Indian Oil

RISK ASSESSMENT (RA) REPORT

FOR

PROPOSED PRODUCT PIPELINE FROM PARADIP TO HYDRABAD

MCPL/EMD/PL 16-17/01/03

Prepared By

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter-1: Scope of Work and Execution Methodology

1.1 INTRODUCTION

Indian Oil Corporation Limited, a fortune 500 company, is a leading public sector undertaking (PSU) engaged in refining, transportation and marketing of petroleum products across the country. Pipelines division of IOCL owns and operates over 10,000 kms of cross country pipeline for transportation of crude oil, LPG and finished petroleum products across the country. Pipeline for transportation of crude oil and finished petroleum products to various consumption centres. Transportation through pipeline is the safest mode of transportation in comparison to other modes of transportation i.e. rail and roads. It is highly reliable, environment friendly, energy efficient and cost efficient.

This report contains the Risk Analysis study for the proposed pipeline from Paradip to Hyderabad. The study is broadly divided into the following:

- Identification of hazards
- Effects Estimation
- Consequence Analysis
- Risk Estimation
- Risk Reduction.

1.2 SCOPE OF STUDY

Mantec Consultants Pvt. Ltd, D-36, Sector-6, NOIDA (U.P.) was appointed for the purpose of carrying out the Risk Analysis study. The objective of the Risk Analysis study was to identify vulnerable zones, major risk contributing events, understand the nature of risk posed to nearby areas and form a basis for the Disaster Management Plan or DMP. In addition, the Risk Analysis study is also necessary to ensure compliance to statutory rules and regulations. The scope of work & methodology for the Risk Analysis study is described below:

1.3 EXECUTION METHODOLOGY

The methodology adopted for executing the assignment is briefly given below:

***Kick off meeting with IOCL*:** this was used to set the study basis, Objectives and related matters and also identify in detail the facilities to be covered in the QRA.

Study of IOCL operating parameters: this involved collection of pertinent project information on the operation process details such as Pipe dimensions, route, storing temperature and pressure and other details. The data so collected would ensure a more realistic picture for the risks subsequently identified and estimated

Identification of hazards- this includes estimation of possible hazards through a systematic approach. It typically covers identification and grouping of a wide ranging possible failure cases and scenarios. The scenario list was generated through generic methods for estimating potential failures (based on historical records worldwide and domestic accident data bases) and also based on IOCL's experience in operating the facilities.

Consequence Effects Estimation- this covers assessing the damage potential in terms of heat radiation,

Risk Analysis broadly comprises of the following steps:

I. Project Description
II. Identification of Hazards and Selection of Scenarios
III. Effects and Consequence Calculations
IV. Likelihood Estimation
V. Risk Summation
VI. Risk Mitigation Measures

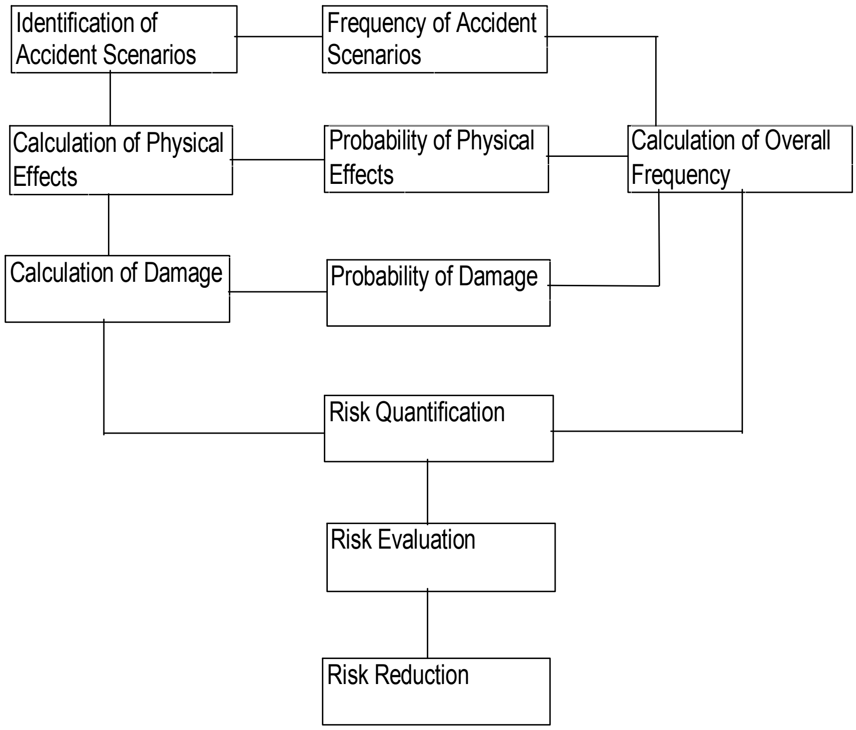


Fig 1.1 Risk Analysis Scheme

Chapter-2: Project Description

2.1 TYPE OF PROJECT

In order to cater the growing requirement of MS (Motor Spirit), HSD (High Speed Diesel) and SKO (Superior Kerosene Oil) and ATF (Aviation Turbine Fuel). IOCL has planned to lay pipeline facility from Paradip in Orissa to Hyderabad in Telangana. The basic activity of this proposed facility will be transportation of products through a pipeline which is intended to be laid from Paradip to Hyderabad. Various pump stations and delivery stations are thus an intermediary in this pipeline route.

Proposed Paradip-Hyderabad product Pipeline will be constructed with the prime objective of transporting of MS, HSD, SKO and ATF in a totally safe and reliable manner.

Other facilities of the proposed project will include, pipeline system configuration, control system and cathodic protection etc. for Paradip-Hyderabad in Telangana product Pipeline Project.

2.2 LOCATION

The proposed pipeline is originating from Paradip in Orissa and traversing through Berhampur, Vizag and then to Rajamundhry, Vijayawada and Hyderabad in Telangana.

The general topography of the area is undulate flat and the general elevation of the site varies from district to district.

2.3 PIPELINE DESCRIPTION

The proposed pipeline would originate from pumping station at Paradip and then it would follow an independent pipeline route towards Southern direction almost more or less parallel to existing NH-5 up to Visakhapattanam terminal. Thereafter, the pipeline would traverse South-Western direction parallel to existing NH-5 up to Rajahmundry terminal. From Rajahmundry, the pipeline would traverse South-Western direction further for an approximately 150 km up to Vijayawada terminal more or less following the parallel route of existing NH-5. From Vijayawada onwards, the pipeline would traverse towards North-Western direction for approximately 305 km up to Hyderabad more or less following the parallel route of existing NH-9. The terrain along the pipeline route is mostly flat and plain with agricultural and paddy field, which includes stretches of Rocky terrain and low lying area in between.

The pipeline would be provided with motor operated Sectionalizing Valves (SVs) at regular intervals all along the pipeline route including additional SVs on both sides of each major river / canal crossings as per prevailing requirements of OISD-141.

The pipeline would cross a number of rivers, canals, roads and railway tracks. The pipeline across major perennial rivers / canals is proposed to be installed by using Horizontal Directional Drilling (HDD) technique. Pipeline would be laid across minor rivers / canals by submerged crossing method. Provision has also been kept for installing pipeline by HDD method across selected National / State Highways. Pipeline across railway crossings and selected National / State Highways would be laid by using bored cased crossing method.

2.4 SALIENT FEATURES OF THE PROJECT

The salient features of the proposed project are as follows:

Length (km) of the Pipeline: 1212 km

This proposal of laying Paradip-Hyderabad product pipeline system broadly involves the following activities.

- Installation of pump station at Paradip.
- Laying of 315 km long, 18” OD, 0.281” WT pipeline section from Paradip to Berhampur.
- Installation of delivery cum pumping station at Berhampur.
- Laying of 290 km long, 16” OD, 0.281” WT pipeline section from Berhampur to Vizag.
- Installation of delivery cum pumping facilities at Vizag.
- Laying of 66 Km long, 16” OD, 0.25” WT pipeline section from Vizag to Achutapuram.
- Installation of delivery facilities at Achutapuram.
- Laying of 145 km long, 16” OD, 0.25” WT pipeline section from Achutapuram to Rajahmundry.
- Installation of delivery cum pumping facilities at Rajahmundry.
- Laying of 174 km long, 16” OD, 0.25” WT pipeline section from Rajahmundry to Vijayawada.
- Installation of delivery cum pumping facilities at Vijayawada.
- Laying of 222 km long, 14” OD, 0.25” WT pipeline section from Vijayawada to Hyderabad.
- Installation of delivery facilities at Hyderabad.
- Installation of scraper facilities in between Paradip-Vizag section and Vijayawada-Hyderabad section.

2.4.1 Civil Work

Civil structures are envisaged to be erected at the stations to provide shelter to men and machinery. Pump sheds and booster sheds to accommodate the pumping units with associated facilities have been planned to be of steel structure. The civil structures are also intended to house control panels, MCC panels, HT/LT panels, batteries, etc. All the safety factors like wind load, seismic load, soil bearing capacity etc. would be taken into account while designing the civil structures.

Facilities such as pump shed, control building, HT/LT panel rooms, VFD room, workshop, stores, watchman cabin, etc. have been envisaged at Originating and Intermediate pump station locations whereas facilities like control building, MCC building, workshop, store, watchman cabin, etc. have been envisaged at delivery station locations.

2.4.2 Cathodic Protection System

Temporary Cathodic Protection system with the requisite design life is envisaged during the construction works using the Mg anodes in line with OISD guidelines. To mitigate the external corrosion of mainlines, impressed current cathodic protection system shall be provided. The system envisaged impressed current anodes with AC/AC cum DC operated Cathodic protection inputs having uninterrupted power supply arrangement. At repeater station, power shall be made available through state electricity board with back up by DG set of adequate capacity.

However, at pump station and terminal stations, the CP units will have features of automatic control of pipe to
soil potential and will be linked with Supervisory Control and Data Acquisition system for remote monitoring of the CP Parameters from the station. Electric resistance (ER) probe has been considered at all the manned stations to monitor the health of the pipeline.

2.4.3 Mechanical Work

Pipes, pipe fittings, flanges etc. will conform to International Standards such as API 5L, ANSI B-16.5, ANSI B-16.25, WPB-234, MSS-SP-44, MSS-SP-75 etc. and will be suitable for ANSI-400, 600 and 900 pressure classes. Gate valves, ball valves, swing check valves will conform to API 6D standards. Electric motor actuators of suitable power ratings will be installed for the operation of gate and ball valves.

The mainline pumps would be axially split Horizontal Centrifugal type conforming to API 610 standard. They would be fitted with mechanical seals conforming to, API 682 std. and coupled with Horizontal, Flame proof, weather proof Electrical Motors. These Motors would be provided with VFD.

In Phase-I, mainline pumping units (MLPUs) would be provided at 5 locations as per following details.

- At Paradip Originating station**,** 3 (Two running and one stand by)
- At Vizag pumping cum Delivery Station, 3 (Two running and one stand by).
- Rajahmundry pumping cum delivery system
- At Vijayawada pumping cum Delivery Station, 5 (Three running and two standby).

In Phase-2, one IPS with 3 MLPUs (2 running + 1 standby) would be provided in between Paradip and Vizag. In addition to above, Rajahmundry delivery station would be converted into pumping cum delivery station.

2.4.4 Electrical Work

Power requirement at Paradip would be met through Paradip Refinery at 6.6 KV level. The power requirement at Berhampur, Vizag, Rajamundhry and Vijayawada has been designed for receiving power supply at 33 KV level through independent feeder from state electricity board. 33/6.6 KV, 6 MVA outdoor switchyard works have been envisaged for this purpose. Power demand at scraper and delivery stations would be met through incoming grid supply at HT level through State Electricity Board.

One 6.6 KV, 2 MVA HT DG Set has been considered at Vizag for running the station in case of mains power failure. Similarly, one 6.6 KV, 1.5 MVA HT DG set is envisaged at Vijayawada. Similar electrical facilities has been envisaged at Rajahmundry.

2.4.5 Instrumentation and Station Control Centre

Necessary instrumentation system would be provided for the operation and control of the pipeline so as to optimize the use of equipment and manpower and to protect the equipment. The stations would be self protected and be made fail safe by means of local sequence control as well as instrument closed loop control.

Field instrumentation at stations will comprise of pressure transmitters, pressure switches, pressure gauges, flow meters, flow switches, level switches, level transmitters, density meters, temperature transmitters, differential pressure transmitters, scrapper detector and emergency shutdown switches etc.

Mass Flow Meters have been considered for Paradip, Vizag, Rajahmundry & Vijayawada. Mass Flow meters are also considered on delivery side at Vizag, Rajahmundry, Vijayawada & Hyderabad stations.

System power supply will be through UPS system with battery back up for uninterrupted operation. Fire & Safety system has been envisaged at attended as well as unattended stations with fire alarm panels & hydrocarbon detectors.

2.4.6 Telecommunication System

A state of the art 24 Fiber (Composite G.655 & G.652D), single mode OFC based, SDH communication system with 99.9% availability is envisaged. The 24 fiber OFC cable shall be laid in the same trench as the mainline pipe through HDPE conduit as per the recommended codes & practices. For the communication network of the pipeline, the following type of stations has been considered:

- Attended Stations: 5 (Paradip, Vizag, Rajahmundry, Vijayawada, Hyderabad)
- Scraper/ Repeater cum SV locations: 33 Nos.
- River MOV Stations: 18 Nos.

Each attended station will have multiplexing equipment and electronic exchange will be used in order to interconnect the local subscribers through telephone instruments. Each station/ repeater is envisaged to have uninterrupted supply from the combination of DG set, battery bank, float-cum-boost charger with automatic changeover facility to ensure continuous and uninterrupted equipment operations under prolonged mains power failure.

The system envisaged above is highly flexible and is up-gradable for future operational requirement by addition of suitable hardware/ software. The switchover from the failed part to the hot standby is automatic, without operator's intervention.

2.4.7 Tele supervisory (SCADA) System

Dual redundant hot standby PLC based Station Control System would be provided at attended stations to perform local control functions and to monitor and report local conditions. RTUs would be provided to perform local control functions and to monitor and report local conditions at the Scrapper stations. Besides, Mainline SV locations (33) & River MOVs (18) would also be equipped with RTUs for communication throughout the pipeline network.

The Master Control Station has been considered at Paradip, while other attended stations shall have respective Station Control Centre (SCC). The computers shall be connected to dual local area networking (LAN) in client-server mode. They shall work in hot standby configuration and shall be connected to the PLC control system over LAN. They shall be interfacing with the PLC system on continuous basis for monitoring of station parameters and control. SCC computers shall have several graphic screens depicting the station pipeline network and equipment in the station.

Operators shall monitor, operate and control the station equipment and parameters through these graphic screens. All alarms, events, status of equipment etc. shall be logged in the computer system and print out can be obtained on periodic basis or on demand through printers connected on LAN. This package will enable the operator to take optimal control actions and thus ensure the safety and security of the pipeline network.

Chapter-3: Legal Aspects

The section (3) sub-section (2) of the Environment (Protection) Act, 1986 refers to the provisions related to hazardous chemicals management. According to the MSIHC rules the hazard assessment study must include information on the following:-

a) Identification of hazards
b) Cause of major accidents
c) Assessment of hazards according to their occurrence frequency
d) Assessment of accident consequences
e) Safety systems
f) Known accident history

Risk analysis study is also necessary to ensure compliance to statutory rules and regulations. The various acts that include the guidelines to be followed for the management of hazardous wastes and their related risks are listed in the paragraphs below.

3.1 ENVIRONMENT (PROTECTION) ACT, 1986

According to the Environment (Protection) Act, 1986, no person shall handle any hazardous substance except in accordance with such procedures and after complying with prescribed safeguards.

3.1.1 Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 & amendments there-of

Based on the accidents in the chemical industry in India over a few decades, a specific legislation covering major hazardous activities has been enforced by Govt. of India in 1989 in conjunction with Environment Protection Act, 1986. This is referred here as GOI rules 1989. For the purpose of identifying major hazard installations the rules employ certain criteria based on toxic, flammable and explosive properties of chemicals that are listed in Table-3.1

a. Toxic Chemicals

Chemicals having the following values of acute-toxicity and which, owing to their physical and chemical properties, are capable of producing major accident hazards.

Table-3.1: Indicative Criteria for Identification of Toxic, Flammable & Explosive Chemicals (GOI Rules, 1989)

S.No.	Toxicity	Oral toxicity LD_{50}(mg/kg)	Dermal toxicity LD_{50}(mg/kg)	Inhalation toxicity LC_{50}(mg/l)
1.	Extremely toxic	>5	<40	<0.5
2.	Highly toxic	>5-50	>40-200	<0.5-2.0
3.	Toxic	>50-200	>200-1000	>2-10

b. Flammable chemicals

i. Flammable gases: Chemicals which in the gaseous state at normal pressure and mixed with air become flammable and the boiling point of which at normal pressure is 20^{0}C or below.

ii. Highly flammable liquids: Chemicals which have a flash point lower than 21^{0}C and the boiling point of which at normal pressure is above 20^{0}C.

iii. Flammable liquids: Chemicals which have a flash point lower than 55^{0}C and which remain liquids under pressure, where particular processing conditions, such as high pressure and high temperature, may create major accident hazards.

c. Explosion

Chemicals, which may explode under the effect of flame, heat or photochemical conditions or that, are more sensitive to shocks or friction than dinitrobenzene.

a) A list of hazardous substances is provided in Part-II of Schedule I of the rules.

b) Schedule II of rules gives out the threshold quantities for isolated storage units.

c) Schedule II gives a list of hazardous chemicals with their threshold quantities. In this schedule different chemicals are classified into distinct groups viz.
Group 1 - Toxic substances
Group 2 - Toxic substances
Group 4 - Highly reactive substances
Group 4 - Explosive substances and
Group 5 - Flammable substances

d) Schedule IV of the rules indicates various operations, which are hazardous during production, processing or treatment of organic and inorganic chemicals.

