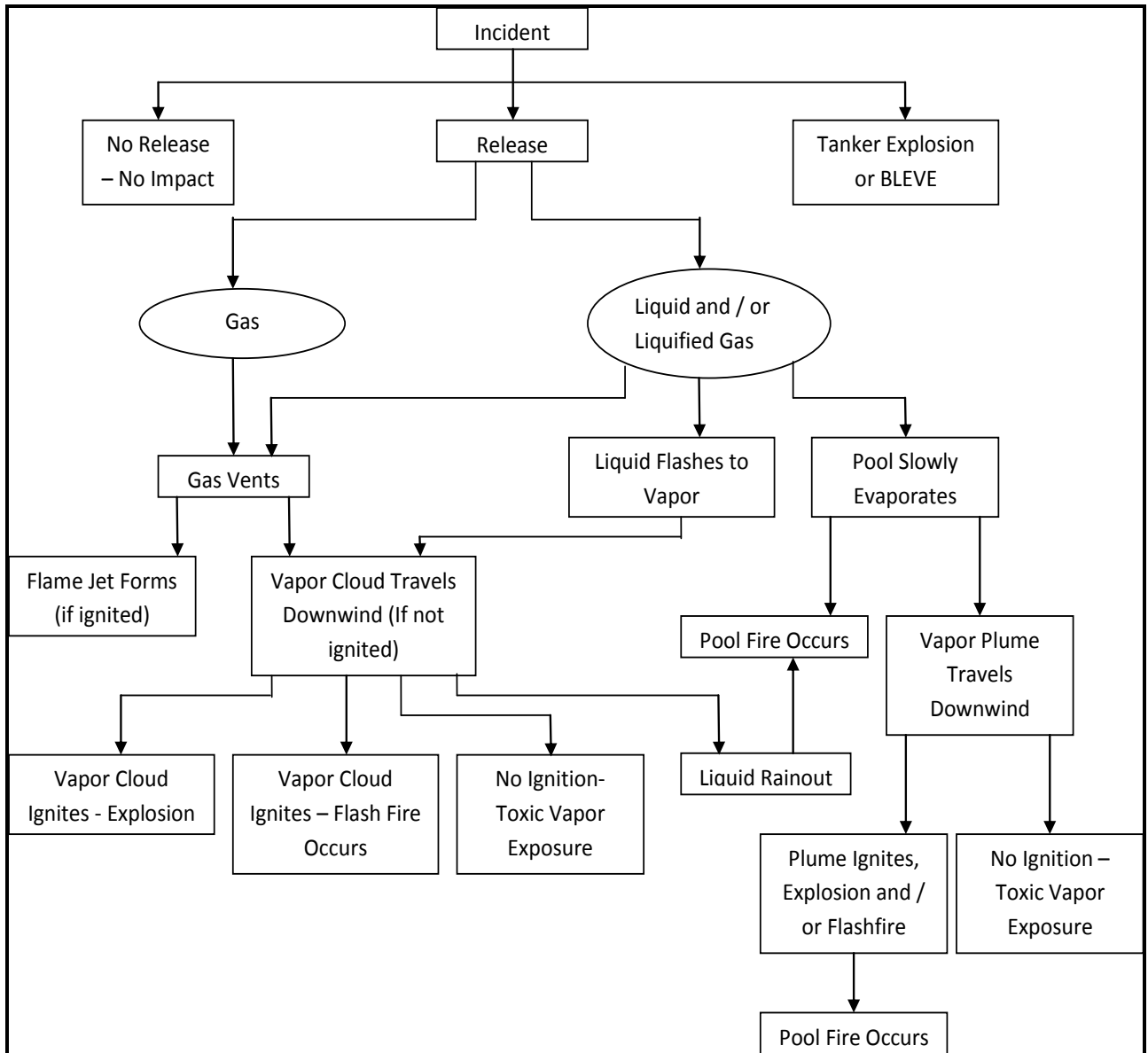


Fig. 1: Methodology adopted for the study

METEOROLOGICAL CONDITION

The consequences of released flammable material are largely dependent on the prevailing weather conditions. For the assessment of major scenarios involving release of flammable



materials, the most important meteorological parameters are those that affect the atmospheric dispersion of the escaping material. The crucial variables are wind direction, wind speed, atmospheric stability and temperature. Rainfall does not have any direct bearing on the results of the risk analysis; however, it can have beneficial effects on absorption / washout of released materials. Actual behavior of any release would largely depend on prevailing weather condition at the time of release. We have used the meteorological data of Challa Chloride, Maharashtra for the present study.

ATMOSPHERIC PARAMETERS

The atmospheric parameters which are considered while conducting this study is as under:

Atmospheric Temperature	:	25 deg C
Relative humidity	:	60%

WIND SPEED AND WIND DIRECTION

The wind speed and wind direction data which have been used for the study is summarized below:

Average Wind Speed	:	1.5 m/s, 3 m/s and 5 m/s
Stability Class	:	F and D
Wind Direction	:	All 360 deg.

WEATHER CATEGORY

One of the most important characteristics of atmosphere is its stability. Stability of atmosphere is its tendency to resist vertical motion or to suppress existing turbulence. This tendency directly influences the ability of atmosphere to disperse pollutants emitted into it from the facilities. In most dispersion scenarios, the relevant atmospheric layer is that nearest to the ground, varying in thickness from a few meters to a few thousand meters. Turbulence induced by buoyancy forces in the atmosphere is closely related to the vertical temperature gradient.

Temperature normally decreases with increasing height in the atmosphere. The rate at which the temperature of air decreases with height is called Environmental Lapse Rate (ELR). It will vary from time to time and from place to place. The atmosphere is said to be stable, neutral or unstable according to ELR is less than, equal to or greater than Dry Adiabatic Lapse Rate (DALR), which is a constant value of 0.98°C/100 meters.



Pasquill stability parameter, based on Pasquill – Gifford categorization, is such a meteorological parameter, which describes the stability of atmosphere, i.e., the degree of convective turbulence. Pasquill has defined six stability classes ranging from `A' (extremely unstable) to `F' (moderately stable). Wind speeds, intensity of solar radiation (daytime insolation) and nighttime sky cover have been identified as prime factors defining these stability categories.

Table 8.1 Pasquill stability classes

Stability class	Definition	Stability class	Definition
A	Very Unstable	D	Neutral
B	Unstable	E	Slightly Stable
C	Slightly Unstable	F	Stable

When the atmosphere is unstable and wind speeds are moderate or high or gusty, rapid dispersion of pollutants will occur. Under these conditions, pollutant concentrations in air will be moderate or low and the material will be dispersed rapidly. When the atmosphere is stable and wind speed is low, dispersion of material will be limited and pollutant concentration in air will be high. In general, worst dispersion conditions (i.e. contributing to greater hazard distances) occur during low wind speed and very stable weather conditions



9. HAZARDS & DAMAGE CRITERIA OF MATERIALS

DEFINITIONS:

The release of flammable liquid can lead to different types of fire or explosion scenarios. These depend on the material released, mechanism of release, temperature and pressure of the material and the point of ignition. Types of flammable effects are as follows.

Hazards associated with Flammable materials

a. Pool fire:

The released flammable material which is a liquid stored below its normal boiling point, will collect in a pool. The geometry of the pool will be dictated by the surroundings. If the liquid is stored under pressure above its normal boiling point, then a fraction of the liquid will flash into vapor and the remaining portion will form a pool in the vicinity of the release point. Once sustained combustion is achieved, liquid fires quickly reach steady state burning. The heat release rate is a function of the liquid surface area exposed to air. An unconfined spill will tend to have thin fuel depth (typically less than 5 mm) which will result in slower burning rates. A confined spill is limited by the boundaries (e.g. a dyke area) and the depth of the resulting pool is greater than that for an unconfined spill.

b. Flash fire:

It occurs when a vapor cloud of flammable material burns. The cloud is typically ignited on the edge and burns towards the release point. The duration of flash fire is very short (seconds), but it may continue as jet fire if the release continues. The overpressures generated by the combustion are not considered significant in terms of damage potential to persons, equipment or structures. The major hazard from flash fire is direct flame impingement. Typically, the burn zone is defined as the area the vapor cloud covers out to half of the LFL. This definition provides a conservative estimate, allowing for fluctuations in modeling. Even where the concentration may be above the UFL, turbulent induced combustion mixes the material with air and results in flash fire.

c. Jet Fire:

Jet flames are characterized as high-pressure release of gas from limited openings (e.g. due to small leak in a vessel or broken drain valve). Boiling liquid expanding vapor explosion (BLEVE) or fireball: A fireball is an intense spherical fire resulting from a sudden release of



pressurized liquid or gas that is immediately ignited. The best known cause of a fireball is a boiling liquid expanding vapor explosion (BLEVE). Fireball duration is typically 5 – 20 seconds.

d. Vapor cloud explosion:

When a large quantity of flammable vapor or gas is released, mixes with air to produce sufficient mass in the flammable range and is ignited, the result is a vapor cloud explosion (VCE). Without sufficient air mixing, a diffusion-controlled fireball may result without significant overpressures developing. The speed of flame propagation must accelerate as the vapor cloud burns. Without this acceleration, only a flash fire will result.

Vapour cloud explosions (VCE) are one of the most serious hazards in chemical process industries. When a large quantity of flammable gas or vapor is accidentally released in to atmosphere it may form a vapour cloud and if its ignition is delayed (5-10 min) could produce a vapour cloud explosion. The damage effects of a vapour cloud explosion are mostly due to the overpressure that is created from the fast expansion of the combustion products. The overpressure is the most important causes of damage to people, equipment and facilities.

UNCONFINED VAPOUR CLOUD EXPLOSION

Definition: Type of explosion in a liquefied hydrocarbons or other flammable gas cloud in a non-confined space (within and/or beyond the premises)

FACTOR AFFECTING FORMATION OF VAPOUR CLOUD

1. Type of leaked oil- Lesser the flash point of flammable liquid, more will be the generation of vapor cloud
2. Rate of leakage:- More the rate –more will be vapor formation
3. Wind velocity- more vapor formation may result due to heavy wind but the cloud will drift in the direction of the wind
4. Type of enclosure:- A solid wall will hold more vapor as compared to a fenced boundary
5. Type of nearby vegetation - More is vegetation near the leak site, more vapors will be trapped. More is the height of the plants; more will be the quantity of vapor trapped



EFFECT OF UNCONFINED VAPOUR CLOUD EXPLOSION

When the vapor cloud is ignited, following may result:-

1. Blast waves
2. Shock waves
3. Fire Ball
4. Multiple fires

Above may causes huge loss of life and property and may also damage the onsite disaster mitigation resources making it an offsite emergency.

MANAGEMENT OF VAPOUR CLOUD

1. Don't switch off or switch on any electrical or heat generating source like DG and Compressor
2. Any hot job inside or outside the station premises should be immediately stopped
3. Declare station emergency and evacuate the station as per evacuation
4. Stay upwind
5. Try to close the valve by remote operation if leakage is from the valve otherwise isolate the oil supply to leak tank/piping/valve
6. If not possible to isolate the valve by remote, wear BA set and close the valve locally. Don't try to approach site without BA set otherwise asphyxiation will lead to collapse and death
7. When the clouds gets ignited causing an explosion, follow the management procedure

VAPOR CLOUD FORMATION & ITS EFFECT:

When a cloud of flammable vapor burns, the combustion may give rise to an overpressure or it may not. If there is no overpressure, the event is a vapor cloud fire, or flash fire: and if there is overpressure, it is vapor cloud explosion.

A vapor cloud explosion is one of the most serious hazards in the process industries. Vapor cloud explosions do occasionally occur and they are generally very destructive.

A feature of vapor cloud is that it may drift some distance from the point where the leak has occurred and thus threaten a considerable area. Such types of vapor cloud find an ignition source and can create overpressure and blast effects which can cause severe damage at considerable distance from the source of leak.

Hazards Associated with Explosive Chemicals:

DAMAGE CRITERIA:

Damage estimates due to thermal radiations and overpressure have been arrived at by taking in to consideration the published literature on the subject. The consequences can then be visualized by the superimposing the damage effects zones on the proposed plan site and identifying the elements within the project site as well as in the neighboring environment, which might be adversely affected, should one or more hazards materialize in real life.

THERMAL DAMAGE:

The effect of thermal radiation on people is mainly a function of intensity of radiation and exposure time. The effect is expressed in terms of the probability of death and different degrees of burn. The following tables give the effect of various levels of heat flux.

FATAL RADIATION EXPOSURE LEVELS

Table 9.1: Fatal Radiation Exposure Level

RADIATION LEVEL kW/m ²	FATALITY		
	1%	50%	99%
	EXPOSURE IN SECONDS		
4.0	150	370	930
12.5	30	80	200
37.5	8	20	50

Table 9.2: Fatal Radiation Exposure Level (Details)

RADIATION KW/m ²	DAMAGE TO EQUIPEMENT	DAMAGE TO PEOPLE
1.2		Solar heat at noon
1.6	PVC insulated cables damaged	Minimum level of pain threshold
2.0		
4.0	***	Causes pain if duration is longer than 20 secs. But blistering is unlikely
6.4	***	Pain threshold reached after 8 secs. Second degree burns after 20 secs.
12.5	Minimum energy to ignite wood with a flame; Melts plastic tubing.	1% lethality in one minute. First degree burns in 10 secs
16.0	***	Severe burns after 5 secs.
25.0	Minimum energy to ignite wood at identifying long exposure without a flame.	100% lethality in 1 minute. Significant injury in 10 secs.
37.5	Severe damage to plant	100% lethality in 1 minute. 50% lethality in 20 secs. 1% lethality in 10 secs.