Table-3.2: Description of Applicable Provisions of GOI Rules, 1989

Applicable Rules	Description
4(1) (a) & 4(2) (i)	General responsibilities of occupier for the listed chemicals of schedule I to prevent major accident and provide information, antibodies, equipment and safety training.
5	Notification of major accidents to concerned authority
7	Notification of sites to competent authority
8	Updating of site notification following changes in threshold quantity
9	Transitional provision for the existing activity
10	Preparation of safety reports for commencement of activity
11	Updating of safety reports based on modification
12	Provision of further information on safety reports to the authority
13	Preparation of on-site emergency plan by the occupier
14	Preparation of off-site emergency plan by the authority
15	Information to be given to persons liable to be affected by a major accident
16	Collection, development and dissemination of information on hazardous chemicals employed by the occupier

Chapter-4: Hazard Identification

The main products transported in the pipeline include Motor spirit (MS), High Speed Diesel (HSD), Superior Kerosene Oil (SKO) and Aviation Turbine Fuel (ATF). These oils are all flammable and slightly toxic. Key properties of the materials are described below:

Table 4.1: Key Properties of material

Material	Flash Point (^oC)	IBP-FBP (^oC)	Density (kg/m3)
MS	-30	30-215	700-750
HSD	32	110-400	800-850
SKO	35	150-300	750-800
ATF	38	160-300	750-840

4.1 FIRE & EXPLOSION INDEX

The major element containing hazardous material is the pipeline, storage tanks, associated pumping units/ transfer processes and tank truck loading. The Fire and Explosion Index has been calculated based on the method developed by Dow Chemical Company (USA).

The Fire and Explosion Index F is calculated from

$F = MF \times (1 + GPH_{tot}) \times (1 + SPH_{tot})$

In which
MF = Material Factor, a measure for the potential energy of the dangerous substances present (According to NFPA data)

GPH_{tot} = General Process Hazards, a measure for the hazards inherent in the process (from the nature and characteristics of the process)

SPH_{tot}= Special Process Hazards, a measure for the hazards originating from the specific installation (process conditions, nature and size of installation, etc.)

Calculations have been made for the F&E Index for storage of petroleum Products as given below.

Table-4.2: Fire and Explosive Index

1. GENERAL PROCESS HAZARDS	Penalty Factor Range	Penalty Factor Used
Base Factor	1	1
A. Exothermic Chemical Reactions- NA	0.30 to 1.25	0
B. Endothermic Chemical Reactions- NA	0.20 to 0.40	0
C. Material Handling and Transfer	0.25 to 1.05	0.5
D. Enclosed or Indoor Process Units- NA	0.25 to 0.90	0

E. Access- NA	0.20 to 0.35	0
F. Drainage and Spill Control	0.25 to 0.50	0.5

GENERAL PROCESS HAZARDS (F1)		**2**
2. SPECIAL PROCESS HAZARDS	**Penalty Factor Range**	**Penalty Factor Used**
Base Factor	1	1
A. Toxic Material (s)	0.20 to 0.80	0
B. Sub - Atmospheric Pressure (< 500 mm Hg)	0.5	0
C. Operation in or near flammable range (non-inerted)		
1. Tank Farms Storage Flammable Liquids	0.5	0.5
2. Process Upset or Purge Failure- No process	0.3	0
3. Always in flammable range - NA	0.8	0
D. Dust Explosion	0.25 to 2.00	0
E. Pressure - Operating Pressure : Ambient		0
F. Low Temperature - NA	0.20 to 0.30	0
G Quantity of Flammable/ Unstable Material		
Quantity :approx. 3E9 lbs, Heat of Combustion : 18-20 E-3 BTU/lb		
1. Liquids or Gases in Process : No Process		0
2. Liquids or Gases in Storage		0.1
3. Combustible Solids in Storage, Dust in Process (<0.1 E9BTU)		0
H. Corrosion and Erosion (<0.5 mm/yr)	0.10 to 0.75	0.1
I. Leakage : Joints and Packing (minor expected)	0.10 to 1.50	0.1
J. Use of Fired Equipment - NA		-
K. Hot Oil Heat Exchange System - NA	0.15 to 1.15	-
L. Rotating Equipment- pumps	0.5	0.5
SPECIAL PROCESS HAZARDS FACTOR (F2)		**2.3**

Hazard Categories as per Dow's F&EI

F & E Index Value	**Hazard Category**
0 to 60	light
61 to 96	Moderate
97 to 127	intermediate
128 to 158	Heavy
>159	Severe

Comparison of the highest calculated F& E Index with the above table shows that the proposed project falls in the light hazard category.

4.2 HAZARD IDENTIFICATION

The fire and health hazards are also categorized based on NFPA (National Fire Protection Association) classifications, described below.

Table-4.3: Hazard Identification

S. No	**PETROLEUM PRODUCT**	N_h	N_f	N_r
1.	MS	1	3	0

S. No	PETROLEUM PRODUCT	N_h	N_f	N_r
2.	HSD	0	2	0
3.	SKO	0	2	0
4.	ATF	0	2	0

N_h NFPA health hazard factor
N_f NFPA flammability hazard factor
N_r NFPA reactivity hazard factor
Evaluation of the hazard based on the F&E Index is done based on the following guidelines.

EXPLANATION OF NFPA CLASSIFICATION

CLASSIFICATION	DEFINITION
Health Hazard	
4	Materials which on very short exposure could cause death or major residual injury even though prompt medical treatment was given
3	Materials which on short exposure could cause serious temporary or residual injury even though prompt medical treatment was given.
2	Materials which on intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given.
1	Materials which on exposure would cause irritation but only minor residual injury even if no treatment is given.
0	Materials which on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material
Flammability	
4	Materials which will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature, or which are readily dispersed in air and which will burn readily.
3	Liquids and solids that can be ignited under almost all ambient temperature conditions.
2	Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.
1	Material that must be preheated before ignition can occur.

0	Materials that will not burn

Reactivity

4	Materials which in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperature and pressures.
3	Materials which in themselves are capable of detonation or explosive reaction but require a strong initiating source or which must be heated under confinement before initiation or which react explosively with water.
2	Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Also materials which may react violently with water or which may form potentially explosive mixtures with water.
1	Materials which in themselves are normally stable, but which can become unstable at elevated temperature and pressures or which may react with water with some release of energy but not violently.
0	Materials which in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.

➔ The following points are relevant with respect to toxic, flammable and reactivity criteria.

Toxic

The highest health hazard rating is reported for MS i.e., 1. It may be noted that a toxicity factor of 1 denotes materials which on exposure would cause irritation but only minor residual injury even if no treatment is given.

Flammable

All the products handled possess flammable characteristics. Motor spirit with a flammability factor (N_f) of 3 may be considered as flammable as it may be ignited even at ambient conditions. HSD, SKO & ATF with a flammability factor of 2 needs to be heated moderately above ambient temperature before they could ignite. The “Flash Point” is a good measure of the flammability potential. It may be inferred that MS is “flammable” with flash point lower than the ambient temperature. These flammable materials on release are expected to form a large pool within the dykes on release from storage tanks. On an encounter with a source of ignition, there exists the potential for a pool fire. Even HSD and SKO are particularly dangerous during summer, when ambient temperatures could well exceed 45^{o}C (flash point is about 32-35^{o}C).

From the boiling point, it is seen that all the products have boiling points in excess of ambient temperature; hence vapour formation subsequently resulting in a Vapour Cloud Explosion (VCE) or a Flash Fire outcome is generally unlikely. However, tank and tanker explosions are simulated for the rare possibility of a flammable mixture forming within the closed tank. In the open (where there is zero extent of confinement), these materials do not have sufficient Vapour pressure to explode.

Reactivity

None of the products handled is rated as a reactive chemical.

4.3 ENUMERATION AND SELECTION OF INCIDENTS

Effective management of a Risk Analysis study requires enumeration and selection of incidents or scenarios. Enumeration attempts to ensure that no significant incidents are overlooked; selection tries to reduce the incident outcome cases studied to a manageable number. These incidents can be classified under either of two categories: low frequency high consequence and high frequency low consequence. Unfortunately, there is an infinite number of ways (incidents) by which accidents can occur in either category. For example, leaks of process materials can be of any size, from a pinhole up to a severed pipeline or ruptured vessel. An explosion can occur in either a small container or a large container and, in each case, can range from a small "puff" to a catastrophic detonation.

The technique commonly used to prepare an incident list is to consider potential leaks and major releases from fractures of all process pipelines, tanks and vessels. This compilation should include all pipe work and vessels in direct communication, as these may share a significant inventory that cannot be isolated in an emergency.

- ➔ Tank and Pipeline description, and dimensions
- ➔ Materials present
- ➔ Tank conditions (phase, temperature, pressure)
- ➔ Inventory and connecting piping and piping dimensions.

The goal of selection is to limit the total number of incident outcome cases to be studied to a manageable size, without introducing bias or losing resolution through overlooking significant incidents or incident outcomes. The purpose of incident selection is to construct an appropriate set of incidents for the study from the Initial List that has been generated by the enumeration process. An appropriate set of incidents is the minimum number of incidents needed to satisfy the requirements of the study and adequately represent the spectrum of incidents enumerated.

4.4 CHARACTERISING THE FAILURES

Accidental release of flammable or toxic vapours can result in severe consequences. Delayed ignition of flammable vapours can result in blast overpressure covering large areas. This may lead to extensive loss of life and property. Toxic clouds may cover yet larger distances due to the lower threshold values in relation to those in case of explosive clouds (the lower explosive limits). In contrast, fires have localized consequences. Fires can be put out or contained in most cases; there are few mitigating actions one can take once a Vapour cloud gets released.

In a petroleum marketing installation such as the plant in question, the main hazard arises due to the possibility of leakage of petroleum products during decanting (number of hose connections, pipeline failure, tank lorry movement etc.), storage, filling and transportation. To formulate a structured approach to identification of hazards and understanding of contributory factors is essential.

4.4.1 Blast over Pressures

Blast Overpressure depends upon the reactivity class of material and the amount of gas between two explosive limits. The petroleum products could give rise to a VCE due to their Vapour pressures - however, as the results will indicate, the cloud flammable masses are quite small due to the low boiling point and low Vapour pressures. In addition, unless there is sufficient extent of confinement, it is unlikely to result in any major explosion. Examples where flammable mixtures could be found are within storage tanks and road tankers. Open-air explosions are unlikely. As a result damage would be limited.

Equations governing the formation of overpressure in an explosion are given later. Blast overpressure are calculated based on comparison of combustion energy per unit mass of a vapour cloud with that of TNT and taking into account that only a fraction of the energy will contribute to the explosion. Overpressure data compiled from measurements on TNT are used to relate overpressure data to distance from explosions. The equivalent mass of TNT is calculated using the following equations:

M_{TNT}= (M_{cloud} X (ΔH_c.)/1155 X Yf) M_{cloud}

Where M_{TNT} is the TNT equivalent mass (lb)

ΔH_c = Heat of combustion is in Kcals/kg
M_{cloud} is mass in cloud in lbs
Y_f is the yield factor

The distance to a given overpressure is calculated from the general equation:

X=M_{TNT} 1/3 exp (3.5031-0.7241 ln (Op) + 0.0398 (ln Op))2)

Where X is the distance to a given overpressure in feet
Op is the peak overpressure

4.4.2 Jet fires

A leak or spill of sufficient size of petroleum products will result in an accumulation of vapour in the atmosphere. If ignited, the result fire is known as spreading of fixed jet fire. Jet fires occur when spilled hydrocarbons burn in the form of large diffusion flames. Calculating the incident flux to an observer involves four steps, namely

1. Characterizing the flame geometry
2. Estimation of the flame radiation properties
3. Computation of the geometric view factors
4. Estimation of flame attenuation coefficients and computation of geometric view factors between observer and flame.

The size of the flame will depend upon the spill and the thermo chemical properties of the spilled gas. In particular, the diameter of the fire, the visible height of the flame, the tilt and drag of the flame etc. The radiative output of the flame will depend upon the fire size, the extent of mixing with air and the flame temperature. Some fraction of the thermal radiation is absorbed by the carbon dioxide and water vapour in the intervening atmosphere.

The calculations for radiation damage distances start with estimation of the burning velocity:

$$Y= 92.6 e – 0.0043TbM_w10-7/(D_{eq} X 6)$$

Where y= burning velocity in m/s
M_w= molecular weight in kg/kgmol
Tb= normal boiling point

The next step involves calculation of the equivalent diameter for the spreading vapour- this depends upon the duration of the spill (continuous, instantaneous, finite duration etc.). This is calculated using expressions like:

$$D_{eq}. =2(V/3.142y) 1/2$$

Where, D_{eq}. Is the steady state diameter of the vapour in m
V= fluid spill rate in m^3/s
Y= fluid burning rate in m/s

In the absence of frictional resistance during spreading, the equilibrium diameter is reached over a time given by:

$$T_{eq}.= 0.949 D_{eq}./(\Delta y X D_{eq}.)^{1/3}$$

The visible flame height is given by;

$$H_{flame}= 42Dp ((BvD/Da (gDp) 1/2)0.61$$

Where H_{flame} = flame height in m
D= Density in kg/m3
Da= Air Density in kg/m3
g = Gravitational Acceleration or 9.81 m/s2

The emissive power of a large turbulent fire is a function of the black body emissive power and the flame emissivity. The black body emissive power can be computed by Planck's law of radiation. The general equation used for the calculation is:

$$E_p= -0.313Tb+117$$

Where Ep is the effective emissive power in kw/m2
T_b= normal boiling point of the fluid. in ^oF

Materials with a boiling point above 30 deg. F typically burn with sooty flames-the emissive power from the sooty section is about 20kw/m2. The incident flux at any given location is given by the equation:

$$Q_{incident} = E_P X t X V F$$

Where $I_{ncident}$ = incident flux in kw/m^2
t= transmitivity (a function of path length, relative humidity and flame temperature.

Often taken as 1 and the attenuation of thermal flux due to atmospheric absorption ignored.

VF= geometric view factor

The view factor defines the fraction of the flame that is seen by a given observer.

V F= 1.143 (Rp/X) 1.757

Where X= distance from the flame center in m
Rp= pool radius in m.

Based on the radiation received, the fatality levels are calculated from Probit equation, which for protected clothing is given by:

Pr.= -37.23 + 2.56 ln (t X Q4/3)

Where Pr. = Probit No.
t= time in seconds
Q heat radiation in w/m^2

4.4.3 Operating Parameters

Potential vapour release for the same material depends significantly on the operating conditions. The petroleum oils are handled at atmospheric temperature and pressure except during pumping operations, where the pressures are those developed by the respective pumps.

4.4.4 Inventory

Inventory Analysis is commonly used in understanding the relative hazards and short listing of release scenarios. Inventory plays an important role in regard to the potential hazard. Larger the inventory of vessel or system, larger the quantity of potential release. A practice commonly used to generate an incident list is to consider potential leaks and major releases from fractures of pipelines and vessels containing sizable inventories. The potential vapour release (source strength) depends upon the quantity of liquid release, the properties of the materials and the operating conditions (pressure, temperature).

4.4.5 Loss of Containment

Plant inventory can get discharged to Environment due to Loss of Containment. Various causes and modes for such an eventuality have been described. Certain features of materials to be handled at the plant need to the clearly understood to firstly list out all significant release cases and then to short list release scenarios for a detailed examination.

Fluid Outflow from a vessel/line
Fluid release can be either instantaneous or continuous. Failure of a vessel/pipeline leading to an instantaneous outflow assumes the sudden appearance of such a major crack that practically all of the contents above the crack shall be released in a very short time. The flow rate will depend on the size of the hole as well as on the pressure in front of the hole, prior to the accident. Such pressure is basically dependent on the pressure in the vessel or pipeline.

Vaporization

The vaporization of released Fluid depends on the vapour pressure and weather conditions. Such consideration and others have been kept in mind both during the initial listing as well as during the short listing procedure. Initial listing of all significant inventories in the process plants was carried out. This ensured no omission through inadvertence. Based on the methodology discussed above a set of appropriate scenarios was generated to carry out Risk Analysis calculations, as listed below:

1. Release of MS from the pipeline.
2. Release of HSD from the pipeline
3. Release of SKO from the pipeline
4. Release of ATF from the pipeline

Chapter-5: Risk Analysis Calculations

5.1 CONSEQUENCE MODELING

If petroleum liquids are released into the atmosphere, they would be expected to form a pool of liquid (the size of which would be determined by the presence of any secondary containment such as bund walls). This pool could be either confined or unconfined and the evaporation from the pool is what determines the strength of the vapour cloud, if at all it forms.

5.2 DAMAGE CRITERIA

In consequence analysis, use is made of a number of calculation models to estimate the physical and chemical effects of an accident (spill of hazardous gases) and to predict the damage (lethality, injury, material destruction) of the effects. The calculations can roughly be divided in three major groups:

a) Determination of the source strength parameters;
b) Determination of the consequential effects;
c) Determination of the damage or damage distances.

The basic physical effect models consist of the following.

5.2.1 Source strength parameters

- Calculation of the outflow of fluid (gases) out of a tank or pipe, in case of rupture.
- Calculation, in case of fluid (gases) outflow, of the instantaneous flash evaporation and of the dimensions of the vapour cloud.
- Calculation of the evaporation rate, as a function of volatility of the material, pool dimensions and wind velocity.
- Source strength equals pump capacities, etc. in some cases of pump discharge line ruptures for catastrophic cases.

5.2.2 Consequential Effects

- Dispersion of gaseous material in the atmosphere as a function of source strength, relative density of the gas, weather conditions and topographical situation of the surrounding area.
- Intensity of heat radiation [in kW/ m^2] due to a fire, as a function of the distance from the source.
- Energy of vapour cloud explosions [in N/m^2], as a function of the distance to the distance of the exploding cloud.
- Concentration of gaseous material in the atmosphere, due to the dispersion of evaporated chemical. The latter can be either explosive or toxic.

It may be obvious, that the types of models that must be used in a specific risk study strongly depend upon the type of material involved:

- Gas, vapour, liquid, solid
- Inflammable, explosive, toxic, toxic combustion products
- Stored at high/low temperatures or pressure
- Controlled outflow (pump capacity) or catastrophic failure

5.2.3 Selection of Damage Criteria

The damage criteria give the relation between extent of the physical effects (exposure) and the percentage of the people that would be killed or injured due to those effects. The knowledge about these relations depends strongly on the nature of the exposure. For instance, much more is known about the damage caused by heat radiation, than about the damage due to toxic exposure, and for these toxic effects, the knowledge differs strongly between different materials. In Consequence Analysis studies, in principle three types of exposure to hazardous effects are distinguished:

1. Heat radiation, from a jet or flash fire.
2. Explosion
3. Toxic effects, from toxic materials or toxic combustion products.