OVERPRESSURE DAMAGE:

Table 9. 3: Over Pressure Damage Criteria with Damage To People

OVER PRESSURE (mbar)	MECHANICAL DAMAGE TO EQUIPMENTS	DAMAGE TO PEOPLE
300	Heavy damage to plant & structure	1% death from lung damage >50% eardrum damage >50% serious wounds from flying objects
100	Repairable damage	>1% eardrum damage >1% serious wounds from flying objects
30	Major glass damage	Slight injury from flying glass
10	10% glass damage	***

Table 9.4: Over Pressure Damage Criteria with Mechanical Damage To Equipments

OVER PRESSURE		Mechanical damage to equipments
Bar	K Pa	
0.0014	0.14	Annoying noise (137 dB if of low frequency 10–15 Hz)
0.0021	0.21	Occasional breaking of large glass windows already under strain
0.0028	0.28	Loud noise (143 dB), sonic boom, glass failure
0.0069	0.69	Breakage of small windows under strain
0.0103	1.03	Typical pressure for glass breakage
0.0207	2.07	"Safe distance" (probability 0.95 of no serious damage below this value);projectile limit; some damage to house ceilings; 10% window glass broken
0.0276	2.76	Limited minor structural damage

0.03-0.069	3.4-6.9	Large and small windows usually shattered; occasional damage to window frames
0.048	4.8	Minor damage to house structures
0.069	6.9	Partial demolition of houses, made uninhabitable
0.138	13.8	Corrugated asbestos shattered; corrugated steel or aluminum panels, fastenings fail, followed by buckling; wood panels (standard housing) fastenings fail, panels blown in
0.09	9.0	Steel frame of clad building slightly distorted
0.138	13.8	Partial collapse of walls and roofs of houses
0.207	20.7	Concrete or cinder block walls, not reinforced, shattered
0.158	15.8	Lower limit of serious structural damage
0.172	17.2	50% destruction of brickwork of houses
0.207	20.7	Heavy machines (3000 lb) in industrial building suffered little damage; steel frame building distorted and pulled away from foundations.
0.207-0.276	20.7-27.6	Frameless, self-framing steel panel building demolished; rupture of oil tanks
0.276	27.6	Cladding of light industrial buildings ruptured
0.345	34.5	Wooden utility poles snapped; tall hydraulic press (40,000 lb) in building slightly damaged
0.345-0.482	34.5-48.2	Nearly complete destruction of houses
0.482	48.2	Loaded, lighter weight (British) train wagons overturned
0.482-0.551	48.2-55.1	Brick panels, 8 –12 in. thick, not reinforced, fail by shearing or flexure
0.62	62.0	Loaded train boxcars completely demolished
0.689	68.9	Probable total destruction of buildings; heavy machine tools (7,000 lb) moved and badly damaged, very heavy machine tools (12,000 lb) survive



10. CONSEQUENCE ANALYSIS

INTRODUCTION

The consequence analysis is carried out to determine the extent of spread (dispersion) by accidental release which may lead to jet fire, pool fire, catastrophic ruptures resulting in generation of heat radiation, overpressures, explosions etc.

In order to form an opinion on potentially serious hazardous situations and their consequences, consequence analysis of potential failure scenarios are conducted. It is qualitative analysis of hazards due to various failure scenarios. In consequence analysis, each failure case is considered in isolation and damage effects predicted, without taking into account the secondary events or failures it may cause, leading to a major disastrous situation. The results of consequence analysis are useful in developing Disaster Management Plan and in developing a sense of awareness among operating and maintenance personnel. It also gives the operating personnel and population living in its vicinity, an understanding of the hazard they are posed to.

Event Outcomes

Upon release of flammable / toxic gas & liquids, the hazards could lead to various events which are governed by the type of release, release phase, ignition etc. PHAST has an inbuilt event tree for determining the outcomes which are based on two types of releases namely continuous and instantaneous. Leaks are considered to be continuous releases whereas, ruptures are considered to be instantaneous releases. These types of releases are further classified into those which have a potential for rain-out and those which do not. Whether the release would leak to a rain-out or not depends upon droplet modeling which is the main cause of formation of pools. Fig 2, Fig 3, Fig 4 and Fig5 present the event trees utilized by PHAST to generate the event outcomes.

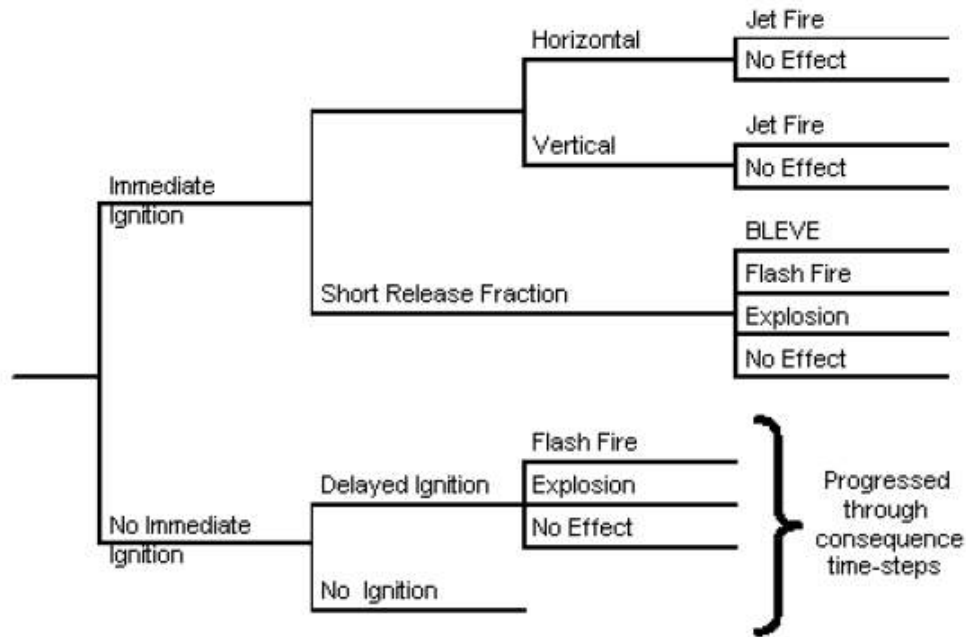


Fig. 2: Event Tree for continuous release without rain-out (from PHAST)

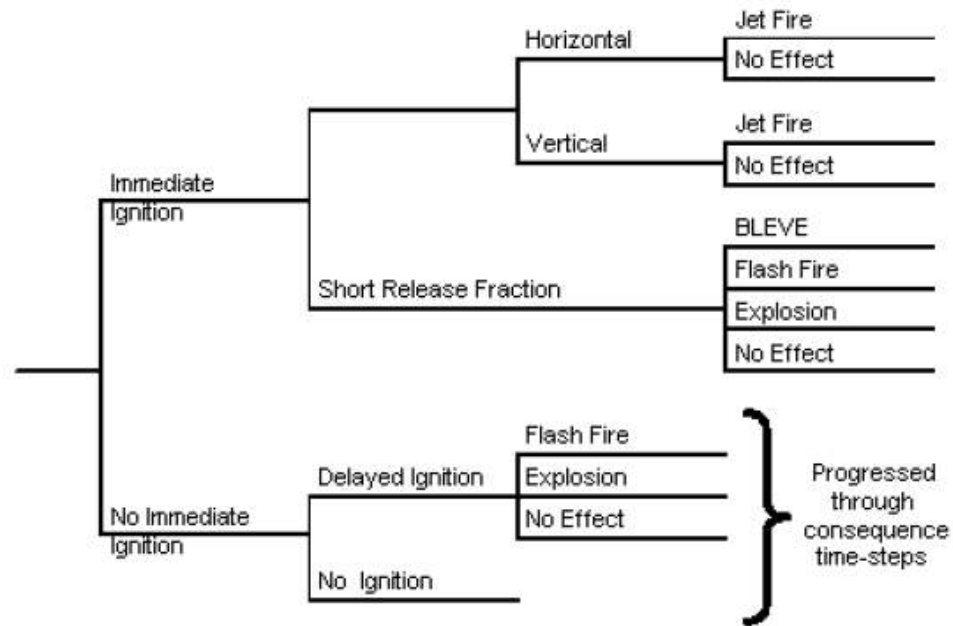


Fig.3: Event Tree for Instantaneous release without rain-out (from PHAST)

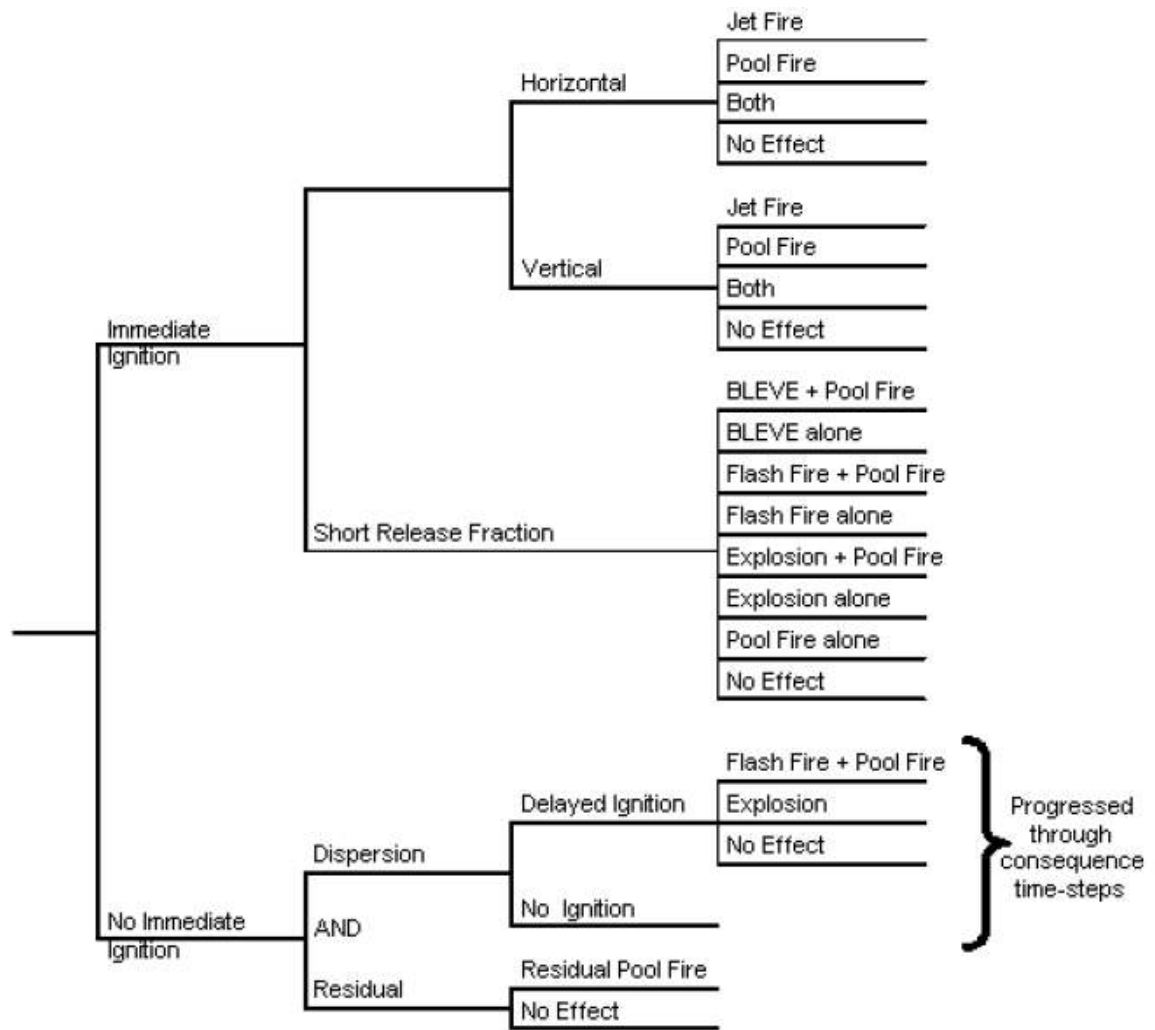


Fig. 4: Event Tree for continuous release with rain-out (from PHAST)

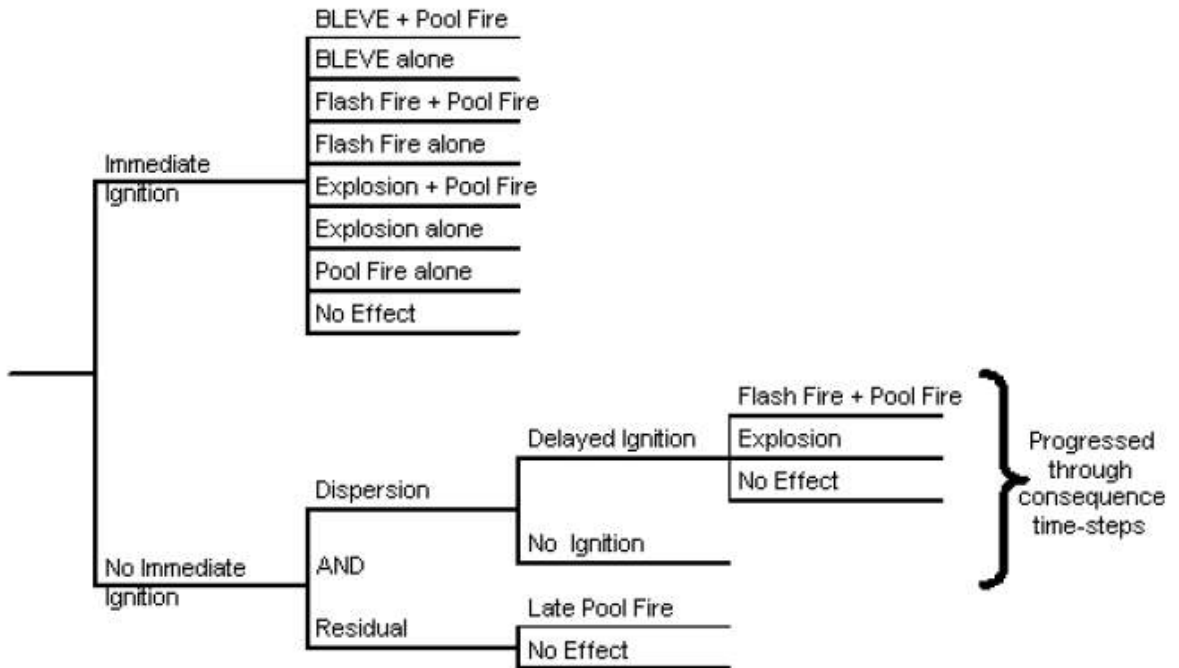


Fig.5: Event Tree for Instantaneous release with rain-out (from PHAST)

EFFECTS OF RELEASE

When hazardous material is released to atmosphere due to any reason, a vapor cloud is formed. Direct cloud formation occurs when a gaseous or flashing liquid escapes to the atmosphere. Release of toxic compounds to atmosphere may usually lead to the following:

1. Spillage of liquid hydrocarbons will result in a pool of liquid, which will evaporate taking heat from the surface, forming a flammable atmosphere above it. Ignition of this pool will result in pool fire causing thermal radiation hazards.
2. A fireball or BLEVE (Boiling Liquid expanding Vapor Explosion) occurs when a vessel containing a highly volatile liquid (e.g. LPG, Propylene etc) fails and the released large mass of vapor cloud gets ignited immediately. It has damage potential due to high intensity of radiation and generation of the overpressure waves, causing large scale damage to nearby equipment and structures.
3. Catastrophic failure of tanks/ pressurized vessels, rotary equipment and valves etc. can result in equipment fragments flying and hitting other equipment of the plant.
4. Release of toxic compounds results in the toxic vapour cloud traveling over long distances, affecting a large area, before it gets sufficiently diluted to harmless concentration in the atmosphere.
5. The material is in two phases inside the containment - liquid & vapor. Depending on the location of the leak liquid or vapor will be released from the containment. If vapor is released a vapor cloud will form by the mixing of the vapor and air. The size of the vapor cloud will depend on the rate of release, wind speed; wind direction & atmospheric stability will determine the dispersion and movement of the vapor cloud.
6. If liquid is released there will be some flashing as the boiling point of liquid is below the Ambient temperature. The vapor formed by immediate flashing will behave as vapors release. The liquid will fall on the ground forming a pool. There will be vaporization from the pool due to the heat gained from the atmosphere & ground.
7. There will be dispersion and movement of vapor cloud formed by evaporation of liquid.

The behavior of material released by loss of containment depends on the following factors:

1. Physical properties of the material
2. Conditions of material in containment (pressure and temperature)
3. Phase of material released (liquid or gas)
4. Inventory of material released
5. Weather parameters (temperature, humidity, wind speed, atmospheric stability)
6. Material with boiling point below Ambient condition.

11. CONSEQUENCE ANALYSIS RESULTS

We have considered below QRA results. The Consequence result tables along with their graphs and maps are shown in the report ahead.

Note: Since Acetic Acid (FP=39-40°C) is not available in the software library hence N-Butyl Acrylate (FP=38.85°C) is used.

Acetic Acid Tank

Table 11.1: Damage Distances

Scenario details		Catastrophic Rupture (m)			100 mm leak (m)			25 mm leak (m)		
Weather Category		1.5 F	3 D	1.5 F	1.5 F	3 D	5 D	1.5 F	3 D	5 D
Flash Fire Envelope										
Furthest Extent (ppm)	7500	46.44	4.9	4.8	10.75	8.85	6.79	6.27	2.32	2.36
	15000	5.23	4.90	4.79	5.61	4.39	2.91	2.77	2.29	2.33
Thermal Damage Distance by Late Pool Fire										
Radiation Intensity (kW/m ²)	4	72.9	80.44	85.25	74.22	81.90	86.74	49.51	54.43	57.30
	12.5	32.69	33.64	34.58	34.09	35.22	36.24	21.42	23.11	24.24
	37.5	Not reached	Not reached	Not reached	Not reached	Not reached	Not reached	Not reached	Not reached	Not reached
Thermal Damage Distance by Jet Fire										
Radiation Intensity (kW/m ²)	4	No Hazard	No Hazard	No Hazard	7.34	6.80	6.22	Not Reached	Not Reached	Not Reached
	12.5	No Hazard	No Hazard	No Hazard	6.03	5.13	4.70	Not Reached	Not Reached	Not Reached
	37.5	No Hazard	No Hazard	No Hazard	Not Reached	Not Reached	3.43	Not Reached	Not Reached	Not Reached
Maximum Distance at Overpressure Level (m)										
Overpressure (bar)	0.02068	No Hazard	No Hazard	No Hazard	24.91	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
	0.1379	No Hazard	No Hazard	No Hazard	13.86	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard

Scenario details		Catastrophic Rupture (m)			100 mm leak (m)			25 mm leak (m)		
		1.5 F	3 D	1.5 F	1.5 F	3 D	5 D	1.5 F	3 D	5 D
	0.2068	No Hazard	No Hazard	No Hazard	12.99	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard

Acetone Tank

Table 11.2: Damage Distances

Scenario details		Catastrophic Rupture (m)			100 mm leak (m)			25 mm leak (m)		
		1.5 F	3 D	1.5 F	1.5 F	3 D	5 D	1.5 F	3 D	5 D
Flash Fire Envelope										
Furthest Extent (ppm)	13000	81.20	68.12	60.75	70.27	38.88	29.80	28.58	19.83	17.70
	26000	51.76	46.47	42.19	52.57	23.29	17.12	20.24	9.45	11.46
Thermal Damage Distance by Late Pool Fire										
Radiation Intensity (kW/m ²)	4	156.88	158.66	158.88	147.513	146.986	146.35	70.03	65.13	66.66
	12.5	97.12	101.45	103.09	91.91	94.67	95.68	43.62	43.41	43.32
	37.5	54.24	61.85	67.72	51.72	58.08	63.27	22.50	23.75	25.25
Thermal Damage Distance by Jet Fire										
Radiation Intensity (kW/m ²)	4	No hazard	No hazard	No hazard	34.55	31.77	29.22	10.41	9.36	8.55
	12.5	No hazard	No hazard	No hazard	28.28	23.63	25.87	8.60	7.50	6.71
	37.5	No hazard	No hazard	No hazard	Not Reached	20.03	21.72	Not Reached	5.66	Not Reached
Maximum Distance at Overpressure Level (m)										
Overpressure (bar)	0.02068	167.26	127.10	112.45	242.653	85.54	63.12	75.08	29.89	23.67
	0.1379	94.31	70.82	62.17	114.70	43.86	31.16	34.44	15.15	13.54
	0.2068	88.81	68.37	59.42	104.59	40.73	28.64	31.18	13.99	12.74

Methanol Tanker

Table 11.3: Damage Distances

Scenario details		Catastrophic Rupture (m)			100 mm leak (m)			25 mm leak (m)		
		1.5 F	3 D	1.5 F	1.5 F	3 D	5 D	1.5 F	3 D	5 D
Flash Fire Envelope										
Furthest Extent (ppm)	36500	161.08	37.53	35.76	39.29	16.71	14.14	12.70	9.72	5.94
	73000	92.73	17.26	19.54	10.06	8.30	6.89	6.31	4.44	2.84
Thermal Damage Distance by Late Pool Fire										
Radiation Intensity (kW/m ²)	4	81.14	82.02	82.71	80.70	81.26	81.82	46.07	45.47	45.50
	12.5	52.15	55.65	57.63	52.42	57.59	55.70	29.47	31.07	32.10
	37.5	32.39	32.09	31.98	33.18	32.87	32.76	18.93	18.38	18.23
Thermal Damage Distance by Jet Fire										
Radiation Intensity (kW/m ²)	4	No Hazard	No Hazard	No Hazard	22.41	20.83	19.02	7.32	6.39	5.16
	12.5	No Hazard	No Hazard	No Hazard	Not Reached	17.41	16.05	Not Reached	Not Reached	Not Reached
	37.5	No Hazard	No Hazard	No Hazard	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
Maximum Distance at Overpressure Level (m)										
Overpressure (bar)	0.02068	149.98	39.52	43.70	69.30	28.65	24.19	18.74	Not Reached	Not Reached
	0.1379	109.74	24.84	26.14	40.18	14.83	13.67	12.26	Not Reached	Not Reached
	0.2068	107.53	23.75	24.75	37.87	13.73	12.84	11.75	Not Reached	Not Reached

Note: Since Acetyl Chloride (FP=4.4°C) is not available in the software library hence Toluene (FP=4°C) is used.

Acetyl Chloride Drum

Table 11.4: Damage Distances

Scenario details		16 mm leak (m)		
Weather Category		1.5 F	3 D	5 D
Flash Fire Envelope				
Furthest Extent (ppm)	6000	6.68	1.86	1.95
	12000	2.43	1.82	1.92
Thermal Damage Distance by Late Pool Fire				
Radiation Intensity (kW/m ²)	4	26.20	27.44	28.31
	12.5	15.55	17.94	19.37
	37.5	6.34	7.11	7.65
Thermal Damage Distance by Jet Fire				
Radiation Intensity (kW/m ²)	4	1.80	1.61	1.49
	12.5	Not Reached	Not Reached	Not Reached
	37.5	Not Reached	Not Reached	Not Reached
Maximum Distance at Overpressure Level (m)				
Overpressure (bar)	0.02068	No Hazard	No Hazard	No Hazard
	0.1379	No Hazard	No Hazard	No Hazard
	0.2068	No Hazard	No Hazard	No Hazard

Ammonia Cylinders

Table 11.5: Damage Distances

Scenario details		Catastrophic Rupture (m)			22 mm leak (m)		
Weather Category		1.5 F	3 D	5 D	1.5 F	3 D	5 D
Flash Fire Envelope							
Furthest Extent (ppm)	80000	4.3	6.2	5.16	28.72	26.07	27.05
	160000	3.16	3.81	3.44	11.89	10.65	11.35
Thermal Damage Distance by Late Pool Fire							
Radiation Intensity (kW/m ²)	4	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
	12.5	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
	37.5	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard	No Hazard
Thermal Damage Distance by Jet Fire							
Radiation Intensity (kW/m ²)	4	No Hazard	No Hazard	No Hazard	91.66	73.68	80.81
	12.5	No Hazard	No Hazard	No Hazard	79.69	62.56	69.55
	37.5	No Hazard	No Hazard	No Hazard	Not Reached	Not Reached	Not Reached
Thermal Damage Distance by Fireball Ellipse							
Radiation Intensity (kW/m ²)	4	35.37	35.37	35.37	35.37	35.37	35.37
	12.5	13.18	13.18	13.18	13.18	13.18	13.18
	37.5	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
Maximum Distance at Overpressure Level (m)							
Overpressure (bar)	0.02068	No Hazard	No Hazard	No Hazard	41.99	39.99	40.84
	0.1379	No Hazard	No Hazard	No Hazard	25.69	25.17	25.39
	0.2068	No Hazard	No Hazard	No Hazard	24.40	24	24.17

Note: Since Ethylene Dichloride (FP=12.8°C) is not available in the software library hence Ethanol (FP=12.85°C) is used.

Ethylene Dichloride Drum

Table 11.6: Damage Distances

Scenario details		16 mm leak (m)		
Weather Category		1.5 F	3 D	5 D
Flash Fire Envelope				
Furthest Extent (ppm)	21500	1.67	1.84	1.92
	43000	1.64	1.80	1.89
Thermal Damage Distance by Late Pool Fire				
Radiation Intensity (kW/m ²)	4	17.17	17.76	18.14
	12.5	10.92	12.13	12.85
	37.5	5.98	6.12	6.33
Thermal Damage Distance by Jet Fire				
Radiation Intensity (kW/m ²)	4	Not Reached	Not Reached	Not Reached
	12.5	Not Reached	Not Reached	Not Reached
	37.5	Not Reached	Not Reached	Not Reached
Maximum Distance at Overpressure Level (m)				
Overpressure (bar)	0.02068	No Hazard	No Hazard	No Hazard
	0.1379	No Hazard	No Hazard	No Hazard
	0.2068	No Hazard	No Hazard	No Hazard

Isopropyl Alcohol Drum

Table 11.7: Damage Distances

Scenario details		16 mm leak (m)		
Weather Category		1.5 F	3 D	5 D
Flash Fire Envelope				
Furthest Extent (ppm)	10000	1.67	1.86	1.94
	20000	1.66	1.83	1.92
Thermal Damage Distance by Late Pool Fire				
Radiation Intensity (kW/m ²)	4	20.32	21.02	21.38
	12.5	12.94	14.21	14.91
	37.5	5.98	6.35	6.71
Thermal Damage Distance by Jet Fire				
Radiation Intensity (kW/m ²)	4	Not Reached	1.43	Not Reached
	12.5	Not Reached	Not Reached	Not Reached
	37.5	Not Reached	Not Reached	Not Reached
Maximum Distance at Overpressure Level (m)				
Overpressure (bar)	0.02068	No Hazard	No Hazard	No Hazard
	0.1379	No Hazard	No Hazard	No Hazard
	0.2068	No Hazard	No Hazard	No Hazard

N-Hexane Barrel

Table 11.8: Damage Distances

Scenario details		15 mm leak (m)		
Weather Category		1.5 F	3 D	5 D
Flash Fire Envelope				
Furthest Extent (ppm)	5250	1.62	1.82	1.93
	10500	1.61	1.79	1.91
Thermal Damage Distance by Late Pool Fire				
Radiation Intensity (kW/m ²)	4	26.62	27.64	28.47
	12.5	15.47	17.95	19.46
	37.5	6.17	7.03	7.60
Thermal Damage Distance by Jet Fire				
Radiation Intensity (kW/m ²)	4	4.63	4.22	3.90
	12.5	3.27	2.82	2.59
	37.5	Not Reached	Not Reached	Not Reached
Maximum Distance at Overpressure Level (m)				
Overpressure (bar)	0.02068	No Hazard	No Hazard	No Hazard
	0.1379	No Hazard	No Hazard	No Hazard
	0.2068	No Hazard	No Hazard	No Hazard

Toluene Barrel

Table 11.9: Damage Distances

Scenario details		15 mm leak (m)		
Weather Category		1.5 F	3 D	5 D
Flash Fire Envelope				
Furthest Extent (ppm)	6000	6.48	1.79	1.94
	12000	2.31	1.76	1.92
Thermal Damage Distance by Late Pool Fire				
Radiation Intensity (kW/m ²)	4	25.97	27.21	28.06
	12.5	15.44	17.80	19.21
	37.5	6.31	7.41	7.75
Thermal Damage Distance by Jet Fire				
Radiation Intensity (kW/m ²)	4	1.61	1.31	1.44
	12.5	Not Reached	Not Reached	Not Reached
	37.5	Not Reached	Not Reached	Not Reached
Maximum Distance at Overpressure Level (m)				
Overpressure (bar)	0.02068	No Hazard	No Hazard	No Hazard
	0.1379	No Hazard	No Hazard	No Hazard
	0.2068	No Hazard	No Hazard	No Hazard

Chlorine Tonner

Table 11.10: Damage Distances

Scenario details		Catastrophic Rupture (m)			35 mm leak (m)		
Weather Category		1.5 F	3 D	5 D	1.5 F	3 D	5 D
Distance to Concentration Results							
Concentration (ppm)	Average Timing	Distance (m)					
User Conc. (10)	1800 s	3360	1527.85	1710.09	29444	7064	5593