<u>Heat Radiation</u>
The consequences caused by exposure to heat radiation are a function of:

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

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

Table-5.1: Damages to Human Life Due to Heat Radiation

Exposure Duration	Radiation Energy (1% Lethality, Kw/M^2)	Radiation Energy For 2nd Degree Burns, Kw/M^2	Radiation Energy For First Degree Burns, Kw/M^2
10 Sec	21.2	16	12.5
30 Sec	9.3	7.0	4.0

Since in practical situations, only the employees will be exposed to heat radiation in case of a fire, it is reasonable to assume the protection by clothing. It can be assumed that people would be able to find a cover or a shield against thermal radiation in 10-sec. time. Furthermore, 100% lethality may be assumed for all people suffering from direct contact with flames, such as the fire ball, flash fire or a jet flame. The effects due to relatively lesser incident radiation intensity are given below.

Table-5.2: Effects Due To Incident Radiation Intensity

Incident Radiation – kW/m^2	Type Of Damage
0.7	Equivalent to Solar Radiation
1.6	No discomfort for long exposure
4.0	Sufficient to cause pain within 20 sec. Blistering of skin (first degree burns are likely)
9.5	Pain threshold reached after 8 sec. Second degree burns after 20 sec.
12.5	Minimum energy required for piloted ignition of wood, melting plastic tubing etc.
25	Minimum energy required to ignite wood at indefinitely long exposure
37.5	Sufficient to cause damage to process equipment

Source: Major Hazard Control, ILO

The actual results would be less severe due to the various assumptions made in the models arising out of the flame geometry, emissivity, angle of incidence, view factor and others. Upon ignition, a spilled fluid hydrocarbon would burn in the form of a large turbulent diffusion flame. The size of the flame would depend upon the spill and the thermo-chemical properties of the spilled gases. In particular, the diameter of the fire, the visible height of the flame, the tilt and drag of the flame due to wind can be correlated to the burning velocity of the gases. The radiative output of the flame would be dependent upon the fire size, extent of mixing with air and the flame temperature. Some fraction of the radiation is absorbed by carbon dioxide and water vapour in the intervening atmosphere. In addition, large hydrocarbon jet fires produce thick smoke, which can significantly obscure flame radiation. Finally the incident flux at an observer location would depend upon the radiation view factor, which is a function of the distance from the flame surface, the observer's orientation and the flame geometry. Estimation of the thermal radiation hazards from jet fire essentially involves 3 steps; characterization of flame geometry, approximation of the radiative properties of the fire and calculation of safe separation distances to specified levels of thermal radiation.

Explosion

In case of vapour cloud explosion, two physical effects may occur:
* a flash fire over the whole length of the explosive gas cloud;
* a blast wave, with typical peak overpressures circular around ignition source.

As explained above, 100% lethality is assumed for all people who are present within the cloud proper.

For the blast wave, the lethality criterion is based on:
* A peak overpressure of 0.1 bar will cause serious damage to 10% of the housing/structures.
* Falling fragments will kill one of each eight persons in the destroyed buildings.

The following damage criteria may be distinguished with respect to the peak overpressure resulting from a blast wave:

Table-5.3: Damage Due To Overpressure

Peak Overpressure	Damage Type
0.83 bar	Total Destruction
0.30 bar	Heavy Damage
0.10 bar 0.03 bar	Moderate Damage Significant Damage
0.01 bar	Minor Damage

From this it may be concluded that p = 0.17 E+5 pa corresponds approximately with 1% lethality. Furthermore it is assumed that everyone inside an area in which the peak overpressure is greater than 0.17 E+5 pa will be wounded by mechanical damage. For the vapour cloud explosion this will be inside a circle with the ignition source as its center.

5.3 EXTERNAL EVENTS

External events can initiate and contribute to potential incidents considered in a Risk Analysis. Although the frequency of such events is generally low, they may result in a major incident. They also have the potential to initiate common cause failures that can lead to escalation of the incident. External events can be subdivided into two main categories:

* Natural hazards: Earthquakes, floods, tornadoes, extreme temperature, lightening etc.

* Man induced events: Aircraft crash, missile, nearby industrial activity, sabotage etc.

TECHNOLOGY

Normal design codes for oil and gas plants have sufficient safety factors to allow the plant to withstand major external events to a particular level (e.g. intense loading of say 120 mph). Quantitative design rules usually used for seismic events, flooding, tornadoes and extreme wind hazards as follows:

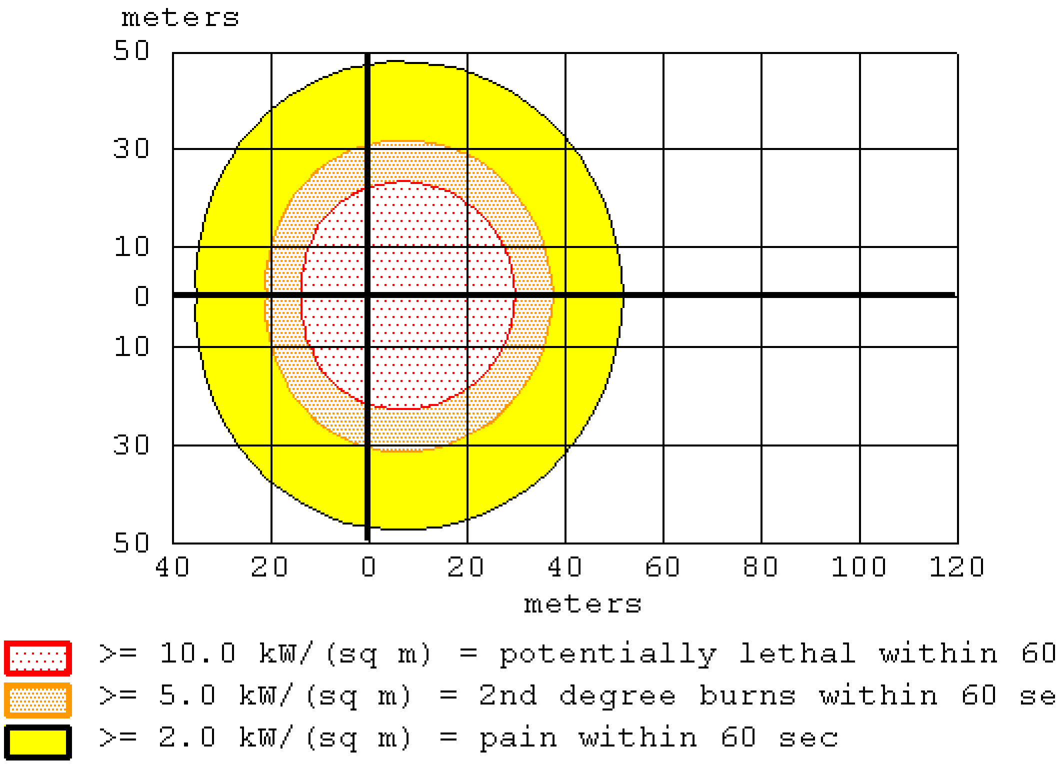
- Seismic: The design should withstand critical ground motion with an annual probability of 10^{-4} or less.
- Flooding: The design should withstand the efforts of worst flooding occurrence in 100-year period.
- Winds: The design should withstand the most critical combination of wind velocity and duration having a probability of 0.005 or less in a 50 year period (annual probability of 10^{-4} or less).

5.4 CONSEQUENCE ANALYSIS CALCULATIONS

This section documents the consequence-distance calculations. A Maximum Credible Accident (MCA) can be characterized as the worst credible accident. In other words: an accident in an activity, resulting in the maximum consequence distance that is still believed to be possible.

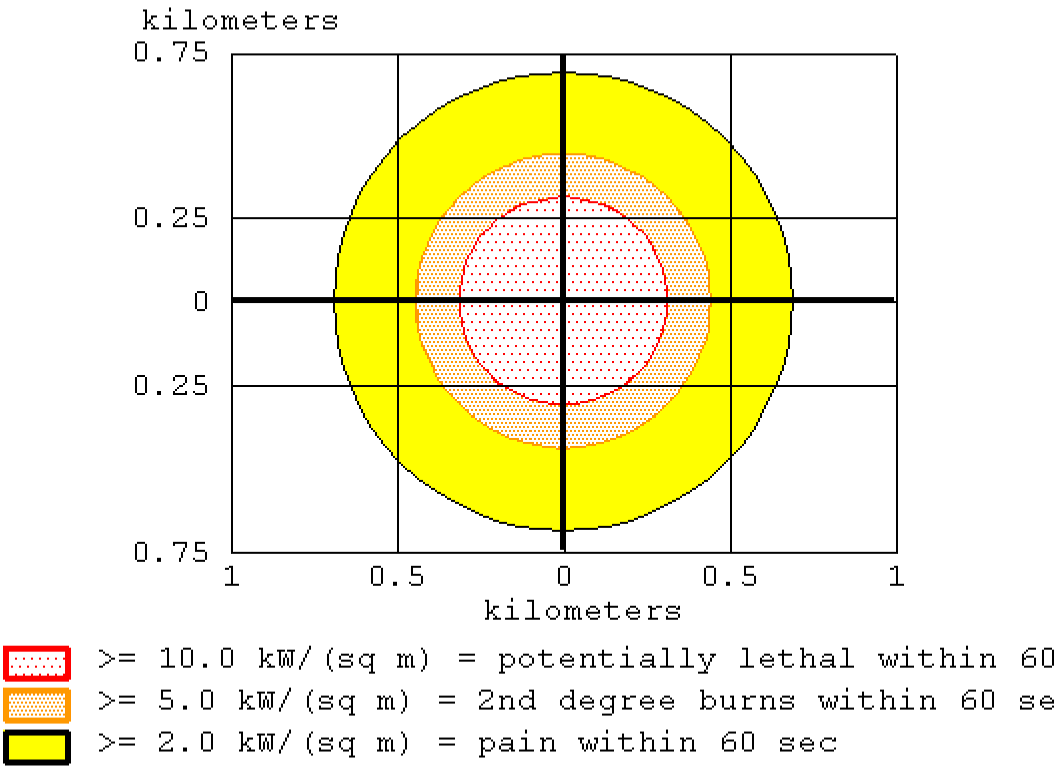
In Risk Analysis studies contributions from **low frequency - high outcome effect as well as high frequency - low outcome events** are distinguished- the objective of the study is emergency planning; hence only holistic & conservative assumptions are used for obvious reasons. Hence though the outcomes may look pessimistic, the planning for emergency concept should be borne in mind whilst interpreting the results. In Consequence Analysis, geographical location of the source of potential release plays an important role. A summary of the results of the analysis are presented below:

SC#1: Release of MS from Pipeline from Paradip to Berahmpur
Pool Fire:



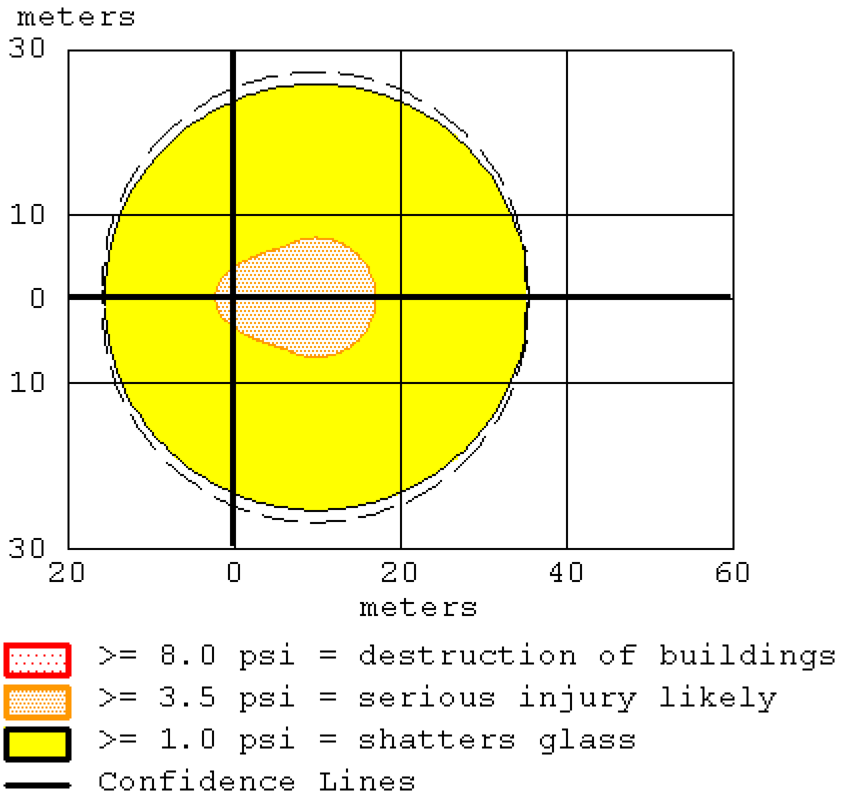
THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : 30 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 37 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 52 meters --- (2.0 kW/(sq m) = pain within 60 sec)

BLEVE



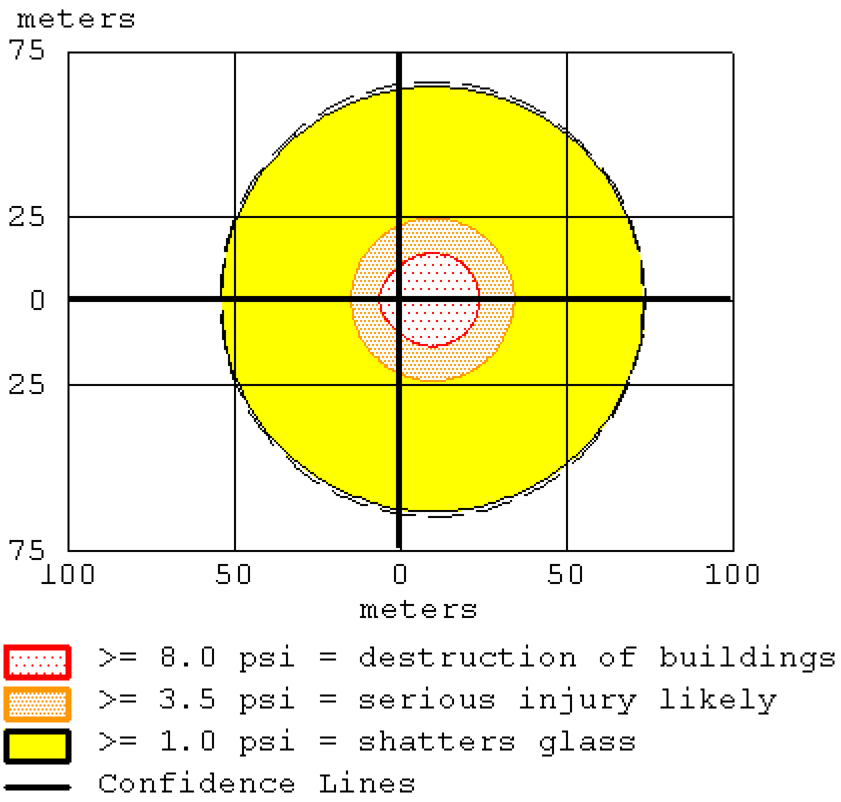
THREAT ZONE:
Threat Modeled: Thermal radiation from fireball
Red : 313 meters --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)
Orange: 442 meters --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)
Yellow: 689 meters --- (2.0 kW/ (sq m) = pain within 60 sec)

Vapor Cloud Explosion (Ignited by Spark)



Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Heavy Gas
Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)
Orange: 17 meters --- (3.5 psi = serious injury likely)
Yellow: 36 meters --- (1.0 psi = shatters glass)

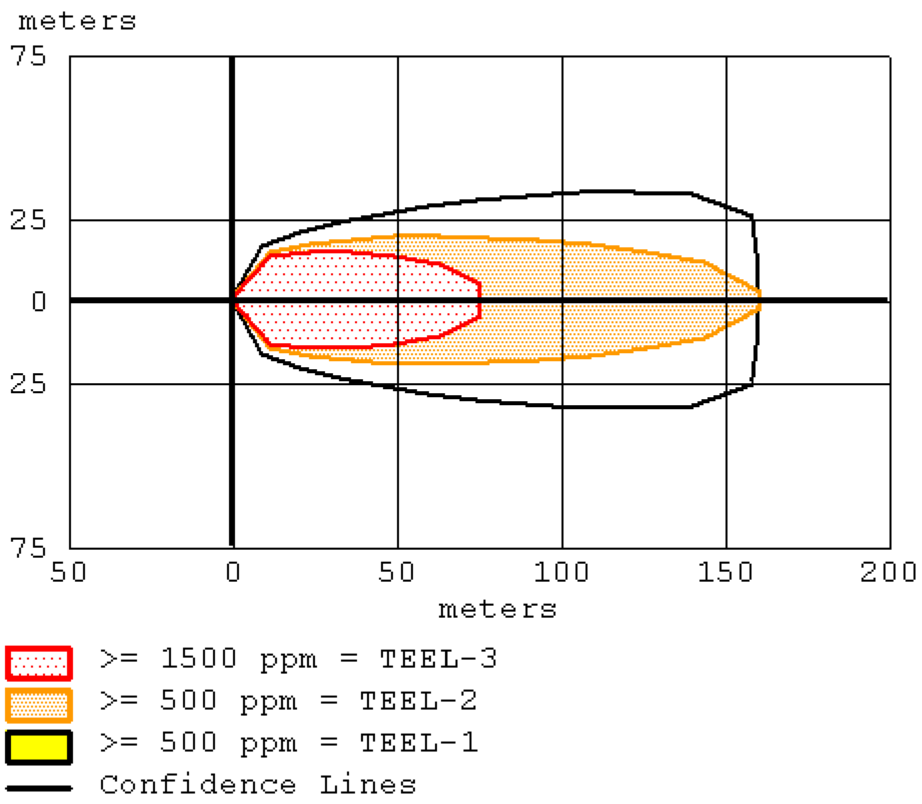
Vapor Cloud Explosion (ignited by detonation)



THREAT ZONE:

Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by detonation
Model Run: Heavy Gas
Red : 24 meters --- (8.0 psi = destruction of buildings)
Orange: 34 meters --- (3.5 psi = serious injury likely)
Yellow: 74 meters --- (1.0 psi = shatters glass)