Consequences Maps & Graphs

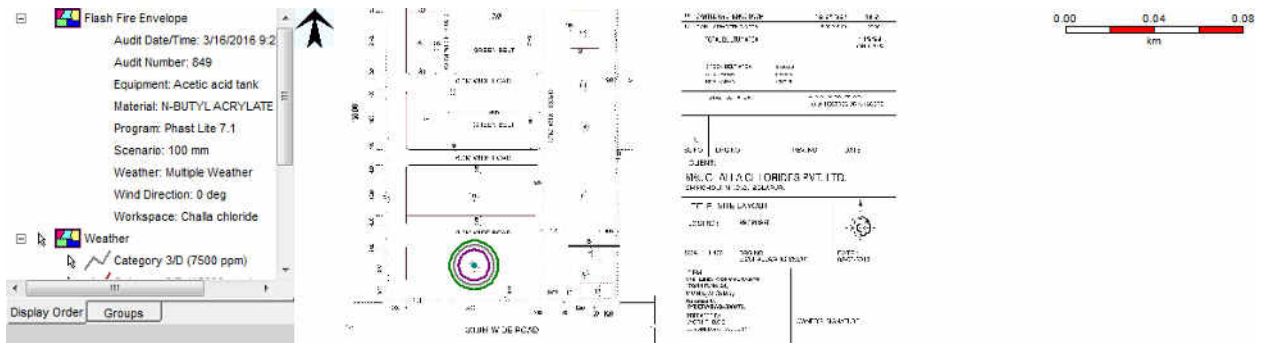


Fig.11.1 Flash fire of Acetic Acid by leak scenario (at 100 mm)

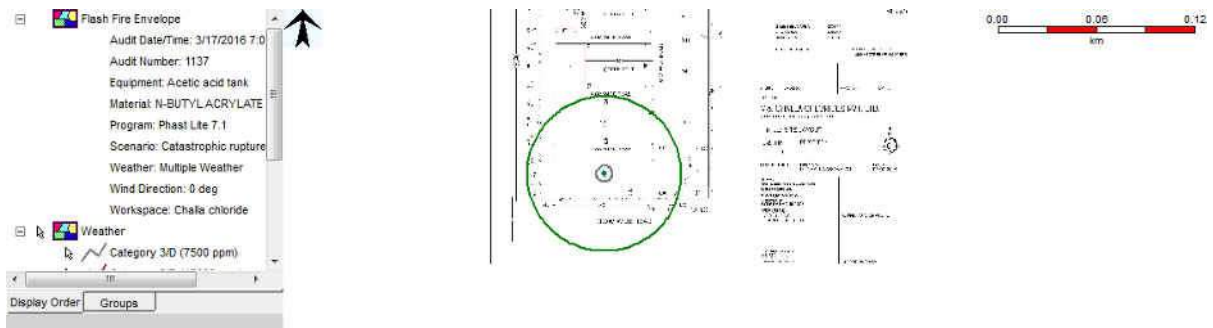


Fig.11.2 Flash fire of Acetic Acid by Catastrophic rupture

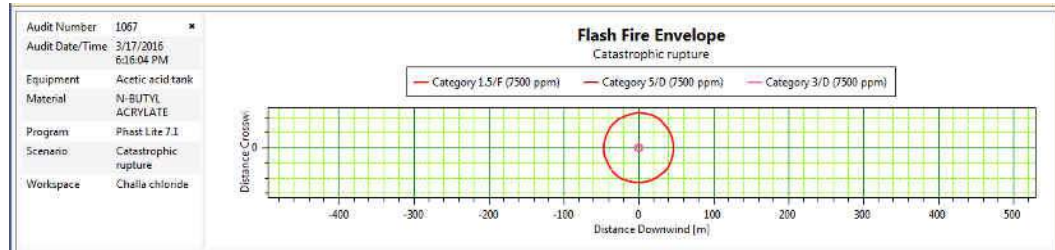


Fig. 11.3 Graph of total distance covered by flash fire

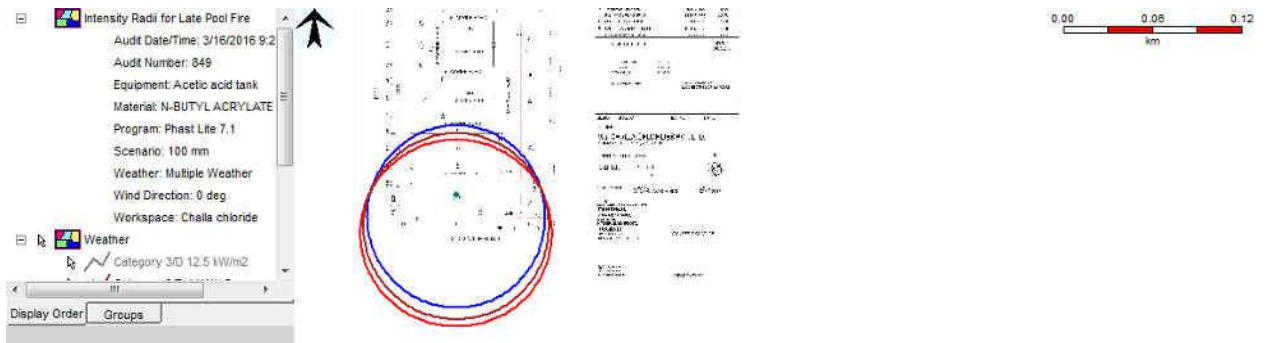


Fig. 11.4 Late Pool fire of Acetic Acid by Leak Scenario

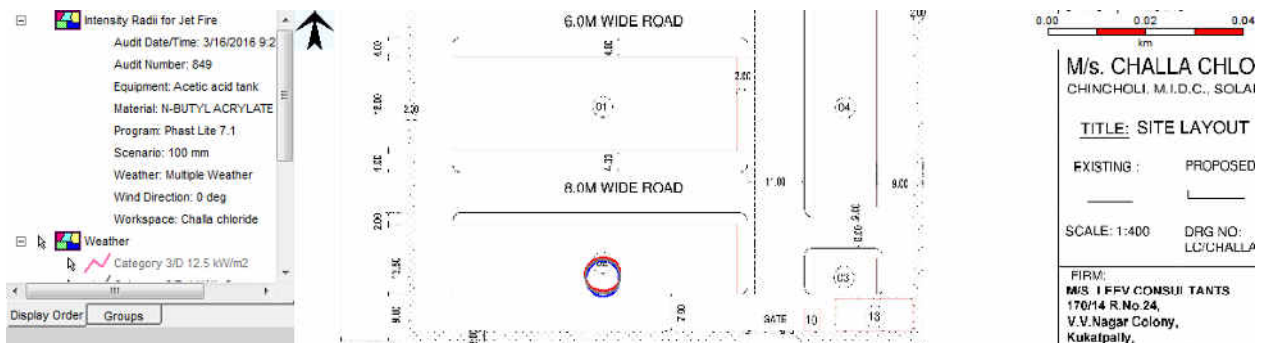


Fig. 11.5 Jet Fire of Acetic Acid by Leak Scenario

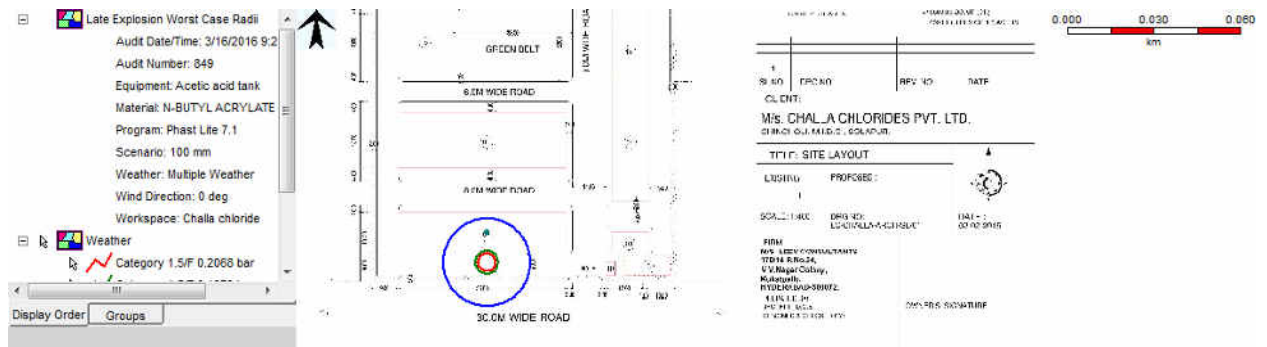


Fig. 11.6 Worst Case of Acetic Acid by Leak Scenario

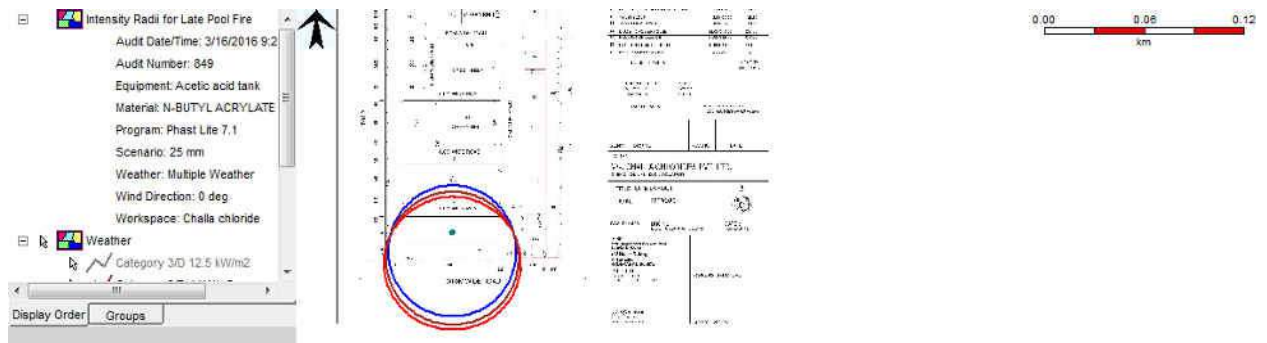


Fig. 11.7 Late Pool Fire of Acetic Acid by Leak Scenario (25 mm)

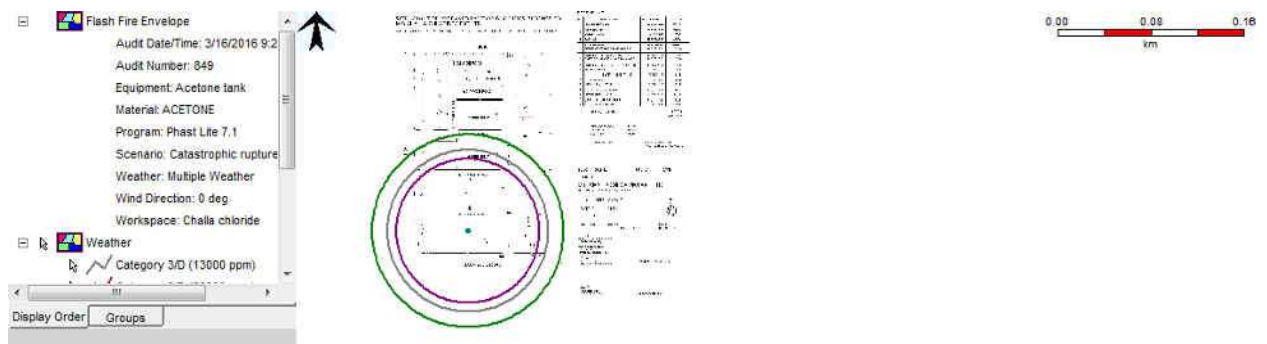


Fig. 11.8 Flash Fire of Acetone by Catastrophic rupture

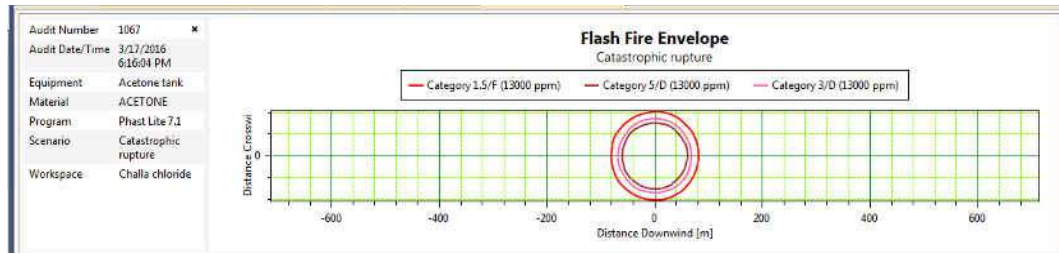


Fig. 11.9 Graph of total distance covered by flash fire

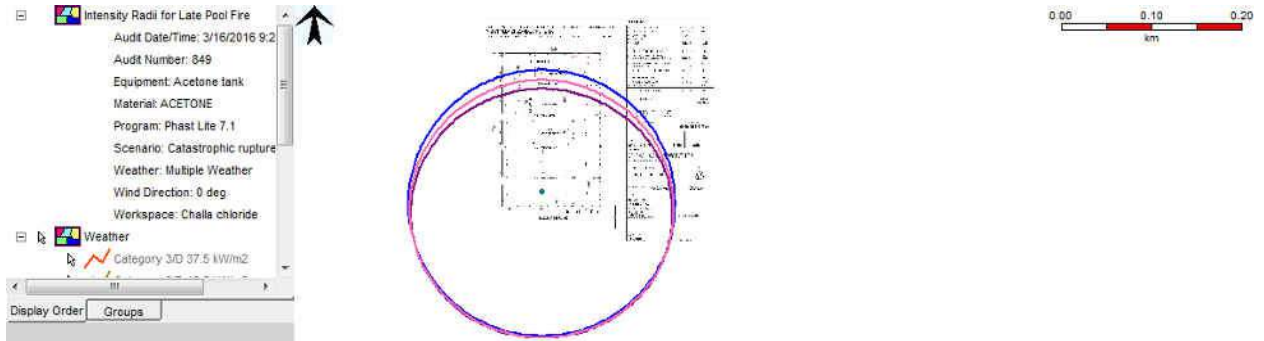


Fig. 11.10 Late Pool Fire of Acetone by Catastrophic rupture

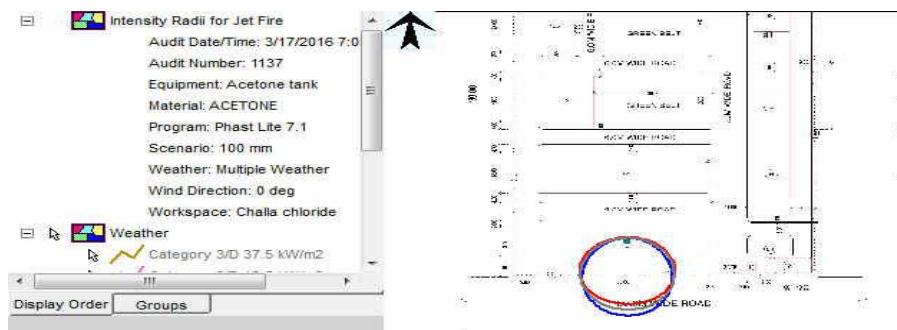


Fig. 11.11 Jet Fire of Acetone by Leak Scenario

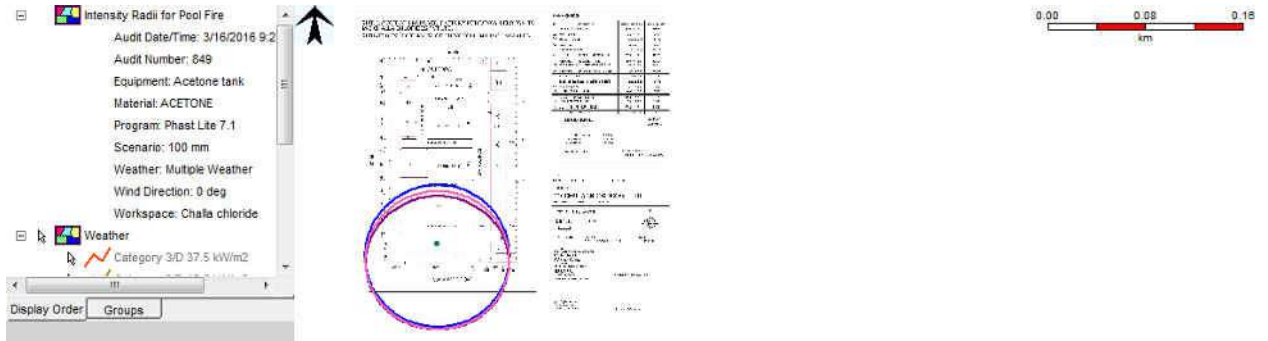


Fig.11.12 Pool Fire of Acetone by Leak Scenario

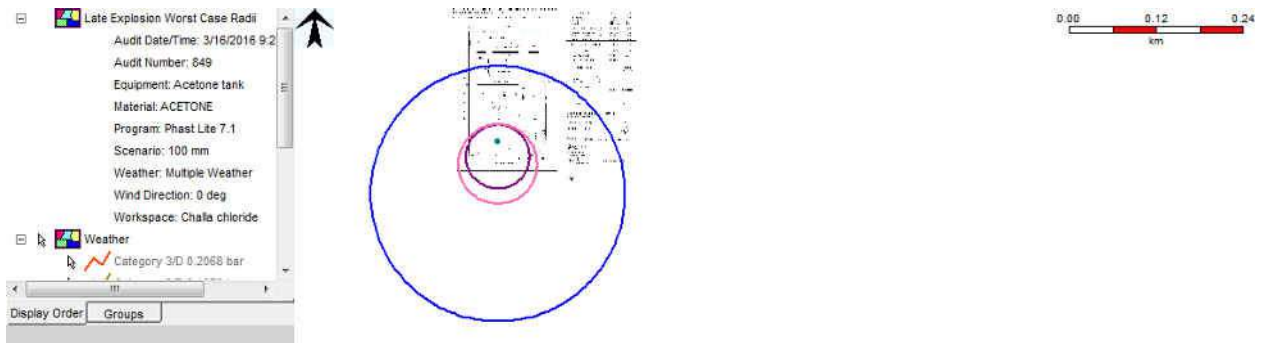


Fig.11.13 Worst case Of Acetone by Leak Scenario

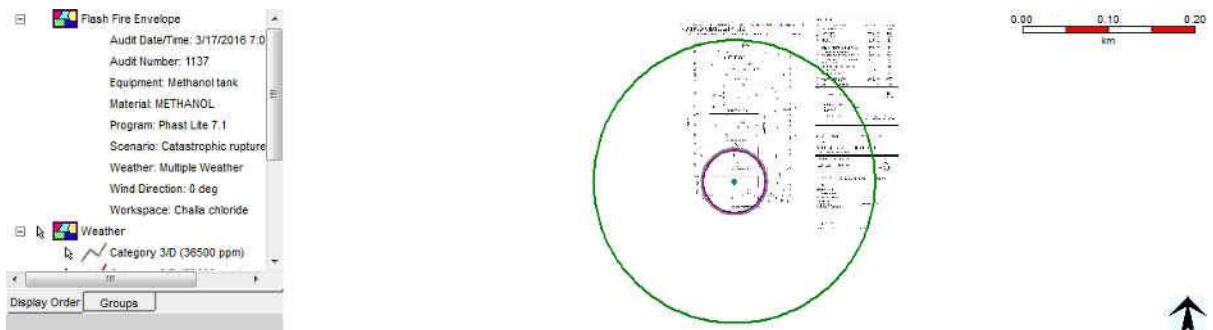


Fig. 11.14 Flash Fire of Methanol by Catastrophic Rupture

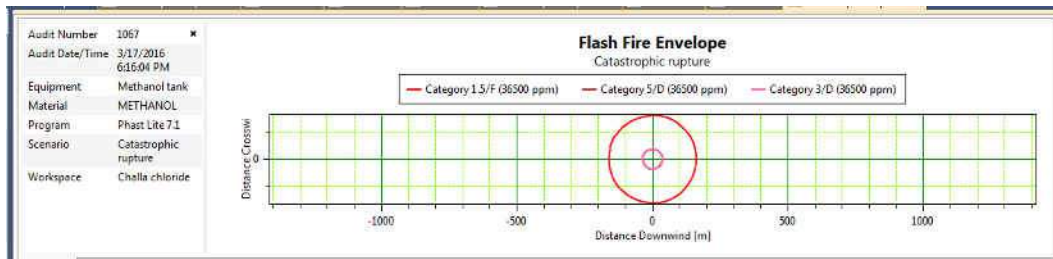


Fig. 11.15 Graph of total distance covered by flash fire

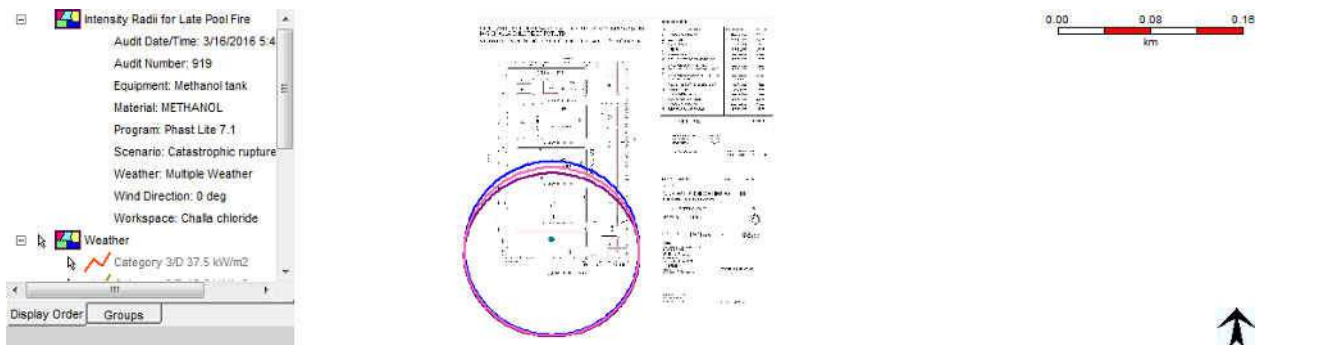


Fig.11.16 Late Pool Fire of Methanol by Catastrophic Rupture



Fig. 11.17 Jet Fire of Methanol by Leak Scenario

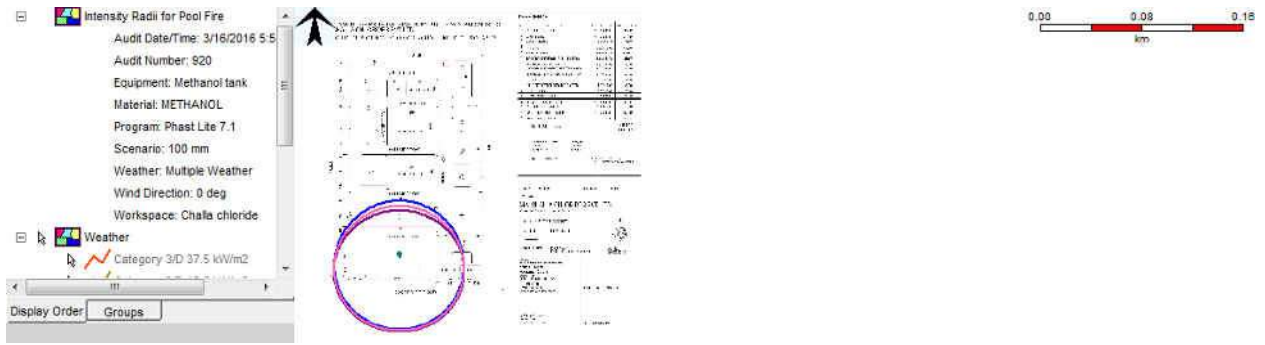


Fig.11.18 Pool Fire of Methanol by Leak Scenario

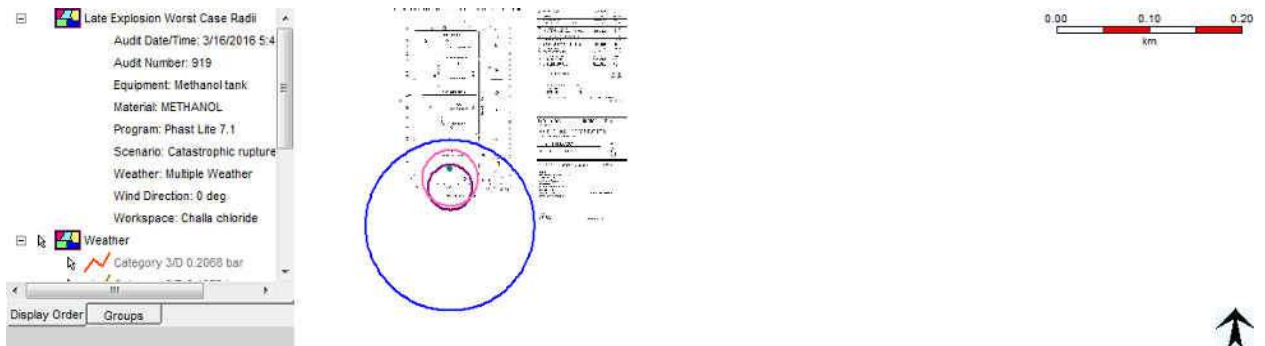


Fig.11.19 Worst Case Radii of Methanol by Catastrophic rupture

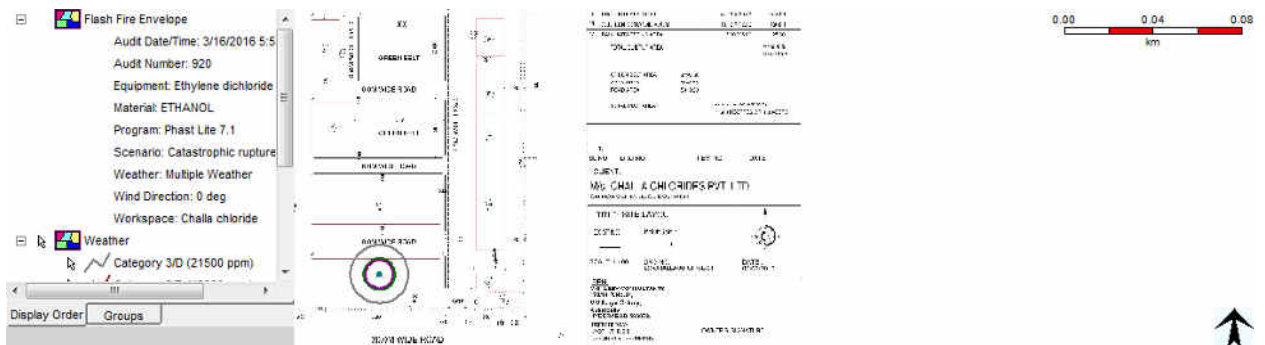


Fig.11.20 Flash Fire of Ethylene Dichloride by Catastrophic rupture

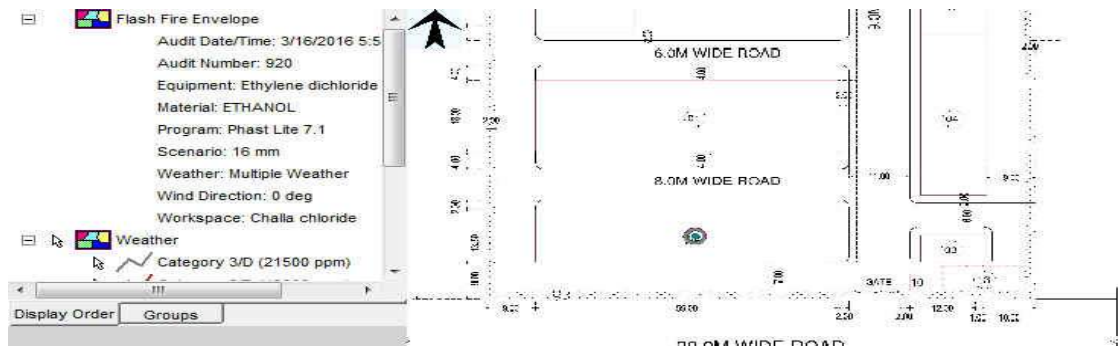


Fig. 11.21 Flash Fire of Ethylene Dichloride by Leak Scenario

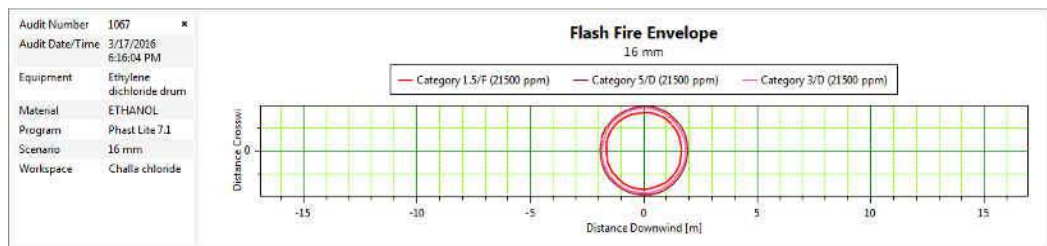


Fig.11.22 Graph of total distance covered by flash fire

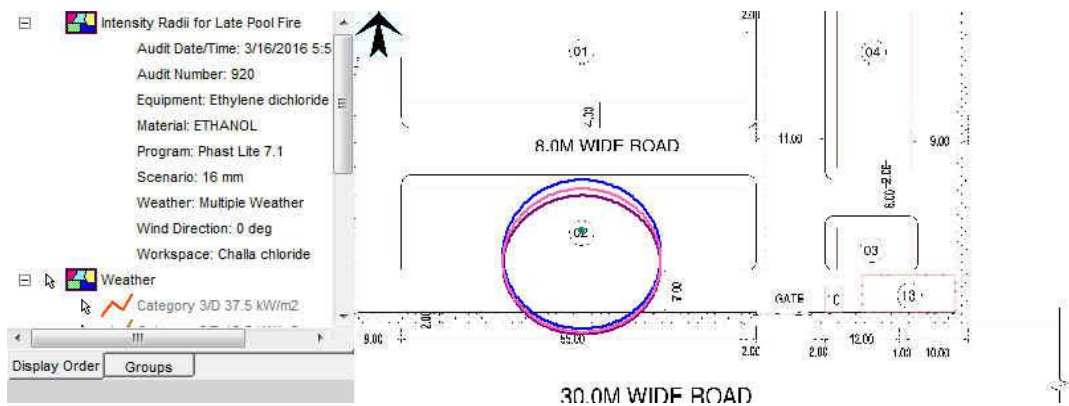


Fig.11.23 Late Pool Fire of Ethylene Dichloride by Leak Scenario

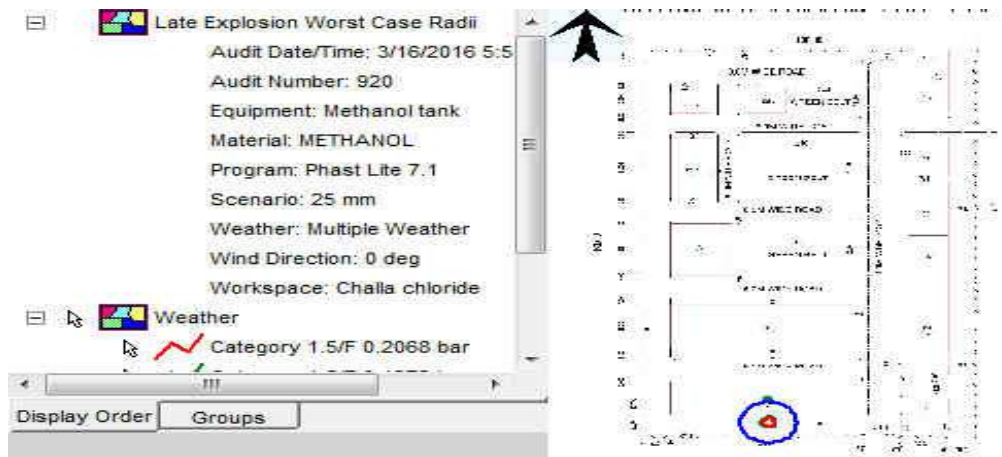


Fig.11.24 Worst case radii of Ethylene Dichloride by Leak Scenario

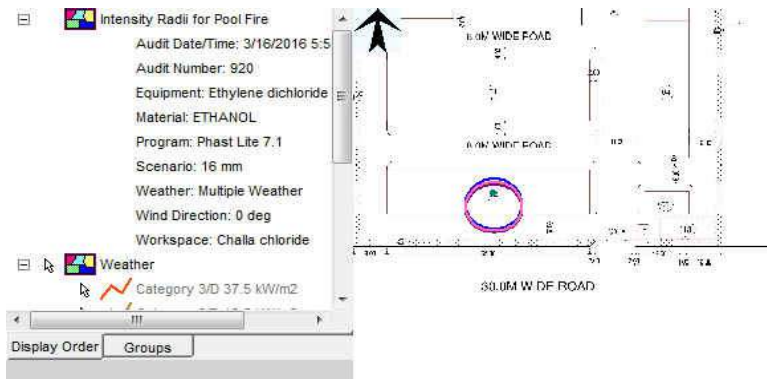


Fig.11.25 Pool Fire of Ethylene Dichloride by Leak Scenario



Fig.11.26 Flash Fire of Acetyl chloride by Catastrophic Rupture

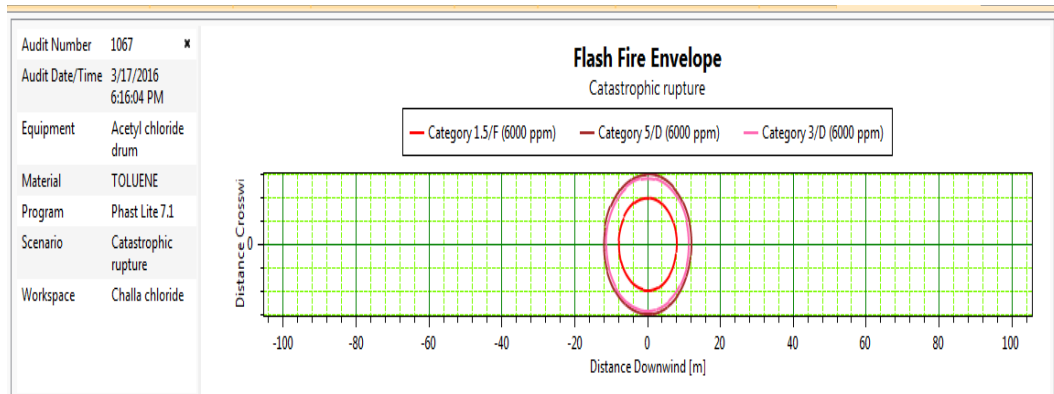


Fig.11.27 Graph of total distance covered by flash fire

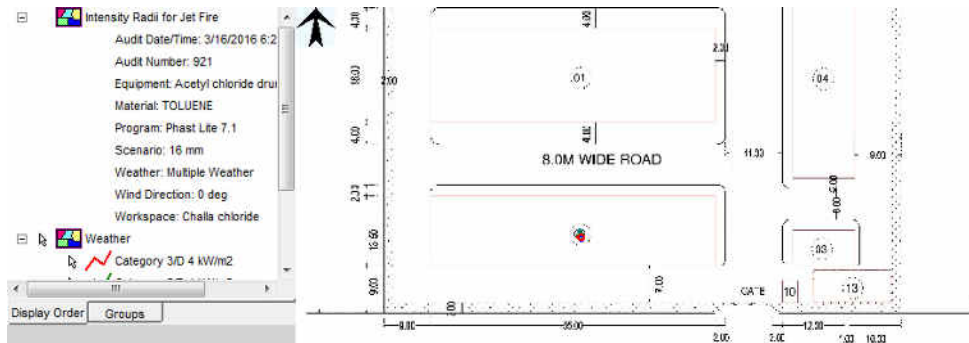


Fig.11.28 Jet Fire of Toluene by Leak Scenario

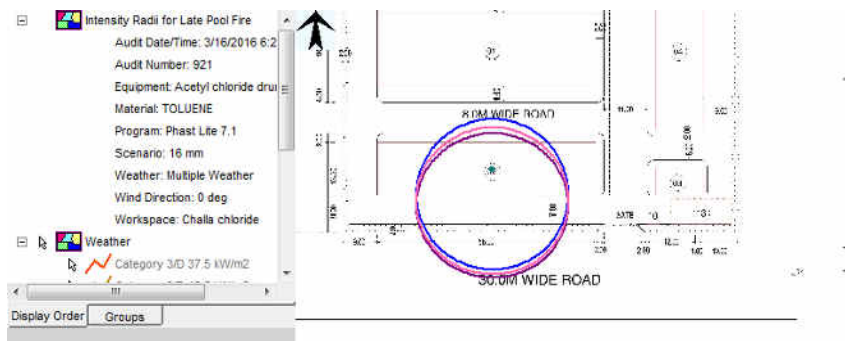


Fig.11.29 Late Pool Fire of Toluene by Leak Scenario

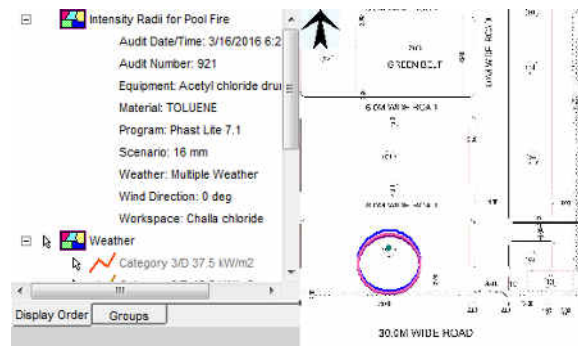


Fig.11.30 Pool Fire of Toluene by Leak Scenario

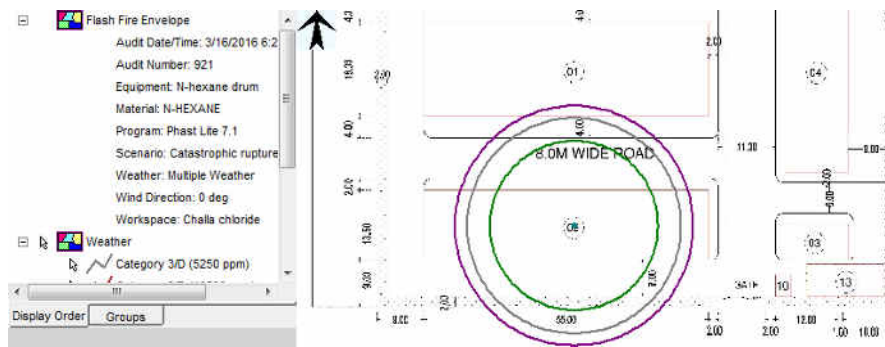


Fig.11.31 Flash Fire of N-Hexane by Catastrophic rupture

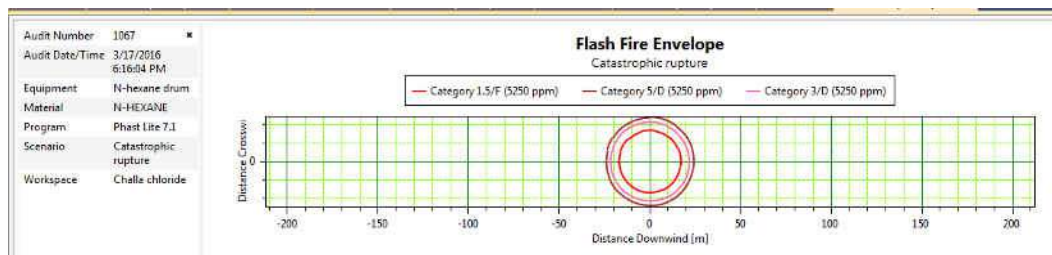


Fig. 11.32 Graph of total distance covered by flash fire

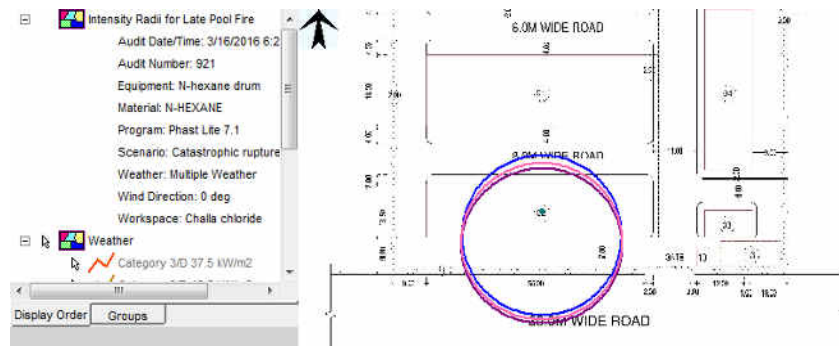


Fig.11.33 Late Pool Fire Of N-Hexane by Catastrophic rupture

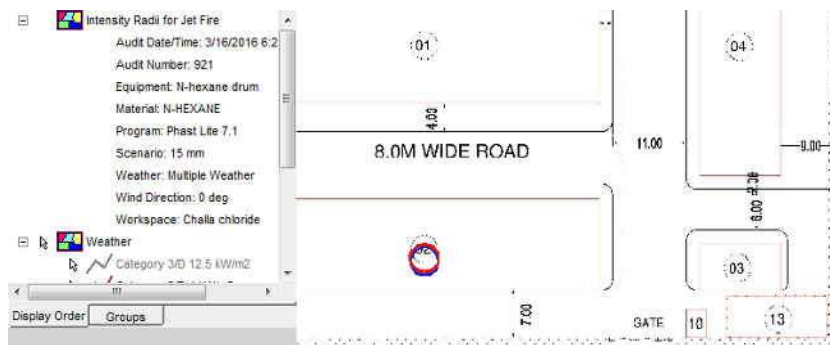


Fig.11.34 Jet Fire of N-Hexane by Catastrophic rupture

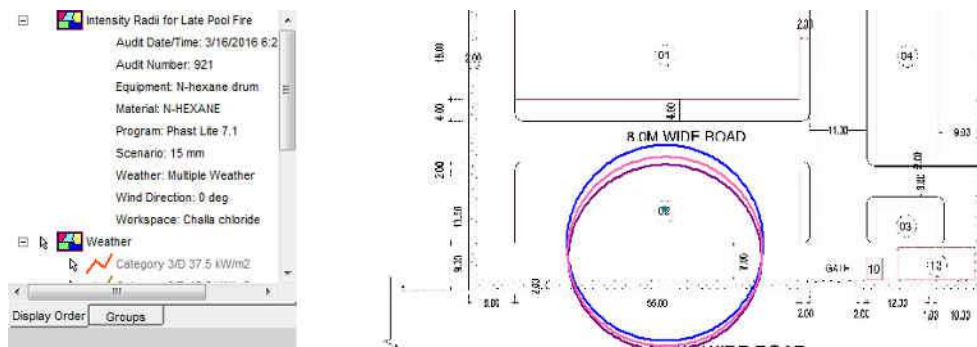


Fig.11.35 Late Pool Fire of N-Hexane by Leak Scenario