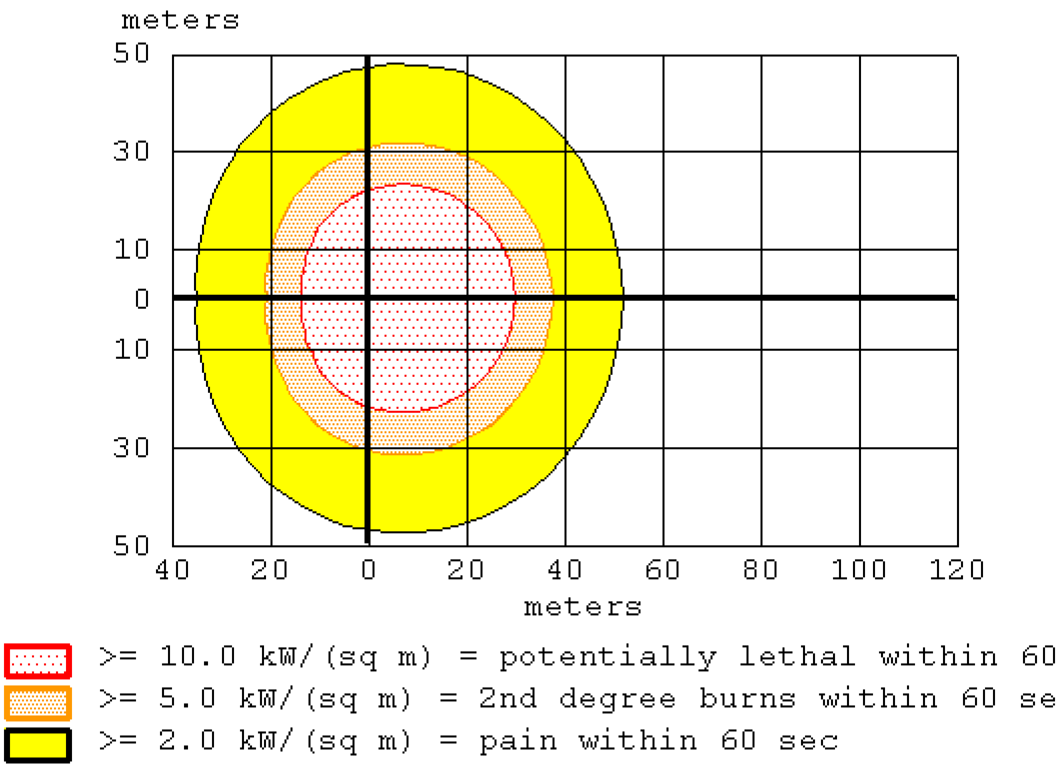
Toxic Area of Vapor Cloud



THREAT ZONE:
Model Run: Heavy Gas
Red : 75 meters --- (1500 ppm = TEEL-3)
Orange: 160 meters --- (500 ppm = TEEL-2)
Yellow: 160 meters --- (500 ppm = TEEL-1)

SC#2: Release of MS from Pipeline from Berahmpur to VIZAG

Pool Fire:



THREAT ZONE:

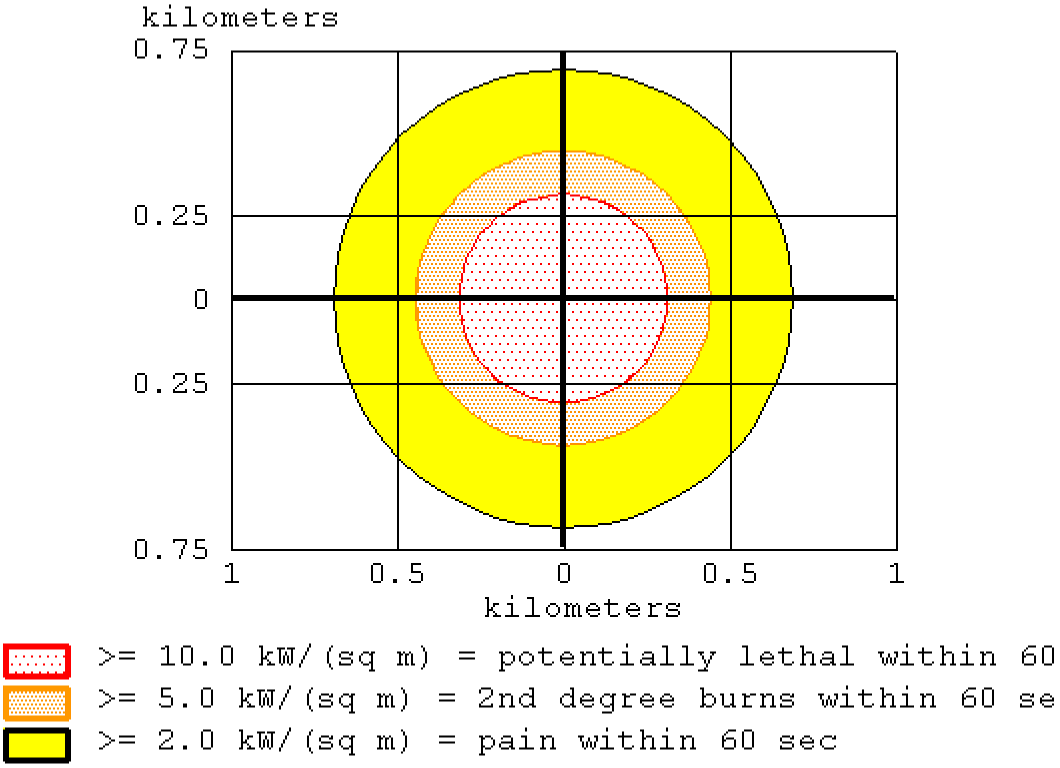
Threat Modeled: Thermal radiation from pool fire

Red : 30 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)

Orange: 37 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)

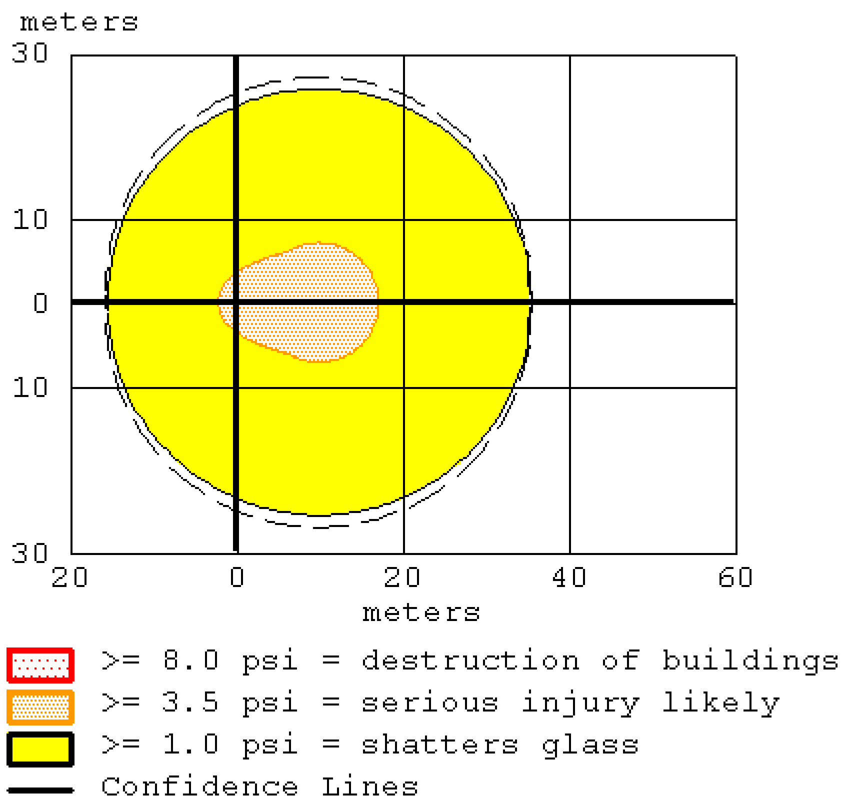
Yellow: 52 meters --- (2.0 kW/(sq m) = pain within 60 sec)

BLEVE



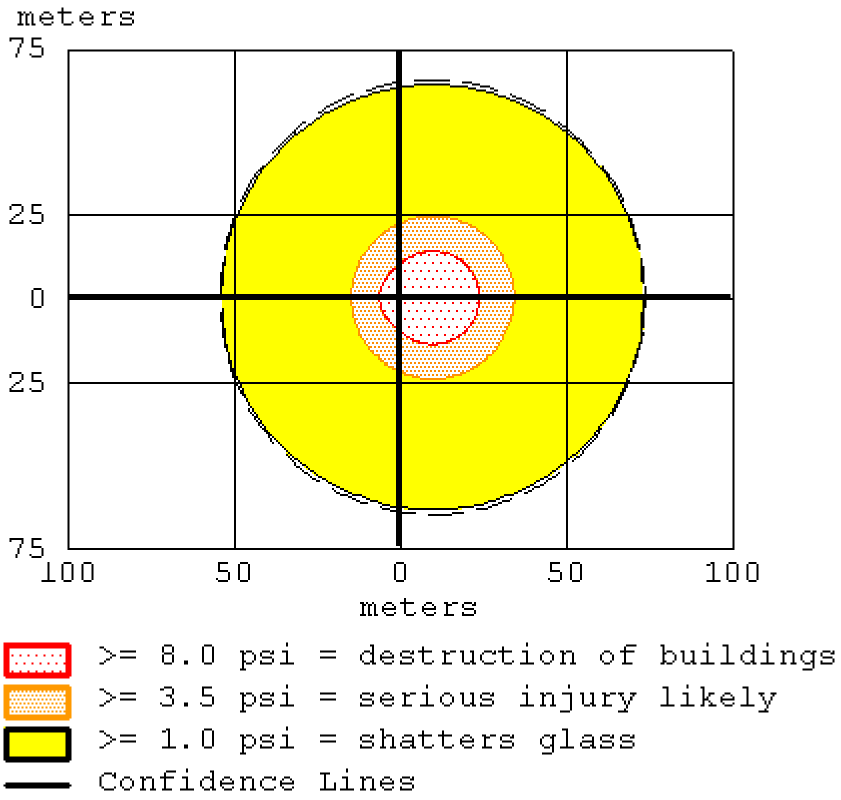
THREAT ZONE:
Threat Modeled: Thermal radiation from fireball
Red : 313 meters --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)
Orange: 442 meters --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)
Yellow: 689 meters --- (2.0 kW/ (sq m) = pain within 60 sec)

Vapor Cloud Explosion (Ignited by Spark)



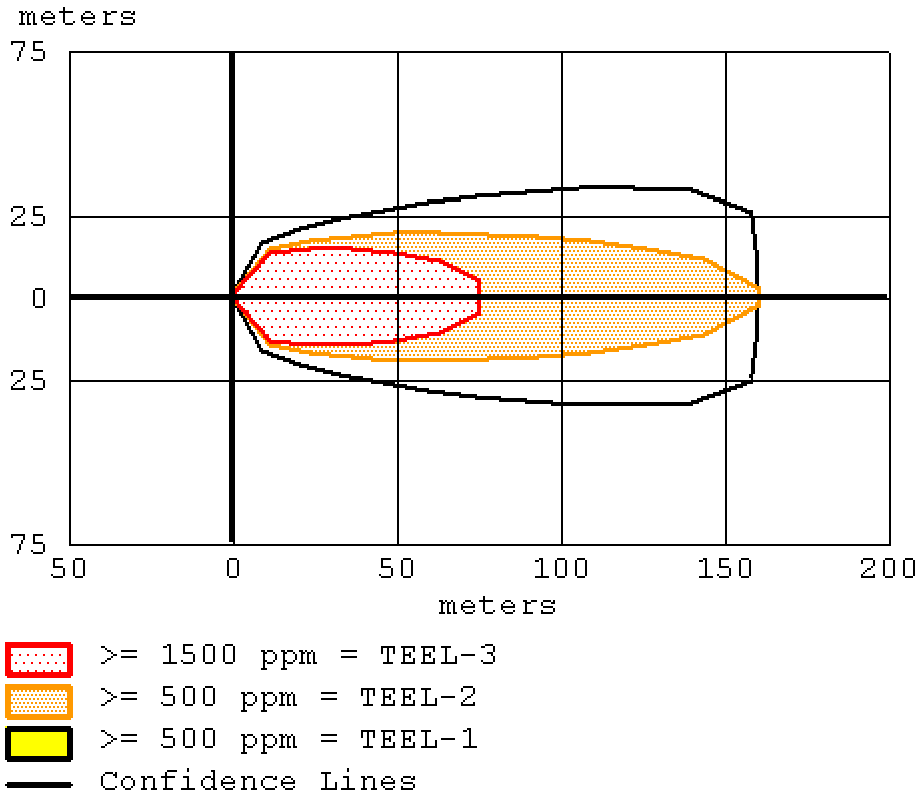
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Heavy Gas
Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)
Orange: 17 meters --- (3.5 psi = serious injury likely)
Yellow: 36 meters --- (1.0 psi = shatters glass)

Vapor Cloud Explosion (ignited by detonation)



THREAT ZONE:
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by detonation
Model Run: Heavy Gas
Red : 24 meters --- (8.0 psi = destruction of buildings)
Orange: 34 meters --- (3.5 psi = serious injury likely)
Yellow: 74 meters --- (1.0 psi = shatters glass)

Toxic Area of Vapor Cloud



THREAT ZONE:

Model Run: Heavy Gas

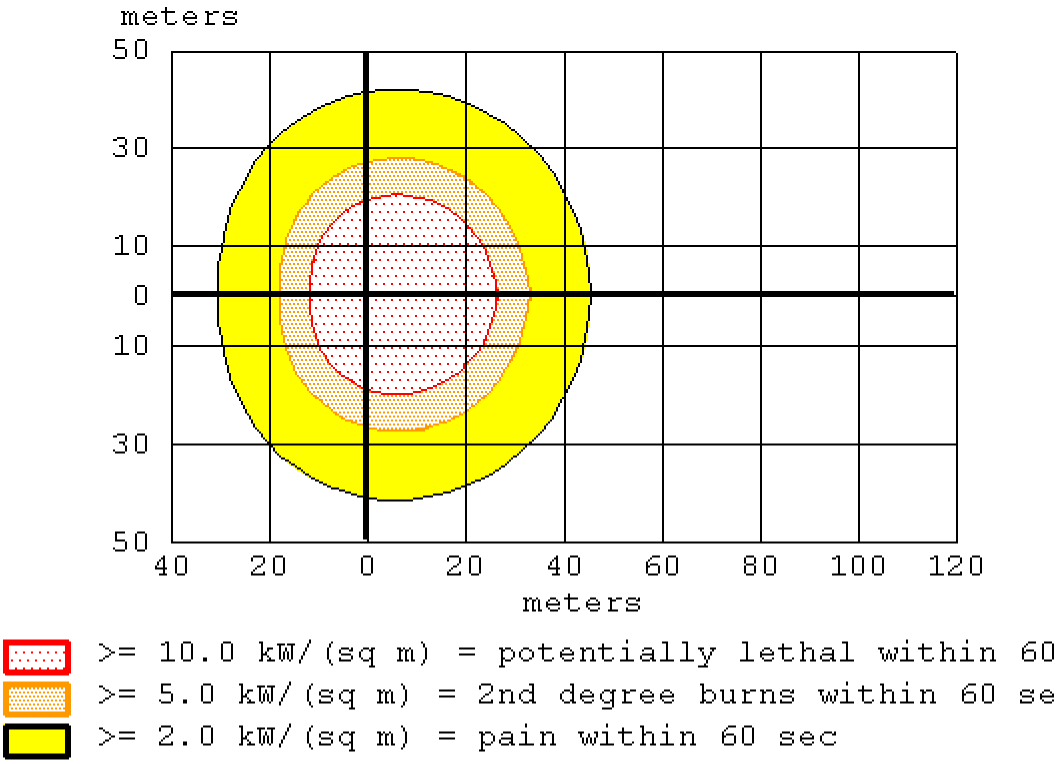
Red : 75 meters --- (1500 ppm = TEEL-3)

Orange: 160 meters --- (500 ppm = TEEL-2)

Yellow: 160 meters --- (500 ppm = TEEL-1)

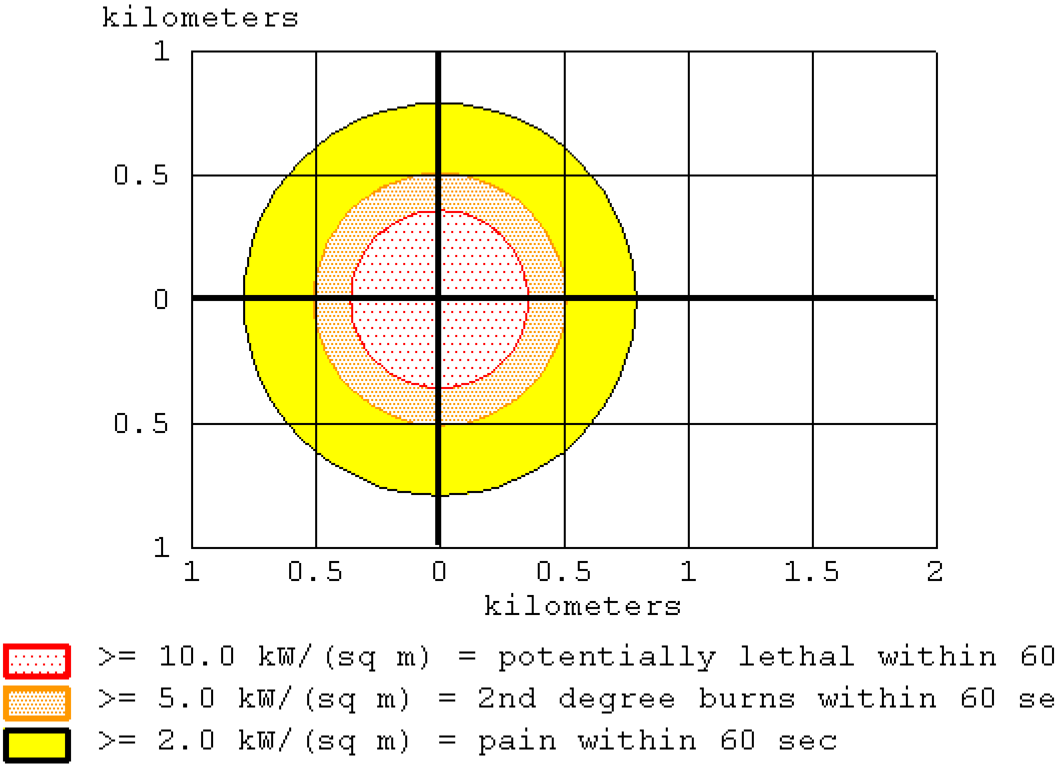
SC#3: Release of MS from Pipeline from VIZAG to Rajamundry

Pool Fire



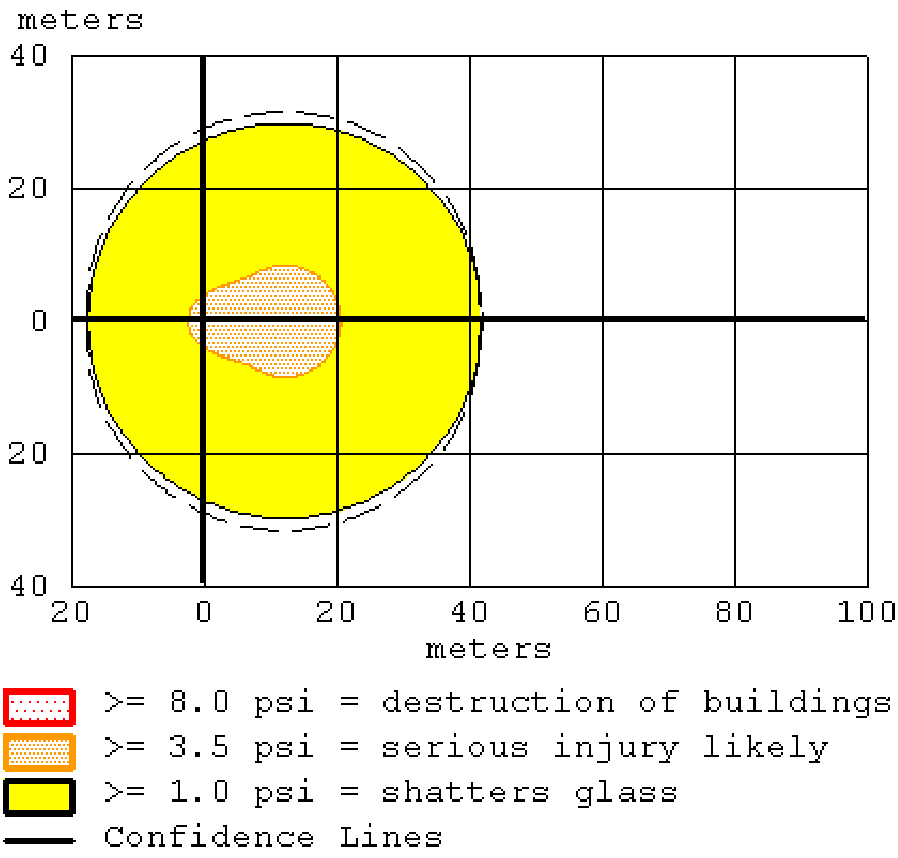
THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : 27 meters --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)
Orange: 33 meters --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)
Yellow: 46 meters --- (2.0 kW/ (sq m) = pain within 60 sec)

BLEVE:



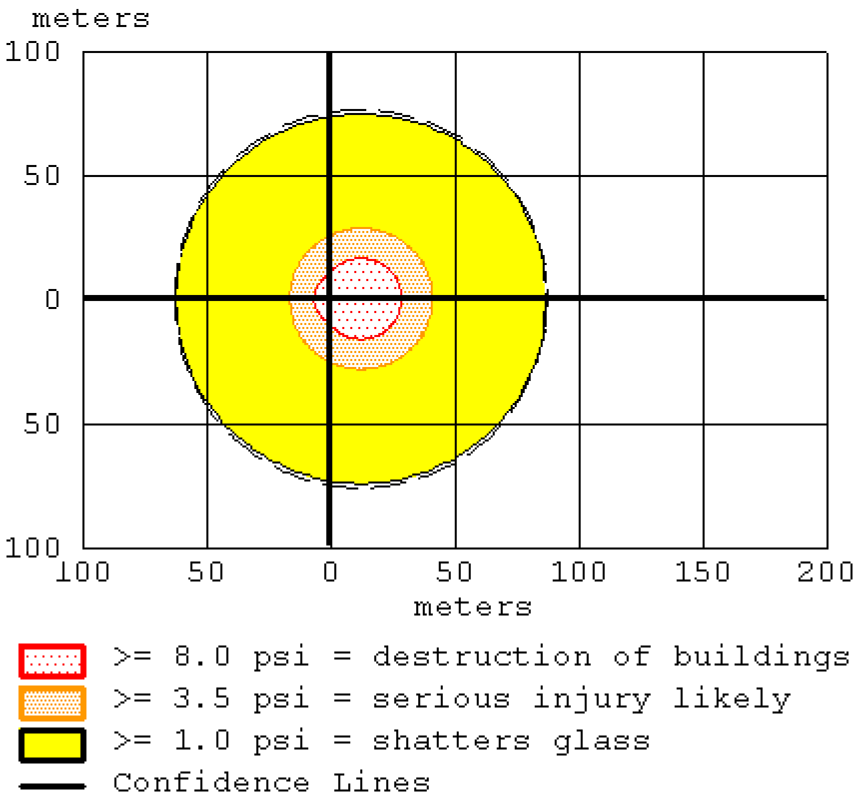
THREAT ZONE:
Threat Modeled: Thermal radiation from fireball
Red : 359 meters --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)
Orange: 507 meters --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)
Yellow: 790 meters --- (2.0 kW/ (sq m) = pain within 60 sec)

Vapour Cloud Explosion (ignited by Spark)



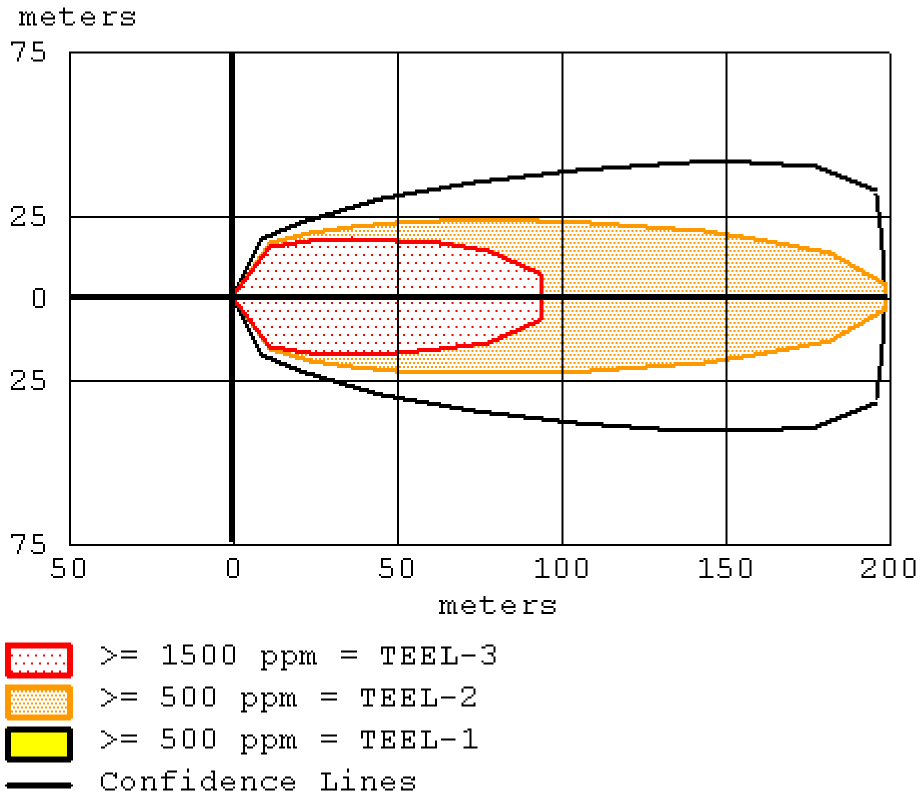
THREAT ZONE:
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Heavy Gas
Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)
Orange: 21 meters --- (3.5 psi = serious injury likely)
Yellow: 42 meters --- (1.0 psi = shatters glass)

Vapour Cloud Explosion (ignited by detonation)



THREAT ZONE:
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by detonation
Model Run: Heavy Gas
Red : 29 meters --- (8.0 psi = destruction of buildings)
Orange: 41 meters --- (3.5 psi = serious injury likely)
Yellow: 87 meters --- (1.0 psi = shatters glass)

Toxic Area of Vapour Cloud:



THREAT ZONE:

Model Run: Heavy Gas

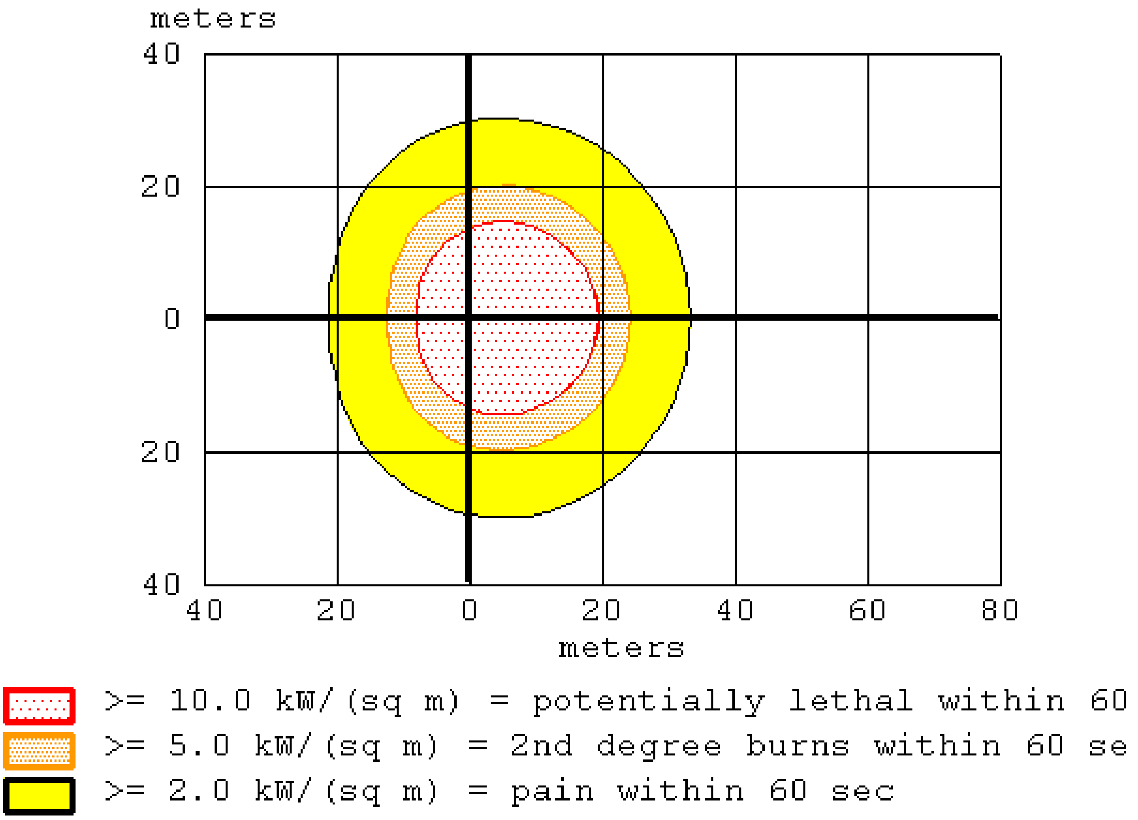
Red : 94 meters --- (1500 ppm = TEEL-3)

Orange: 199 meters --- (500 ppm = TEEL-2)

Yellow: 199 meters --- (500 ppm = TEEL-1)

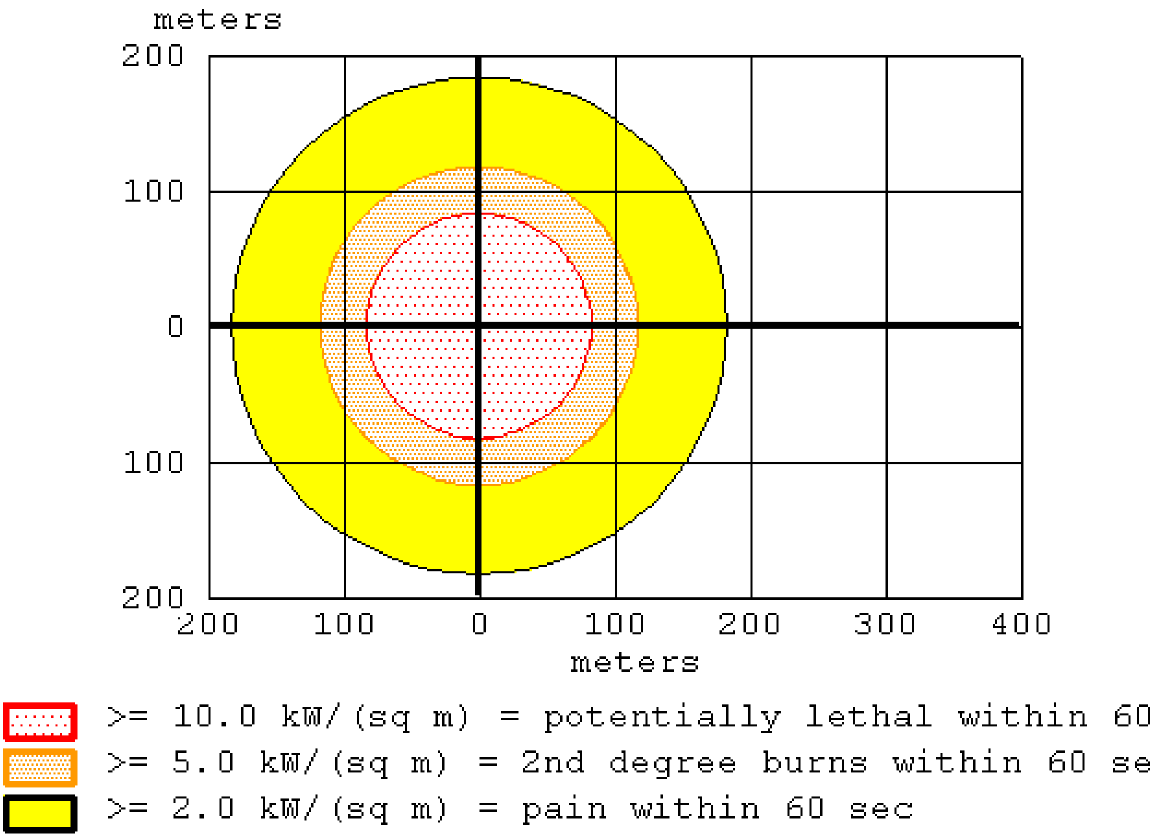
SC#4: Release of MS from Pipeline from Rajamundry to Vijaywada

Pool Fire:



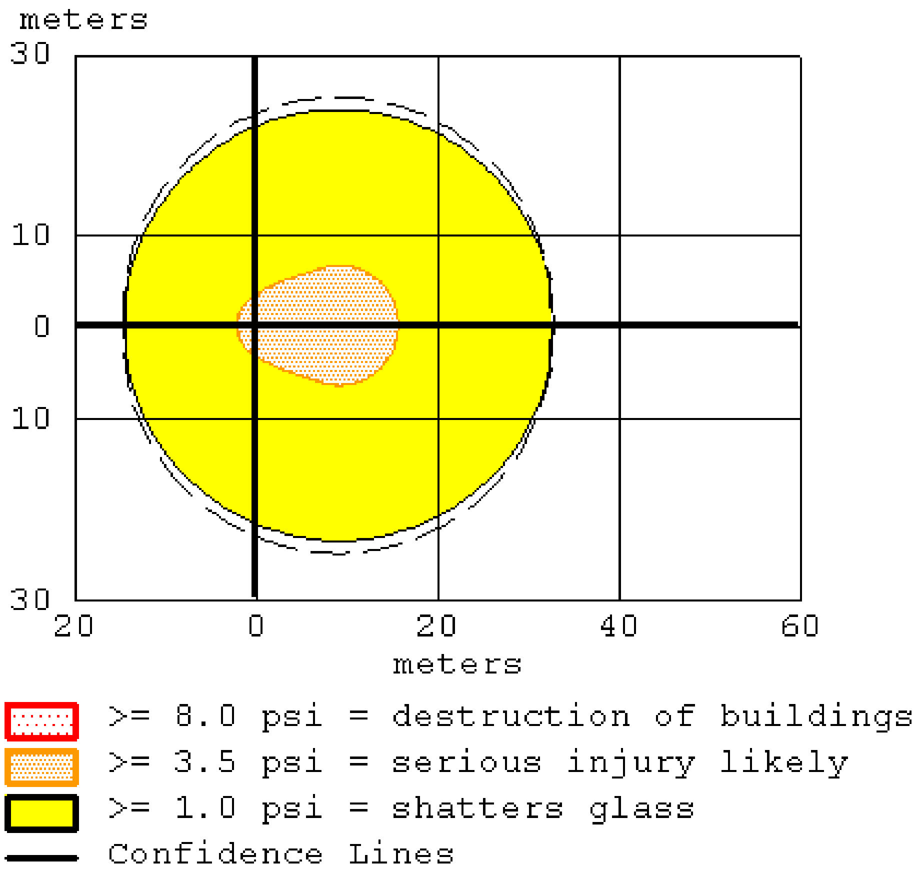
THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : 20 meters --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)
Orange: 24 meters --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)
Yellow: 33 meters --- (2.0 kW/ (sq m) = pain within 60 sec)

BLEVE



THREAT ZONE:
Threat Modeled: Thermal radiation from fireball
Red : 83 meters --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)
Orange: 117 meters --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)
Yellow: 183 meters --- (2.0 kW/ (sq m) = pain within 60 sec)