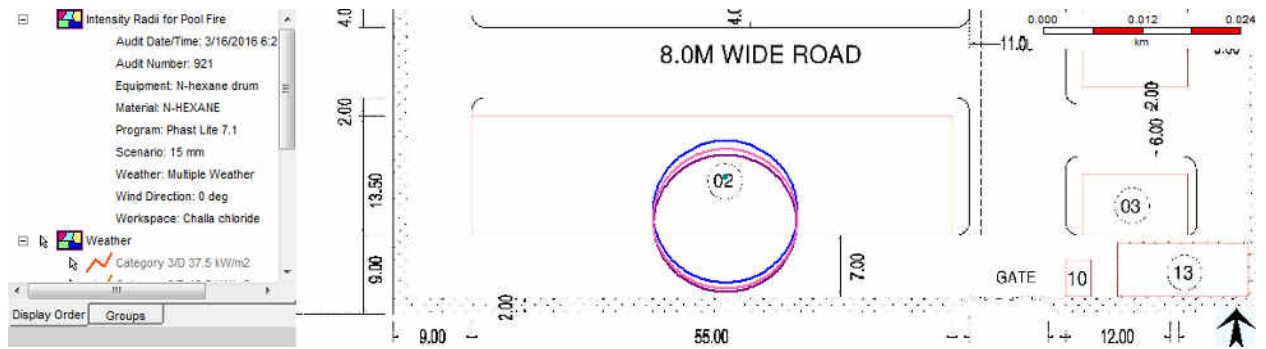


Fig.11.36 Pool Fire of N-Hexane by Leak Scenario

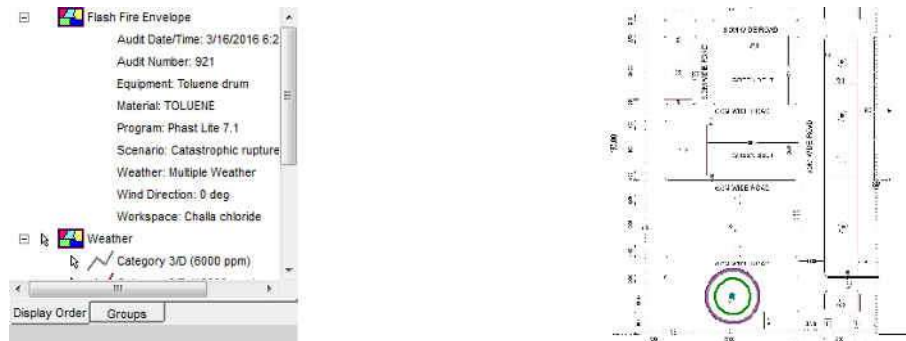


Fig.11.37 Flash Fire of Toluene by Catastrophic Rupture

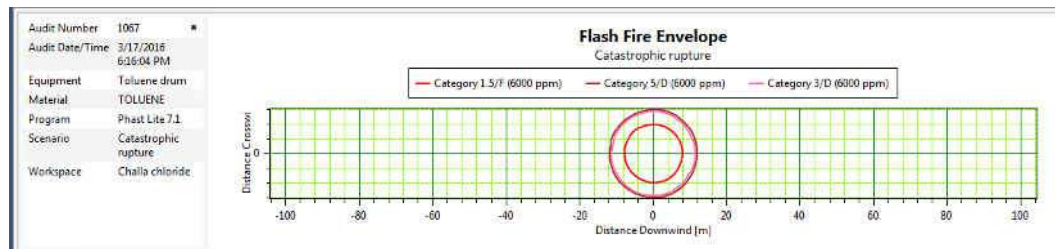


Fig. 11.37.1 Graph of total distance covered by flash fire

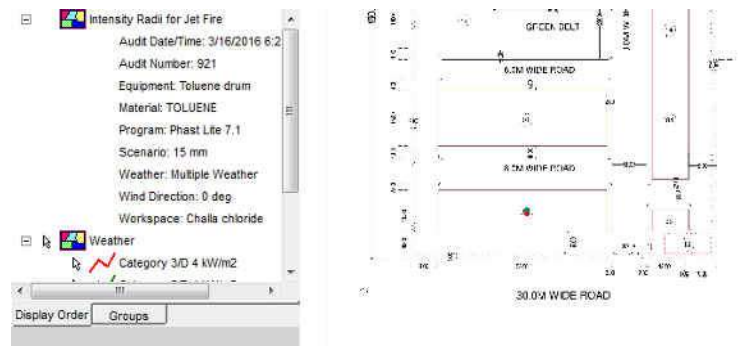


Fig.11.38 Jet Fire of Toluene by Leak Scenario

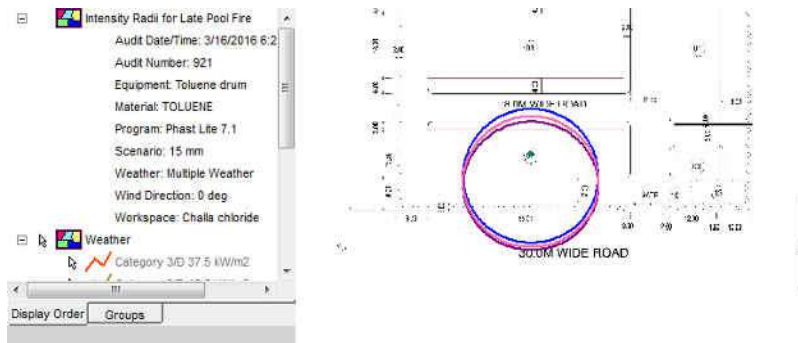


Fig.11.39 Late Pool Fire of Toluene by Leak Scenario

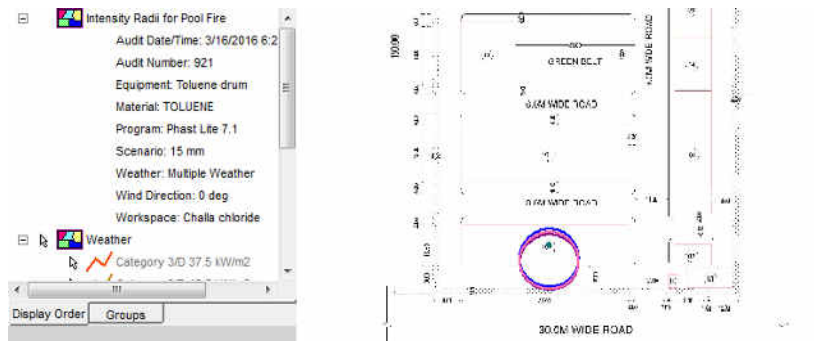


Fig.11.40 Pool Fire of Toluene by Leak Scenario

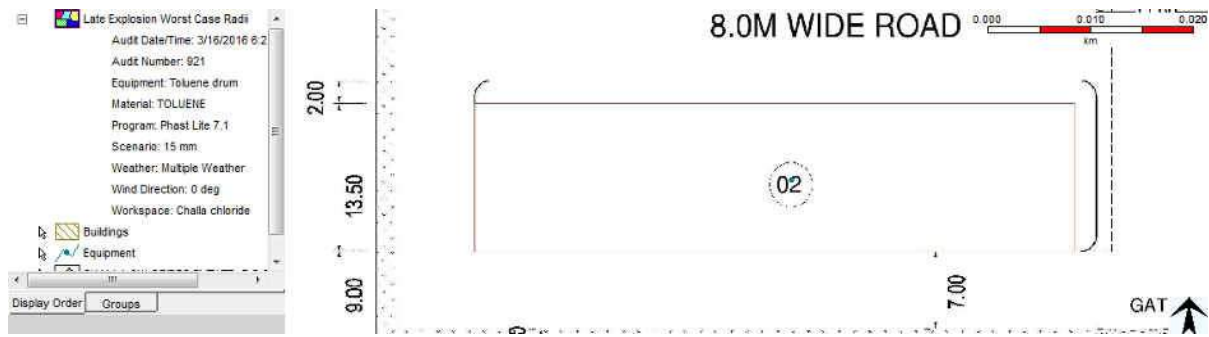


Fig.11.41 Worst case of Toluene by Leak Scenario

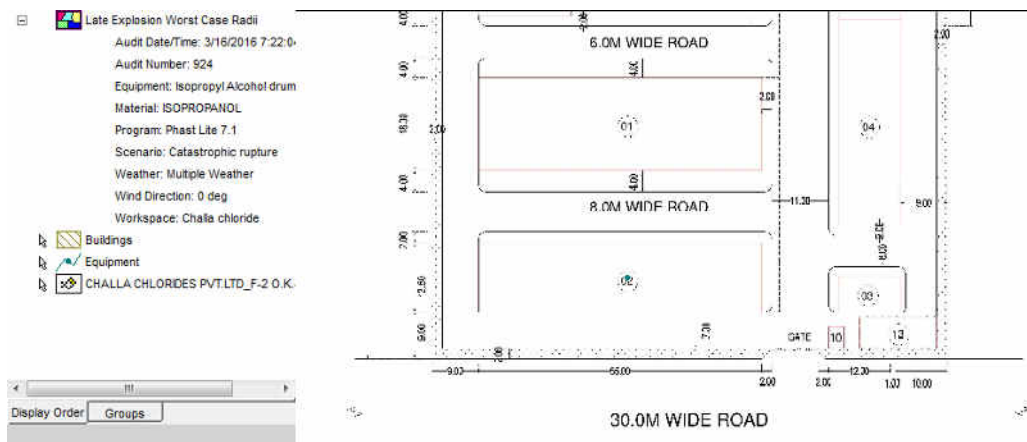


Fig.11.42 Worst case of Toluene by Leak Scenario

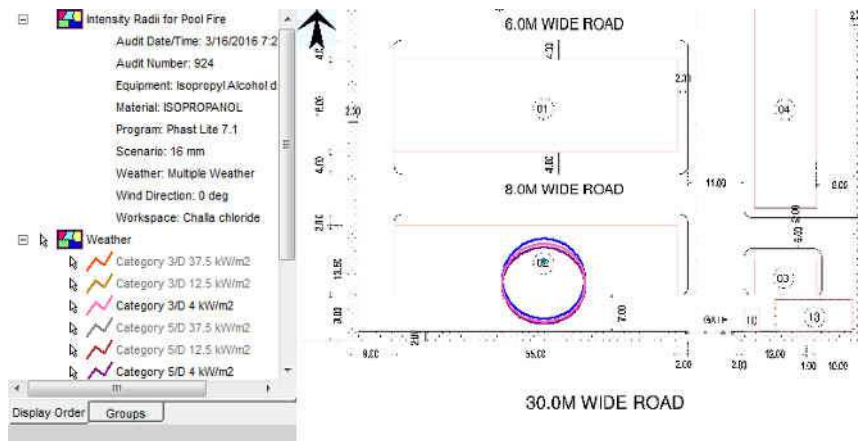


Fig.11.43 Pool Fire of Isopropyl Alcohol by Leak Scenario

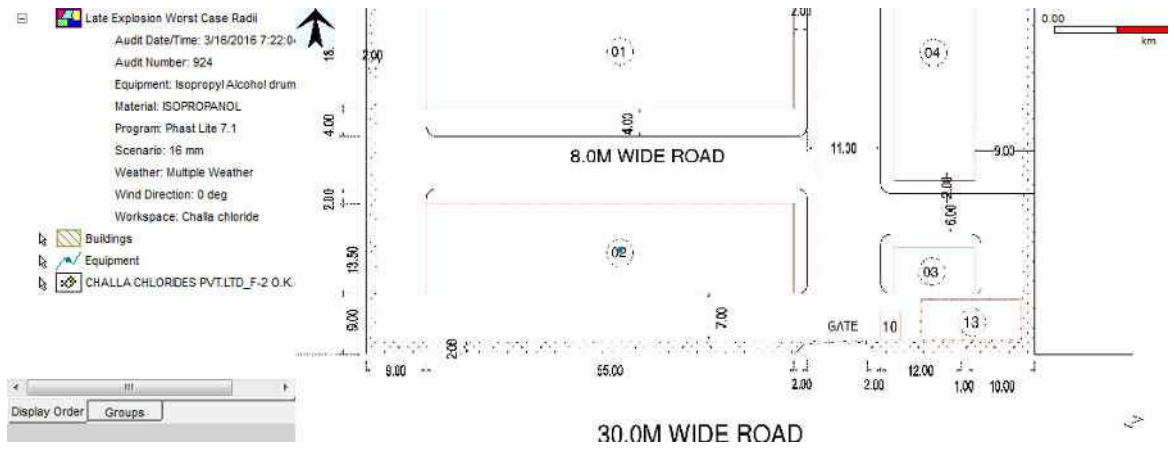


Fig.11.44 Worst case radii of Isopropyl Alcohol by Leak Scenario

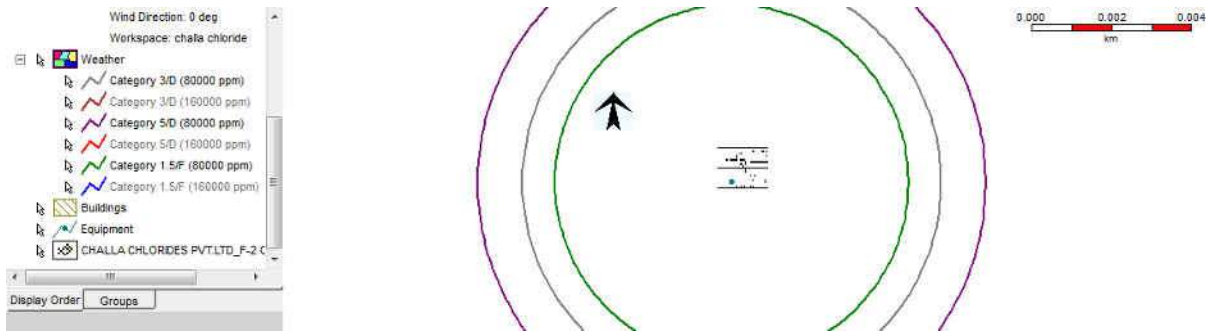


Fig.11.45 Flash Fire of Ammonia by Catastrophic Rupture

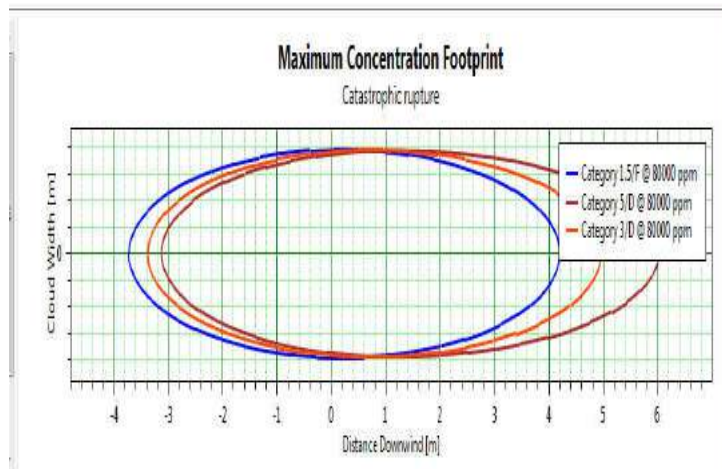


Fig. 11.46 Total distance covered by Ammonia tank by Catastrophic Rupture

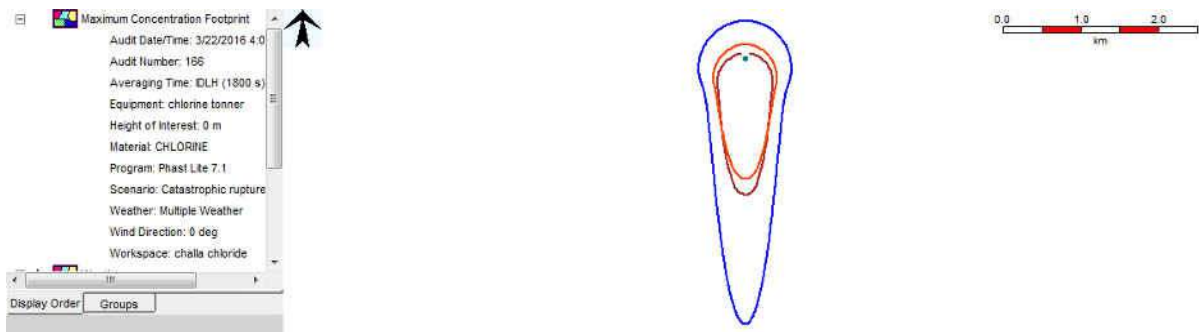


Fig. 11.47 maximum Concentration of Chlorine by Catastrophic Rupture

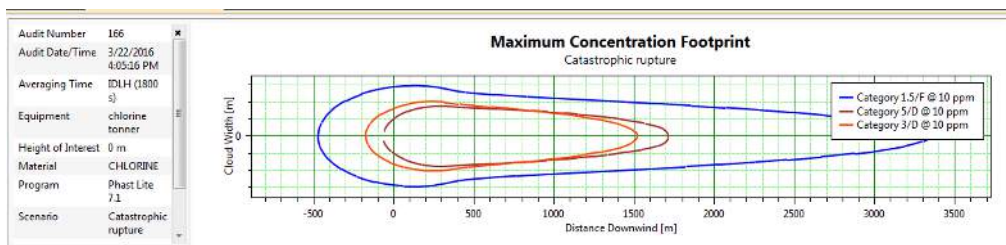


Fig. 11.48 Graph of total distance covered by Catastrophic Rupture

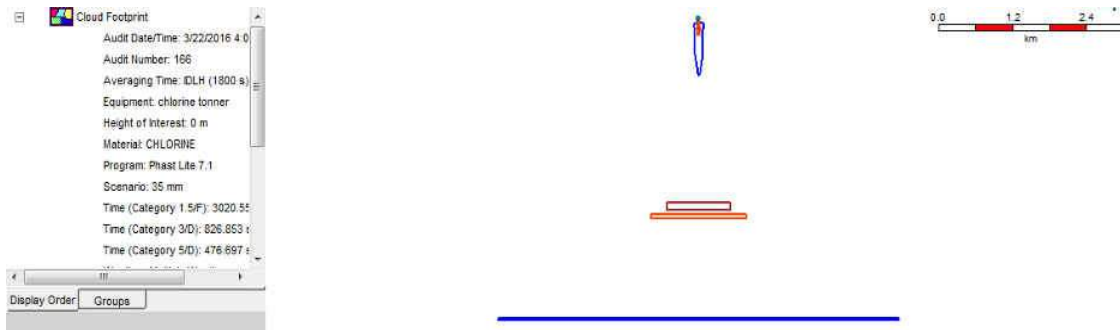


Fig.11.49 Maximum Concentration Footprint of Chlorine by Leak Scenario

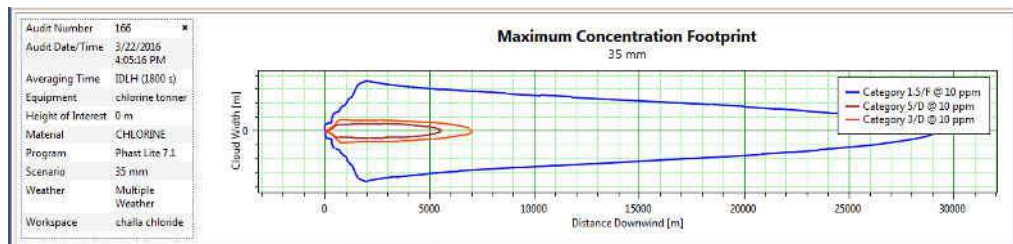


Fig.11.50 Maximum Concentration Footprint graph of Chlorine by Leak Scenario



12. CONCLUSION

- We have considered all possible scenarios for this project. We have found that major facility damage because of leak (100 mm). This will damage around facilities, associated assembly. It will major effect to Economic Property, Public & Environmental. But for controlling that effect, Challa Chloride should use Active, Passive & Process safe guards and Fire Fighting System.
- The Interlocking and tripping arrangements (Auto & Manual) to all critical equipments will reduce the chance of Leakage and spillage hence it will keep the employees & workers of the plant safe.
- M/s. Challa Chloride has been using fire fighting system, Smoke detection system, HC & O₂ Detectors (Portable Gas Detectors) system, etc for control or minimize of reduce major hazard.
- The organization should take timely corrective actions and is prepared for providing required resources to ensure appropriate corrective and preventive actions.
- To analyse the effect of leakages from tank hole of pipelines have been considered. The chances of occurrence of full bore failure are comparatively least case but we considered worst case for major fatality analysis.