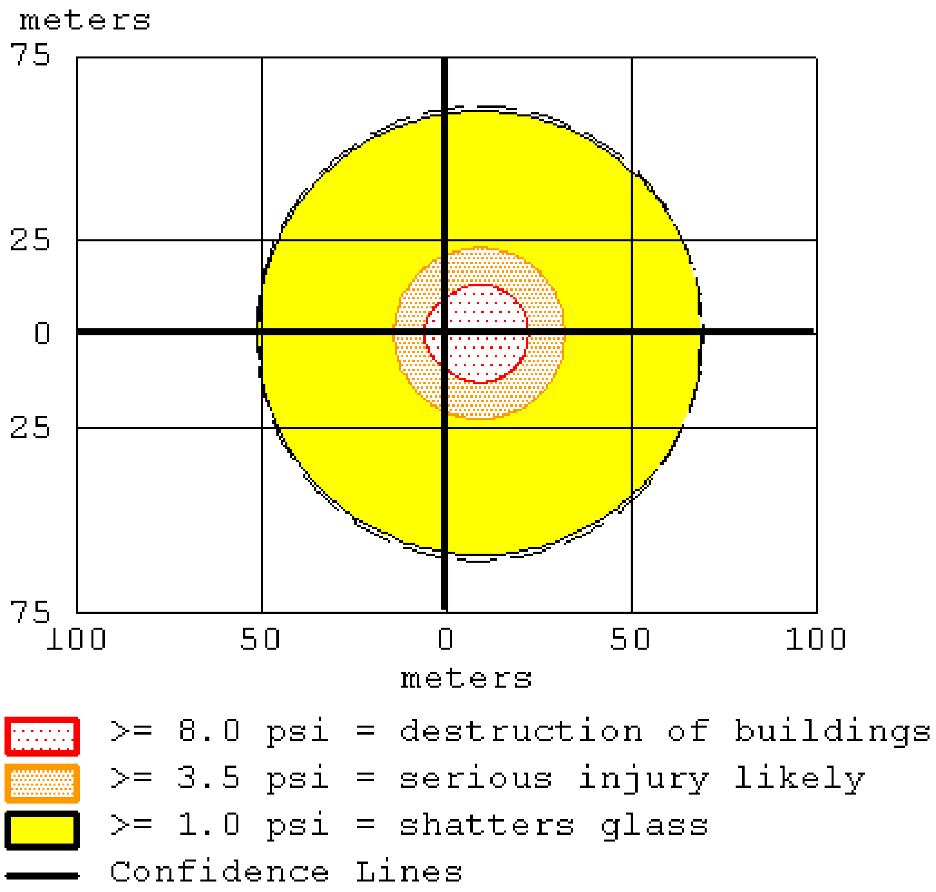
Vapour Cloud Explosion (ignited by Spark)



THREAT ZONE:

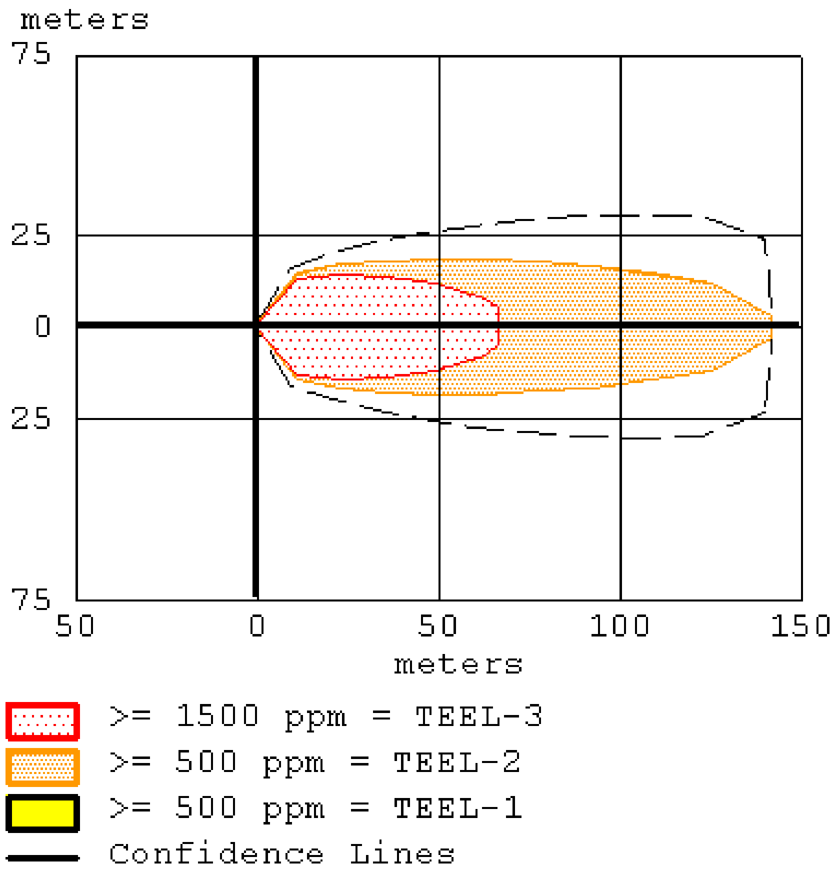
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Heavy Gas
Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)
Orange: 16 meters --- (3.5 psi = serious injury likely)
Yellow: 33 meters --- (1.0 psi = shatters glass)

Vapour Cloud Explosion (ignited by detonation)



THREAT ZONE:
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by detonation
Model Run: Heavy Gas
Red : 22 meters --- (8.0 psi = destruction of buildings)
Orange: 32 meters --- (3.5 psi = serious injury likely)
Yellow: 69 meters --- (1.0 psi = shatters glass)

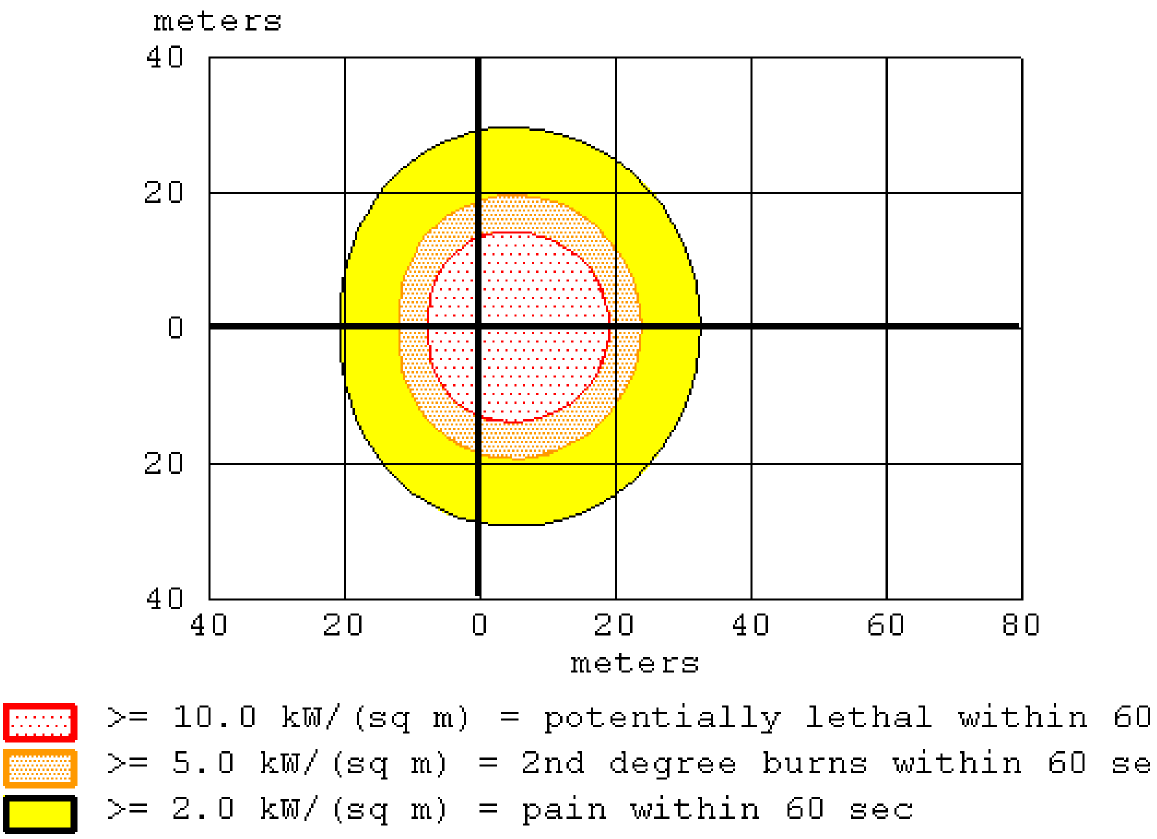
Toxic Area of Vapour Cloud:



THREAT ZONE:
Model Run: Heavy Gas
Red : 67 meters --- (1500 ppm = TEEL-3)
Orange: 142 meters --- (500 ppm = TEEL-2)
Yellow: 142 meters --- (500 ppm = TEEL-1)

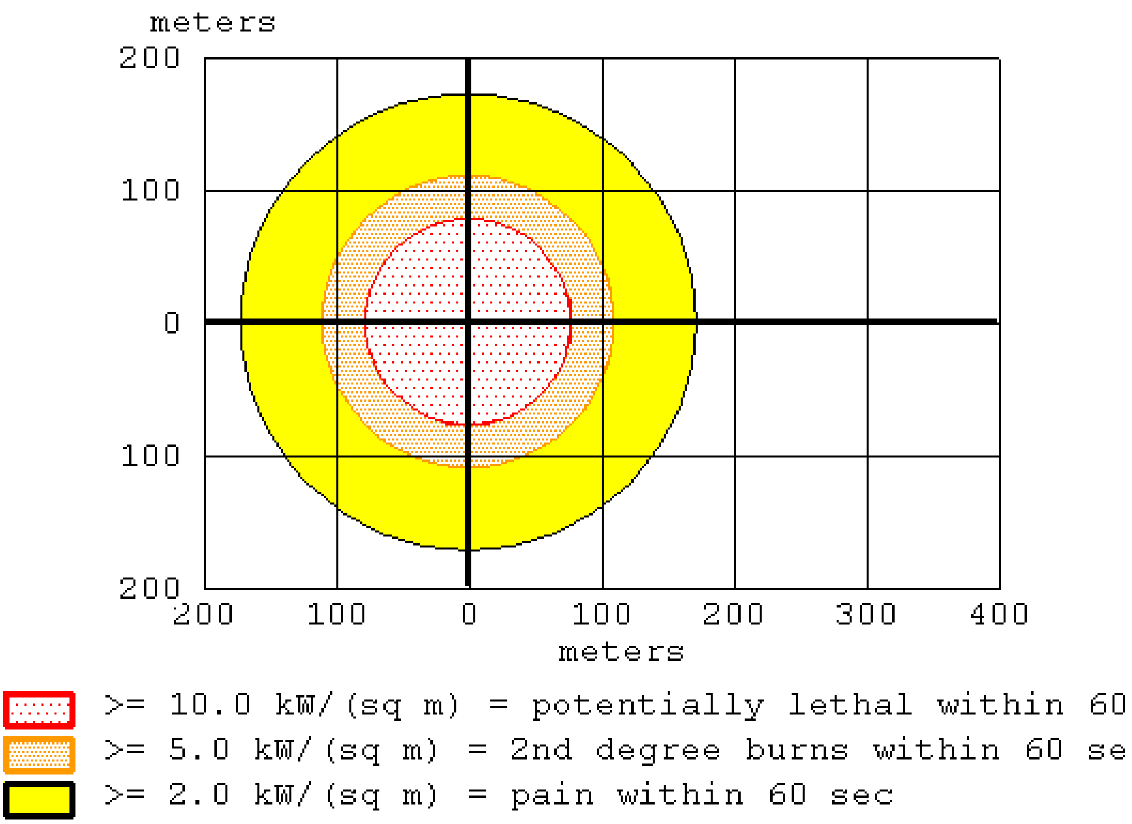
SC#5: Release of MS from Pipeline from Vijaywada to Hyderabad

Pool Fire:



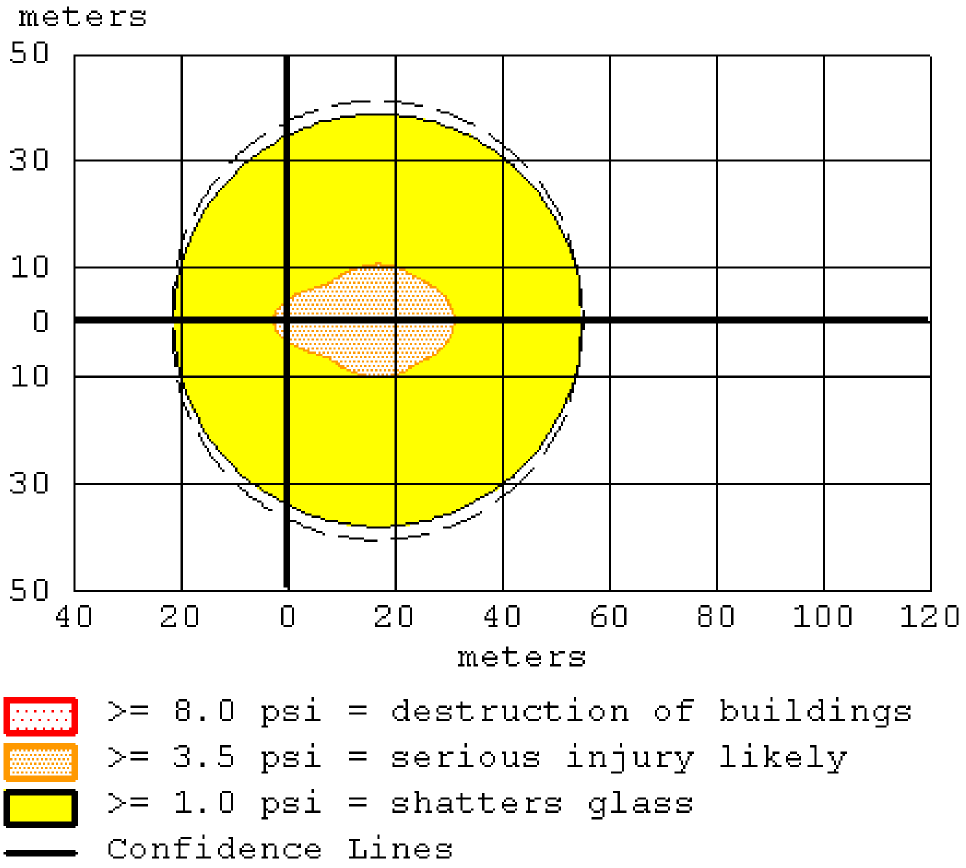
THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : 19 meters --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)
Orange: 24 meters --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)
Yellow: 33 meters --- (2.0 kW/ (sq m) = pain within 60 sec)

BLEVE:



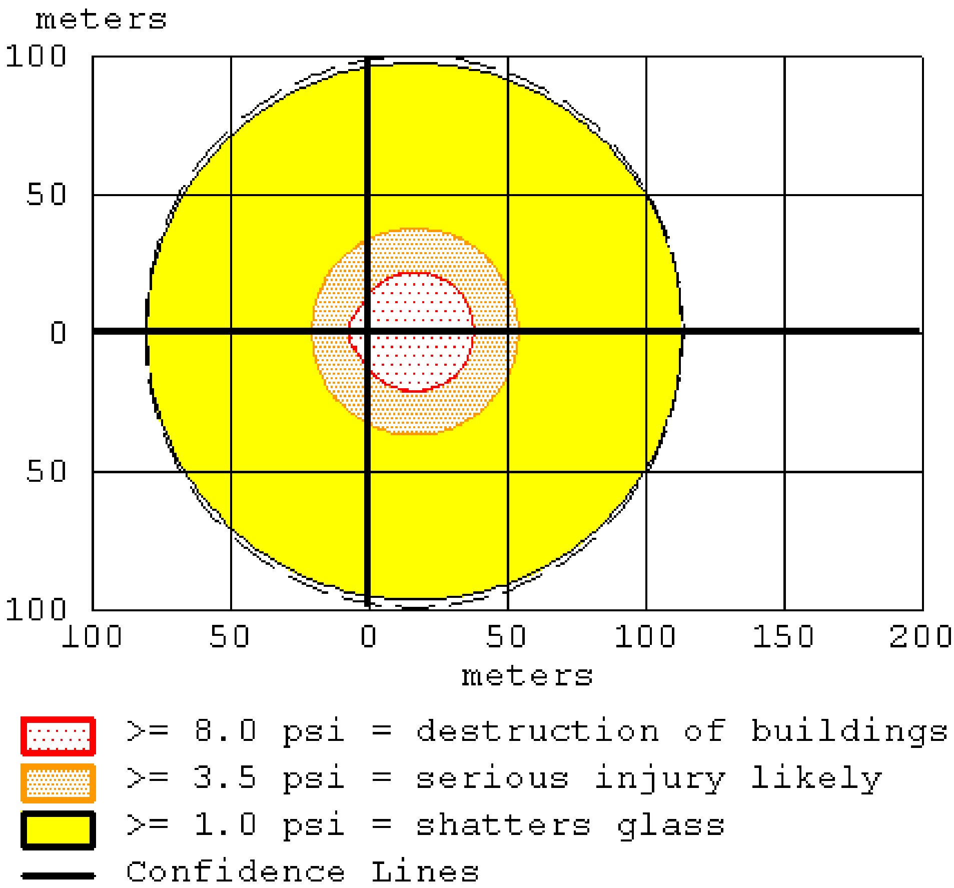
THREAT ZONE:
Threat Modeled: Thermal radiation from fireball
Red : 78 meters --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)
Orange: 110 meters --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)
Yellow: 172 meters --- (2.0 kW/ (sq m) = pain within 60 sec)

Vapour Cloud Explosion (ignited by Spark)



THREAT ZONE:
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Heavy Gas
Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)
Orange: 31 meters --- (3.5 psi = serious injury likely)
Yellow: 55 meters --- (1.0 psi = shatters glass)

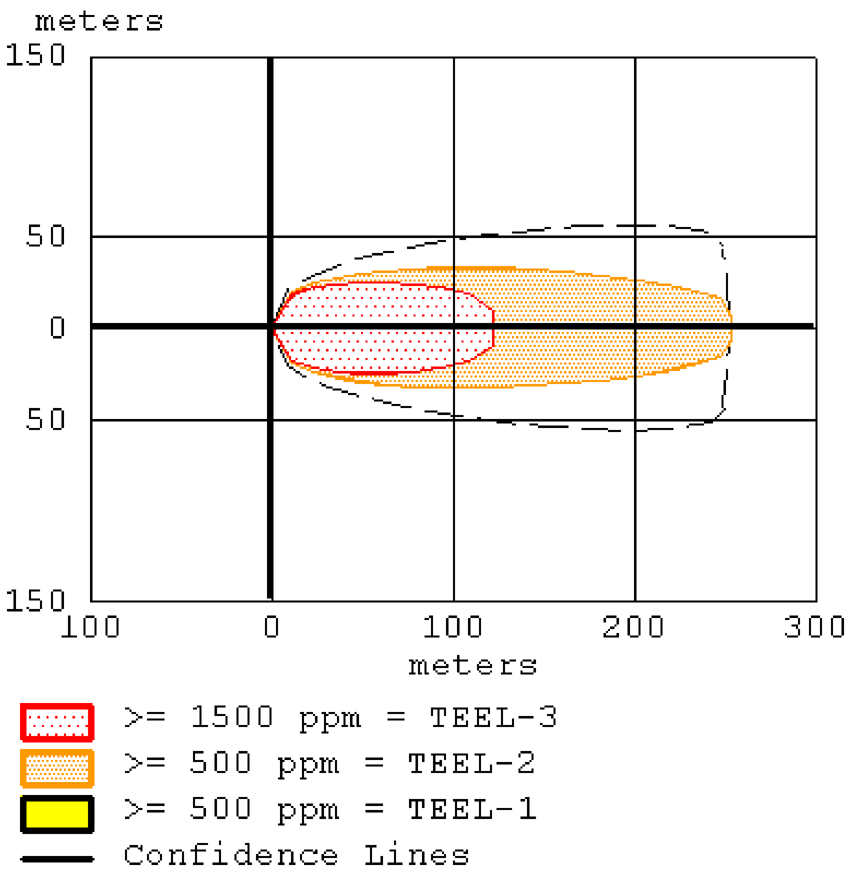
Vapour Cloud Explosion (ignited by Detonation)



THREAT ZONE:

Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by detonation
Model Run: Heavy Gas
Red : 39 meters --- (8.0 psi = destruction of buildings)
Orange: 54 meters --- (3.5 psi = serious injury likely)
Yellow: 114 meters --- (1.0 psi = shatters glass)

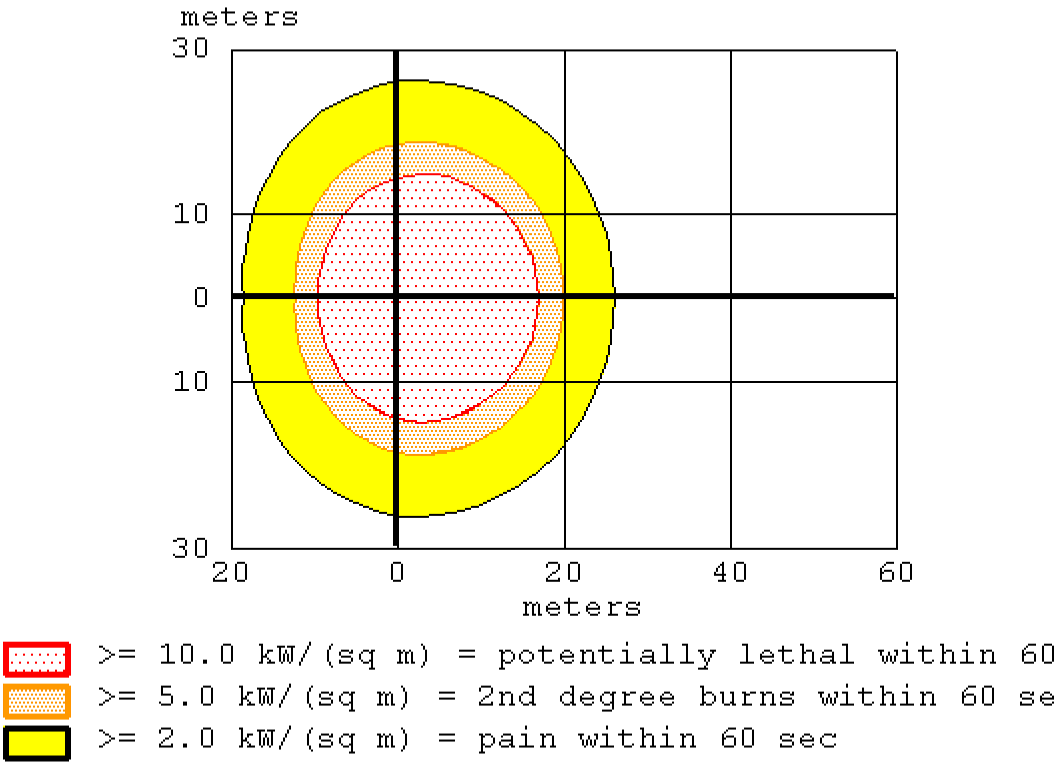
Toxic Threat Zone:



THREAT ZONE:
Model Run: Heavy Gas
Red : 122 meters --- (1500 ppm = TEEL-3)
Orange: 254 meters --- (500 ppm = TEEL-2)
Yellow: 254 meters --- (500 ppm = TEEL-1)

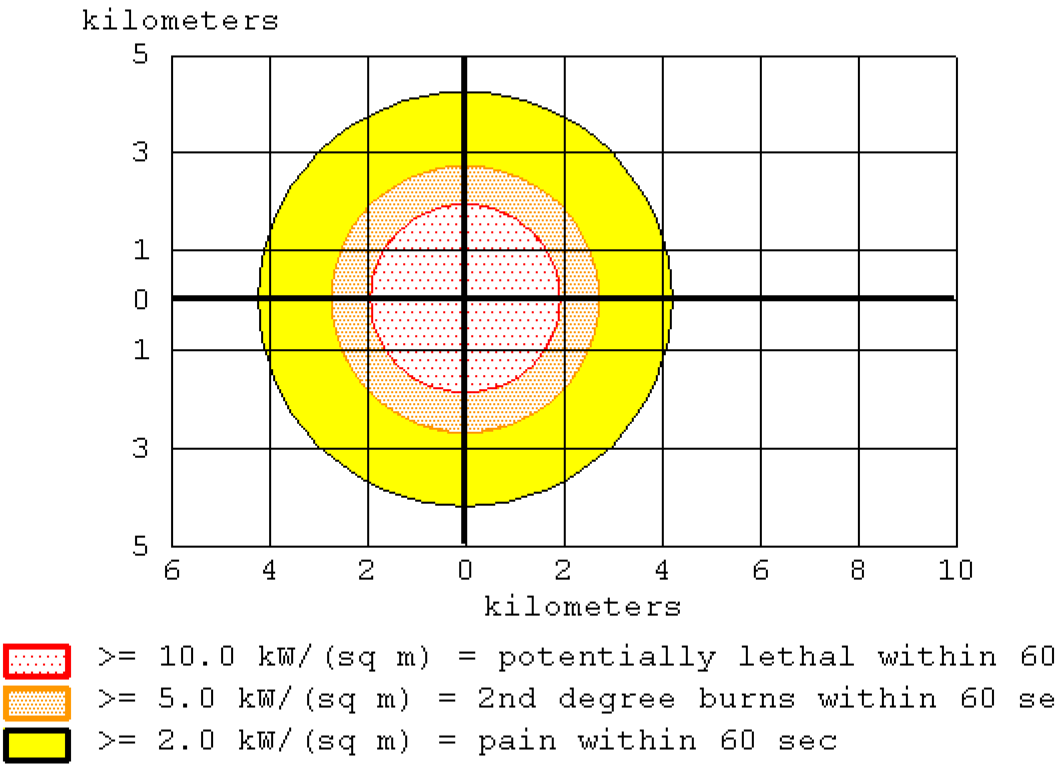
SC#6: Release of HSD from Pipeline from Paradip to Berahmpur

Pool Fire:



THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : 17 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: 27 meters --- (2.0 kW/ (sq m) = pain within 60 sec)

BLEVE



THREAT ZONE:

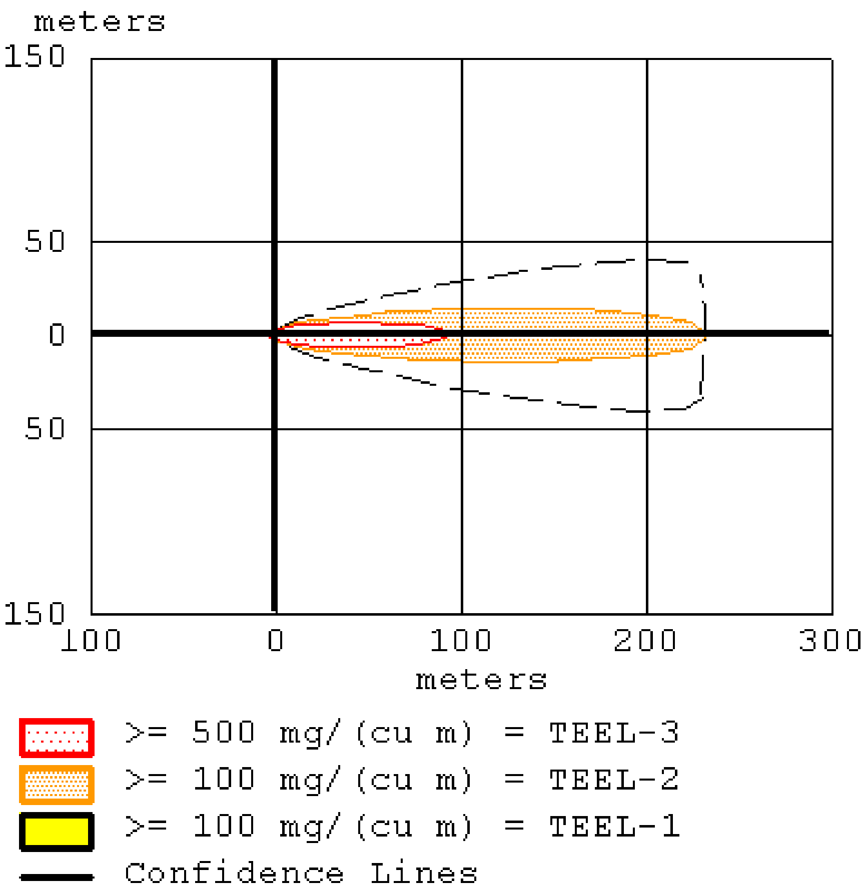
Threat Modeled: Thermal radiation from fireball

Red : 1.9 kilometers --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)

Orange: 2.7 kilometers --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)

Yellow: 4.2 kilometers --- (2.0 kW/ (sq m) = pain within 60 sec)

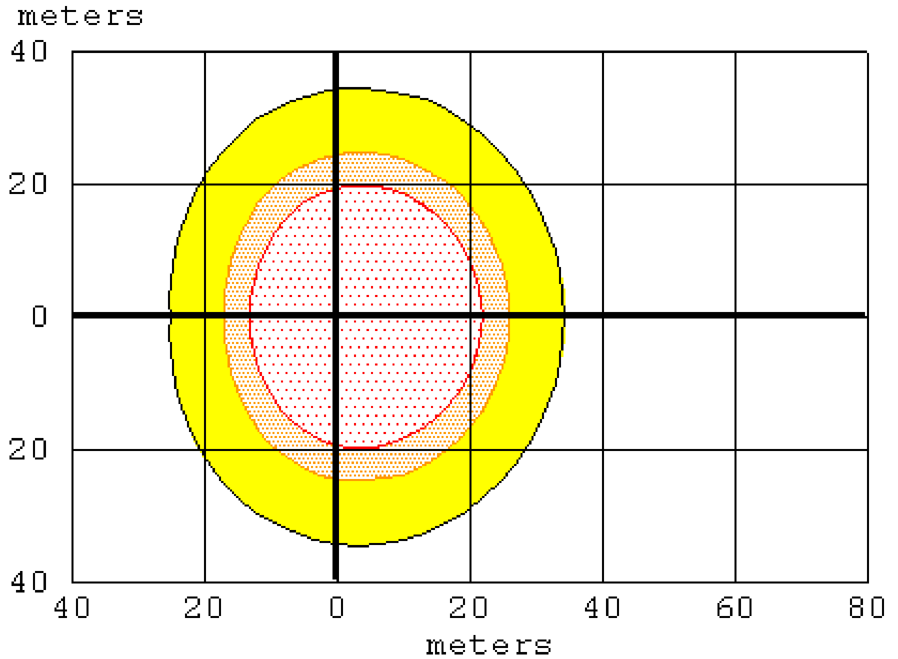
Toxic Threat Zone:



THREAT ZONE:
Model Run: Heavy Gas
Red : 95 meters --- (500 mg/ (cu m) = TEEL-3)
Orange: 232 meters --- (100 mg/ (cu m) = TEEL-2)
Yellow: 232 meters --- (100 mg/ (cu m) = TEEL-1)

SC#7: Release of HSD from Pipeline from Berahmpur to VIZAG

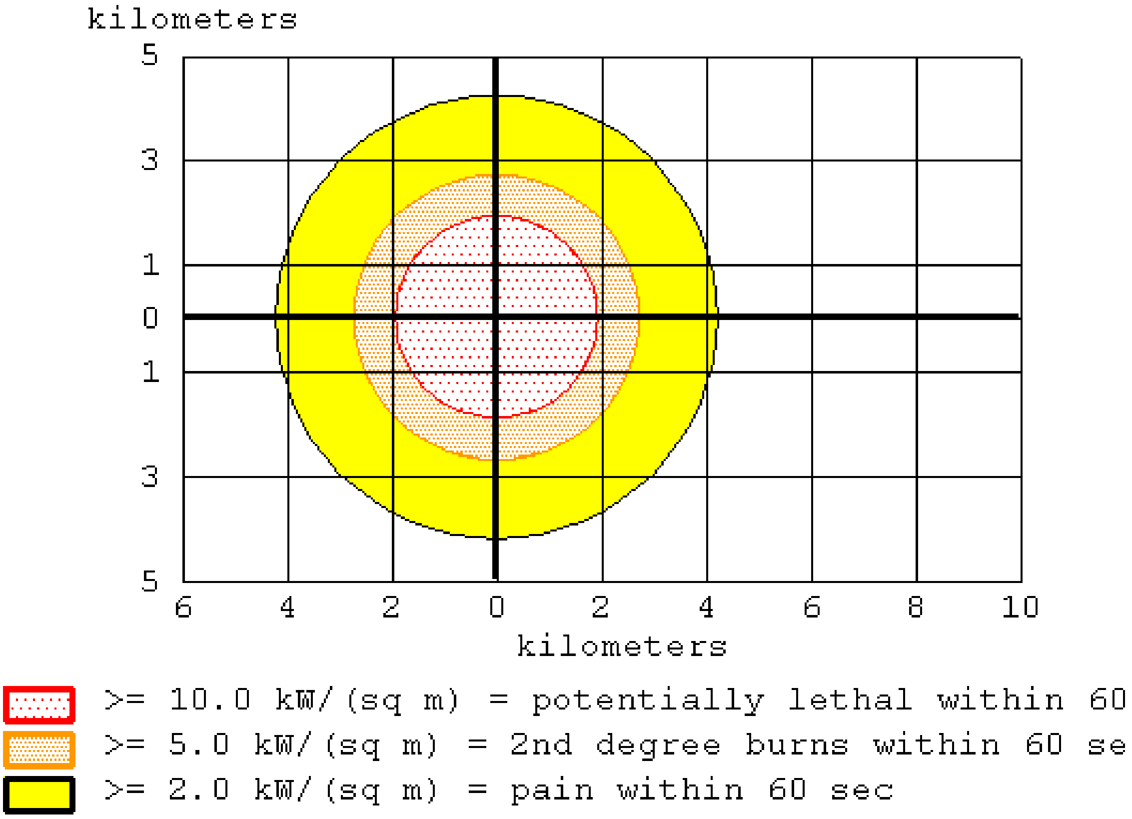
Pool Fire:



>= 10.0 kW/ (sq m) = potentially lethal within 60
>= 5.0 kW/ (sq m) = 2nd degree burns within 60 se
>= 2.0 kW/ (sq m) = pain within 60 sec

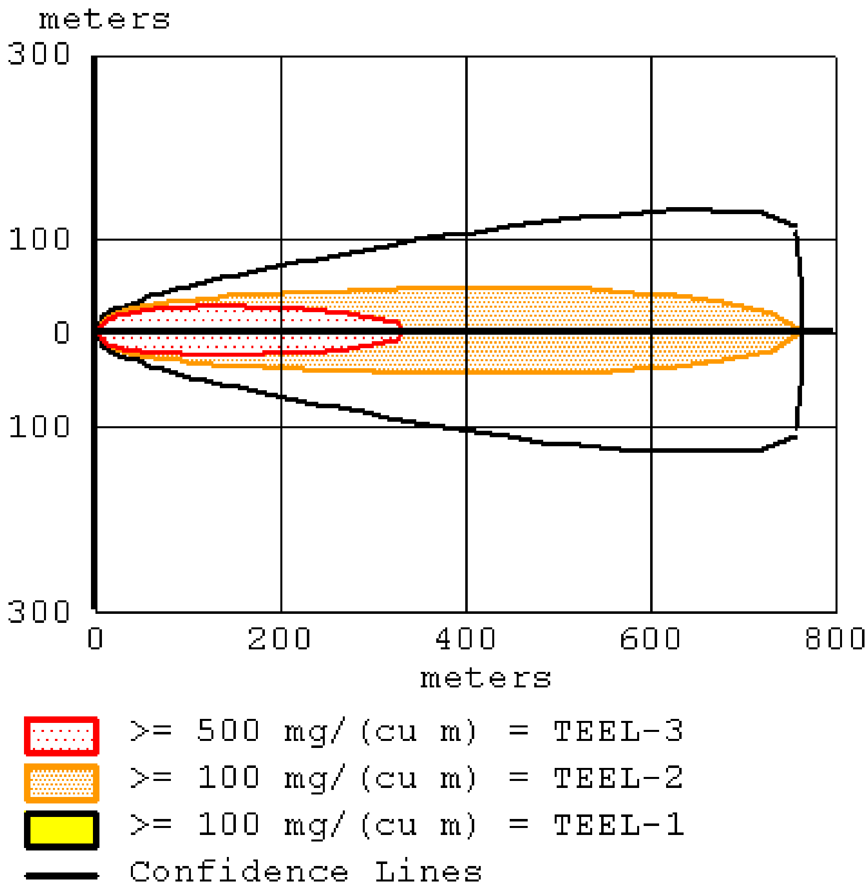
THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : 22 meters --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)
Orange: 26 meters --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)
Yellow: 35 meters --- (2.0 kW/ (sq m) = pain within 60 sec)