- As per analysis major hazard will happen because of the thermal radiation level of 4 kW/m² from the point of release. The radiation hazard due to other intensity radiations that is 12.5 4 kW/m², 37.5 kW/m² also considered.
- During explosion of Acetone, major hazard located as within 242.653 meters are from the location of release.



13. RECOMMENDATIONS & MITIGATION MEASURES

1. Containers of chlorine shall be used on a first-in-first-out basis.
2. Water may not be used on Chlorine leaks because accelerated corrosion, resulting from the formation of hydrochloric acid when water is present, may quickly make the leak worse. Water spray or fog may, however, be used to help suppress the size of a chlorine cloud near the leak.
3. Ignition source should be prohibited.
4. Tanks should be coated with appropriate paints (e.g. epoxy paints) to reduce the chances of corrosion and leakages.
5. Valve maintenance should be performed on monthly basis to ensure effective operability and a random surprise inspection of the same should be done.
6. Health testing of the pipeline, tank, drum or tonner should be performed.
7. Preventive maintenance inspection schedule for pumps shall be observed as per equipment manual.
8. Fire prevention and code enforcement is one of the major areas of responsibility for the fire service.
9. Earthing and bonding should be provided for each tank farm & warehouse.
10. Fires extinguishers are present at all the tank farm and warehouse. Following fire fighting facilities can be used to tackle the fire:
 - Fire hydrant and monitor nozzle installation
 - Water fog and sprinkler system
 - Mobile Firefighting equipment
 - Tank deluge valve based water sprinkler system
 - Periodical mock drills should be conducted.
11. Emergency shut-down procedure to be strictly followed.
12. Good safety management, strict adherence to safety management procedures and competency assurance will reduce the risk.



14. CASE STUDIES

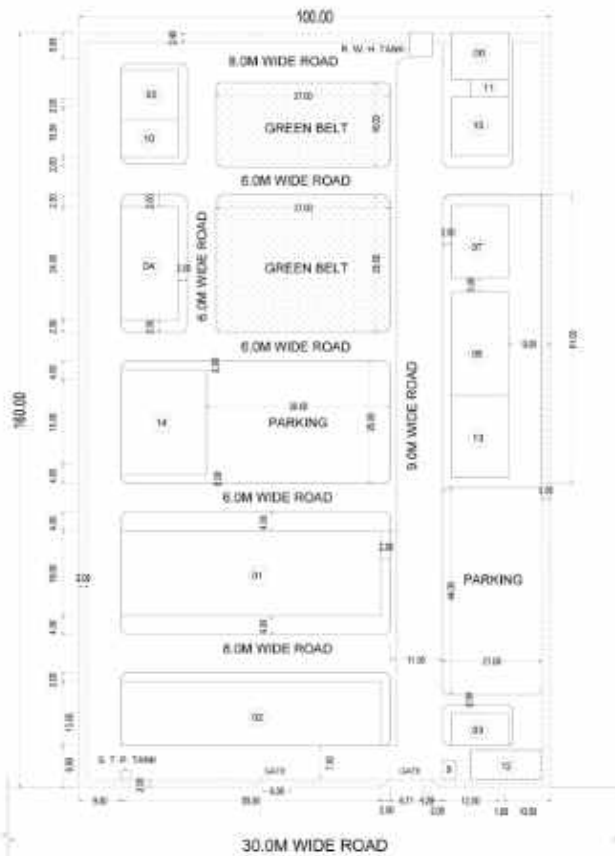
- **March 1967:** The Torrey Canyon supertanker was shipwrecked off the west coast of Cornwall, England, causing an environmental disaster. This was the first major oil spill at sea
- **March 16, 1978:** The Amoco Cadiz, a VLCC owned by the company Amoco (now merged with BP) sank near the northwest coast of France, resulting in the spilling of 68,684,000 US gallons of crude oil (1,635,000 barrels). This is the largest oil spill from an oil tanker in history.
- **March 24, 1989:** Exxon Valdez oil spill. The Exxon Valdez, an oil tanker bound for Long Beach, California, hit Prince William Sound's Bligh Reef, dumping an estimated minimum 10.8 million US gallons (40.9 million litres, or 250,000 barrels) of crude oil into the sea. It is considered to be one of the most devastating human-caused environmental disasters ever to occur.
- **July 6, 2013:** Lac-Mégantic, Quebec Canada. Lac-Mégantic derailment. Forty-seven people were killed when there was a derailment of an oil shipment train. The oil shipment caught fire and exploded, destroying more than thirty buildings. It was the fourth-deadliest rail accident in Canadian history
- **April 20, 2010:** Deepwater Horizon oil spill in the Gulf of Mexico. Eleven oil platform workers died in an explosion and fire that resulted in a massive oil spill in the Gulf of Mexico, considered the largest offshore spill in US history

15. REFERENCES

1. Quantitative Risk Assessment-M.J Borysiewiez, M.A. Borysiewiez, L.Garanty, A. Kozubal
2. Guideline for QRA from the- "PURPLE BOOK"
3. World Bank Technical papers relating to "Techniques for assessing Industrial Hazards".
4. Major Hazard Control by ILO.
5. Risk Management Program guidelines by EPA (US)
6. World Bank Technical Paper no. 55 – Technical Ltd. For assessing hazards – A Manual.
7. PHAST Software-By DNV

Annexure

SITE LAYOUT OF PROPOSED FACTORY BUILDINGS BELONGS TO M/S CHALLA CHLORIDES PVT.LTD. SITUATED IN PLOT NO. F2 OF CHINCHOLI, M.I.D.C., SOLAPUR.



REFERENCE

Sl.No.	DESCRIPTION	SIZE IN METRES	AREA (SQ.MT)
07	PRODUCTION BLOCK-A	30.00 X 18.00	540.00
08	WARE HOUSE	30.00 X 12.50	375.00
09	ROLLER HOUSE	12.00 X 9.75	117.00
04	UTILITIES BLOCK	12.00 X 24.00	288.00
05	EFFLUENT STORAGE TANK AREAS G.L.	12.00 X 10.00	120.00
06	UNDERGROUND WATER TANK	12.00 X 10.00	120.00
07	UNDERGROUND CHEMICALS TANK YARD	12.00 X 15.00	180.00
08	UNDERGROUND SOLVENTS TANK YARD	12.00 X 22.00	264.00
09	SECURITY ROOM	3.00 X 4.00	12.00
10	MULTIEFFECT EVAPORATOR SYSTEM	12.00 X 9.00	108.00
11	TOILET BLOCK	8.00 X 3.00	24.00
12	TRANSFORMER YARD	9.00 X 10.00	90.00
13	COLLET & POWER HOUSE	12.00 X 17.25	207.00
14	PRODUCTION BLOCK-B	37.00 X 29.00	1073.00
15	CANTEN & CHANGE ROOM	12.00 X 12.50	150.00

TOTAL MULTIP AREA	= 4425.00 (SQ) 0.27 %
HAB HARVESTING AREA - 5.00 X 5.00 X 1.00 = 2500.00 Cub. Meter	
S. T. P. TANK - 1.70 X 1.70 X 1.30 = 3727.00 Cub. Meter	
(Permissible Of The Plot - 37.00 X 15.00 = 555.00	
37.00 X 29.00 = 1073.00	
GREEN BELT AREA = 2700.00	
OPEN AREA 2340.00	
ROAD AREA 3816.29	
PARKING AREA 188.00	
TOTAL PLOT AREA	= 10000.00 SQ.MT (OR) 1.000 HECTRES OR 4 FADERS

SL.NO	DRG.NO	REV. NO	DATE
CLIENT			
M/s. CHALLA CHLORIDES PVT. LTD. CHINCHOLI, M.I.D.C., SOLAPUR.			
TITLE: SITE LAYOUT			
EXISTING :	PROPOSED		
SCALE: 1:400	DRG NO: LC/CHALLA/ARCH/SL/01	DATE: 02-02-2015	
FIRM: M/S LEEV CONSULTANTS 17B/14 R.No.24, V.V.Nagar Colony, Kakatpally, HYDERABAD-500072.		OWNER'S SIGNATURE	
PREPARED BY: JYOTIK T. D.C.E. DESIGNED & CHECKED BY:		APPROVED BY	