BLEVE:



THREAT ZONE:
Threat Modeled: Thermal radiation from fireball
Red : 1.9 kilometers --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)
Orange: 2.7 kilometers --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)
Yellow: 4.2 kilometers --- (2.0 kW/ (sq m) = pain within 60 sec)

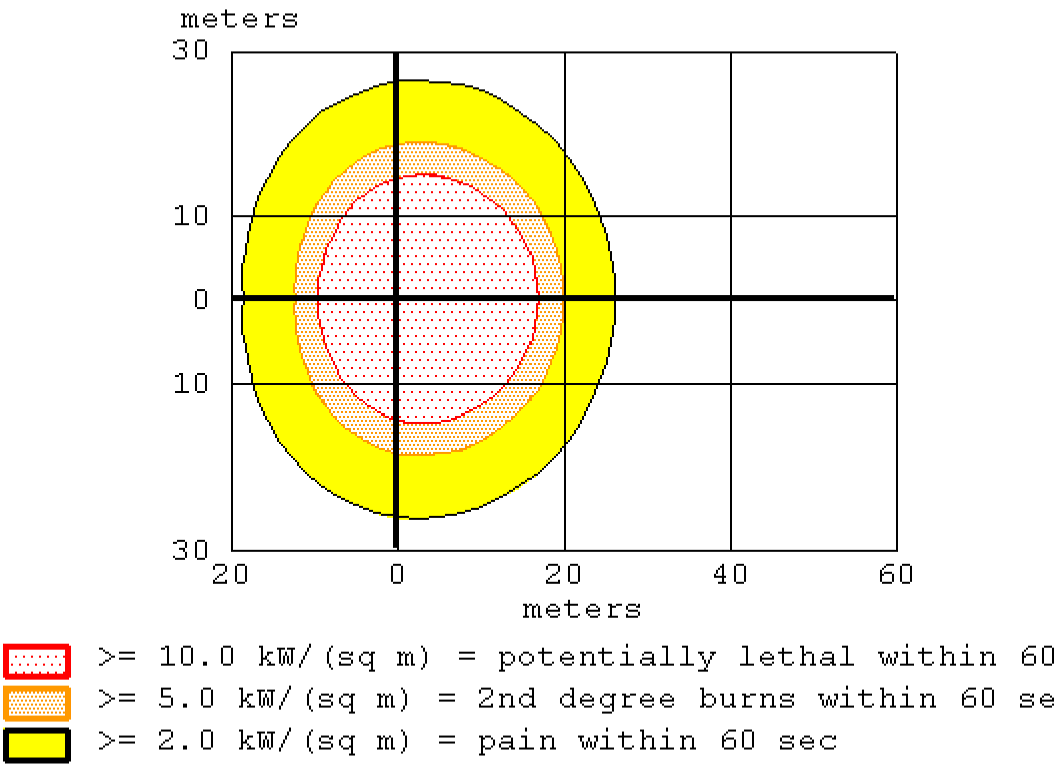
Toxic Threat Zone :



THREAT ZONE:
Model Run: Heavy Gas
Red : 333 meters --- (500 mg/ (cu m) = TEEL-3)
Orange: 765 meters --- (100 mg/ (cu m) = TEEL-2)
Yellow: 765 meters --- (100 mg/ (cu m) = TEEL-1)

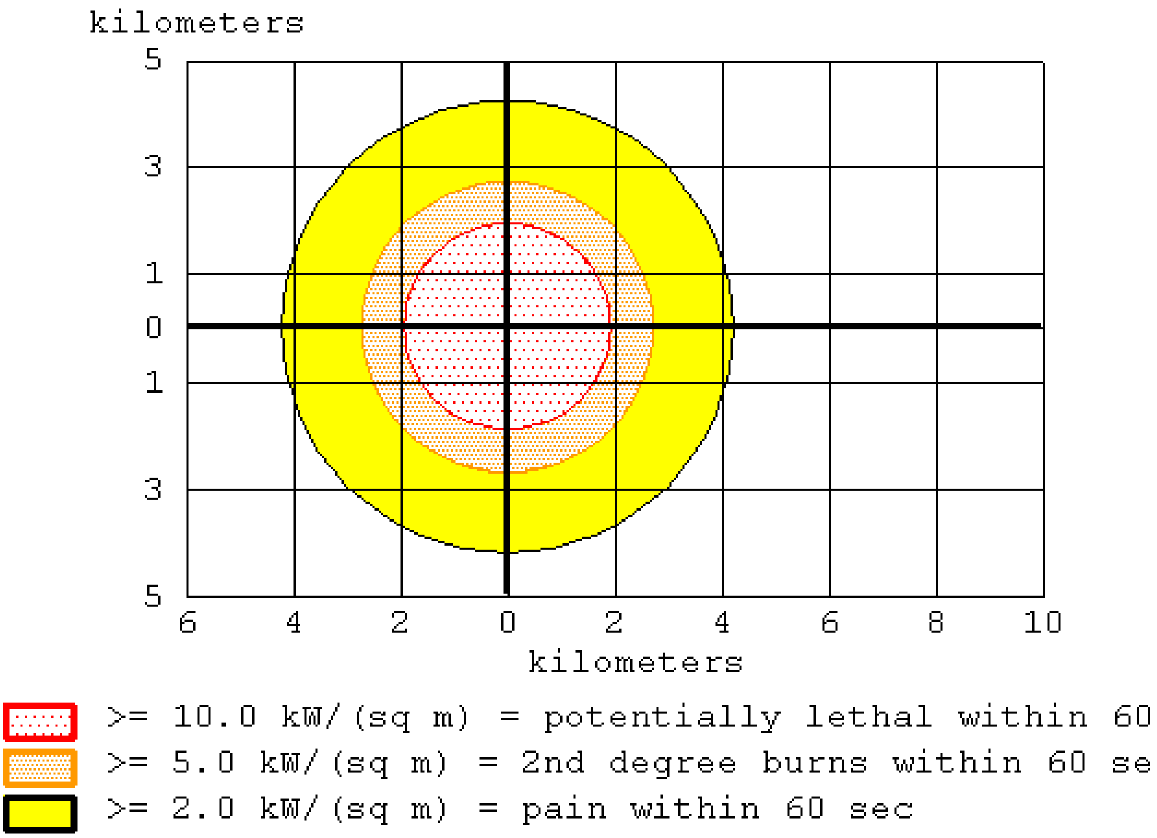
SC#8: Release of HSD from Pipeline from VIZAG to Rajahmundry

Pool Fire:



THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : 17 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: 27 meters --- (2.0 kW/ (sq m) = pain within 60 sec)

BLEVE:



THREAT ZONE:

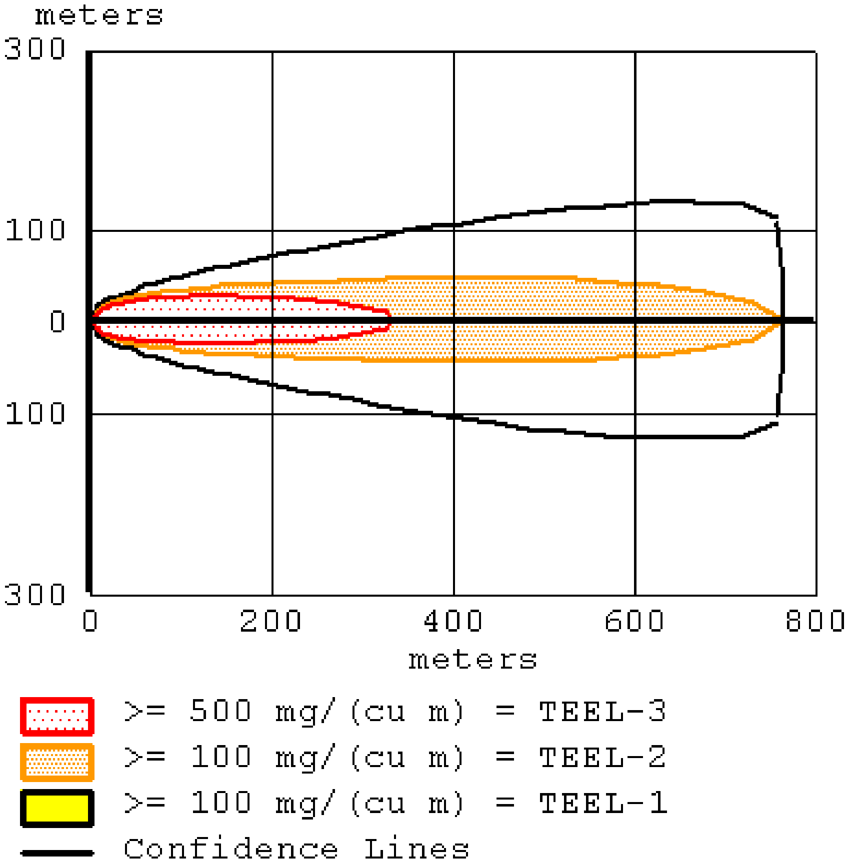
Threat Modeled: Thermal radiation from fireball

Red : 1.9 kilometers --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)

Orange: 2.7 kilometers --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)

Yellow: 4.2 kilometers --- (2.0 kW/ (sq m) = pain within 60 sec)

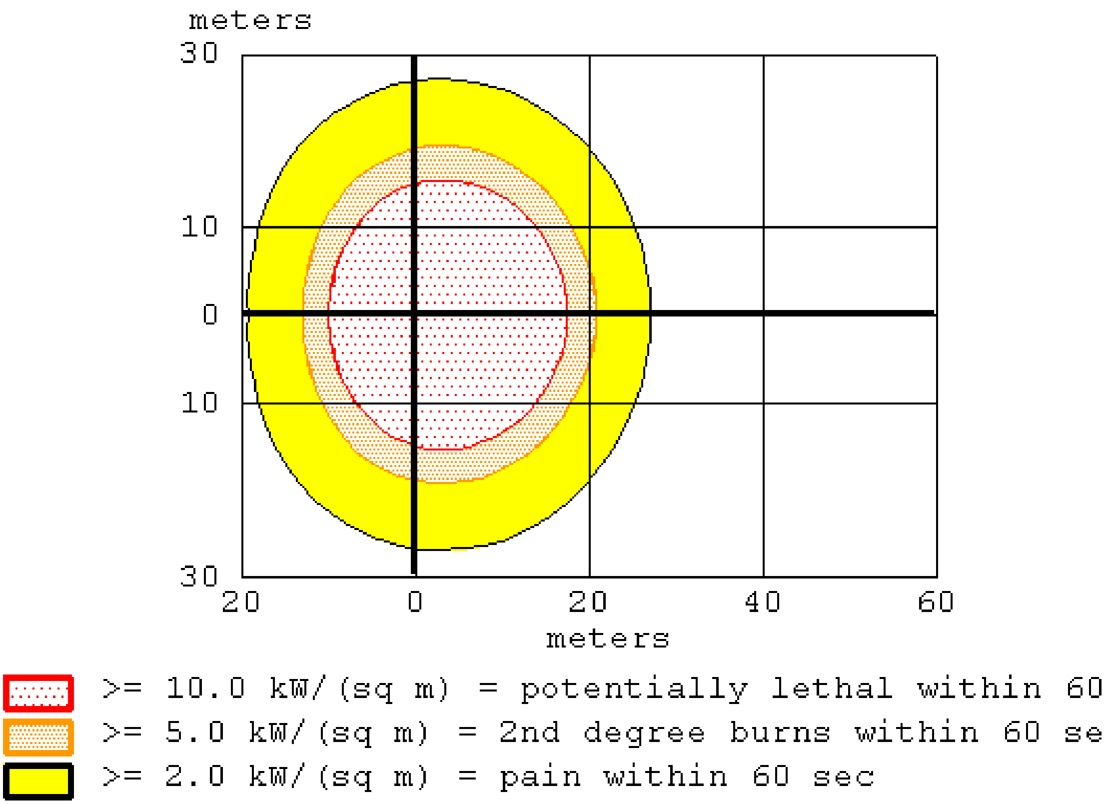
Toxic Threat Zone:



THREAT ZONE:
Model Run: Heavy Gas
Red : 333 meters --- (500 mg/ (cu m) = TEEL-3)
Orange: 765 meters --- (100 mg/ (cu m) = TEEL-2)
Yellow: 765 meters --- (100 mg/ (cu m) = TEEL-1)

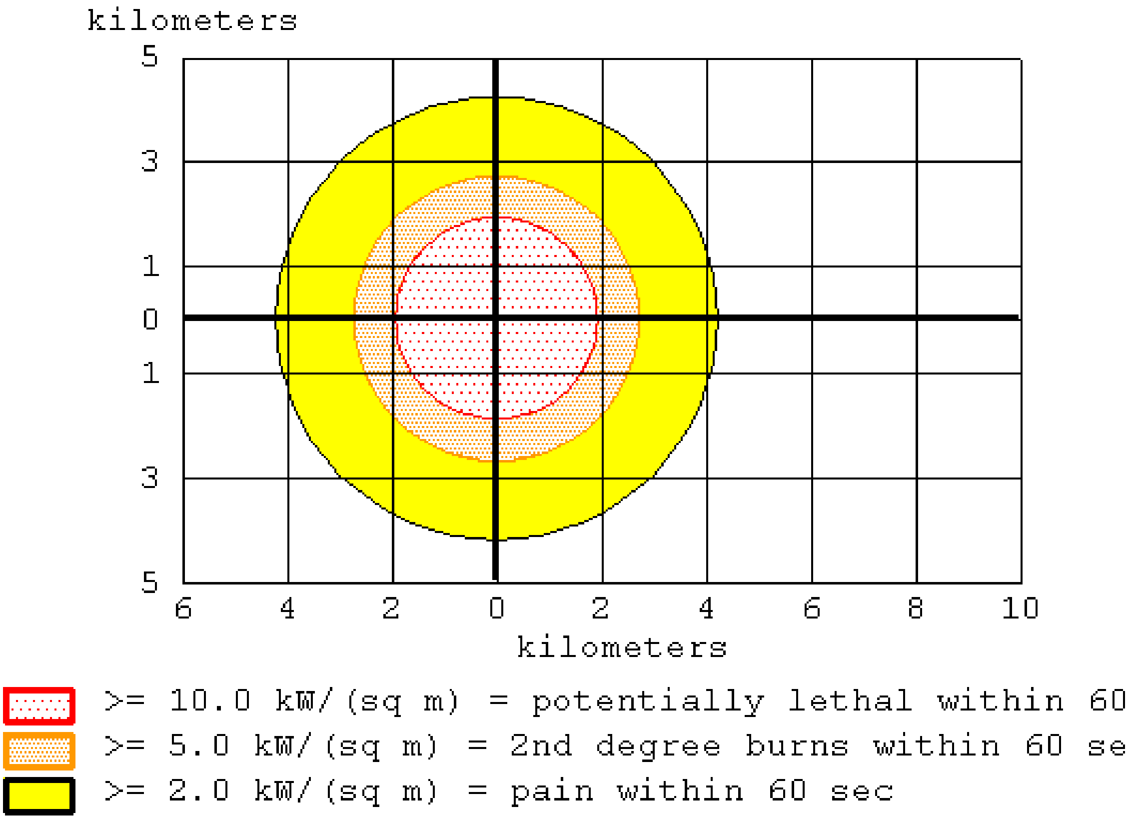
SC#9: Release of HSD from Pipeline from Rajahmundry to Vijaywada

Pool Fire:



THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : 18 meters --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)
Orange: 21 meters --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)
Yellow: 28 meters --- (2.0 kW/ (sq m) = pain within 60 sec)

BLEVE:



THREAT ZONE:

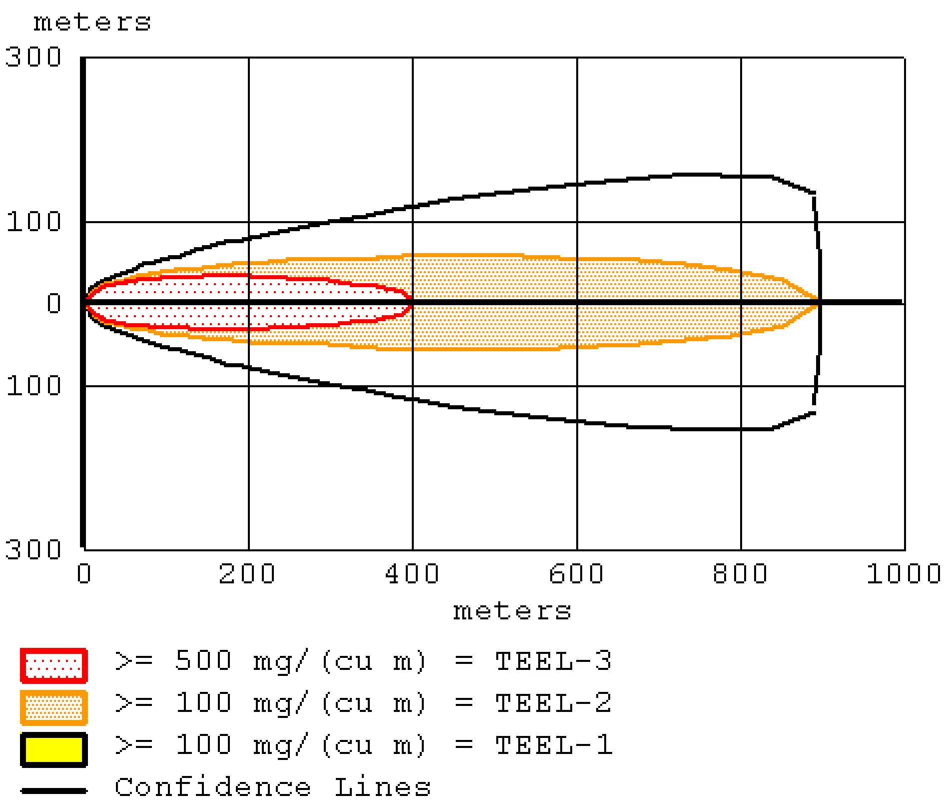
Threat Modeled: Thermal radiation from fireball

Red : 1.9 kilometers --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)

Orange: 2.7 kilometers --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)

Yellow: 4.2 kilometers --- (2.0 kW/ (sq m) = pain within 60 sec)

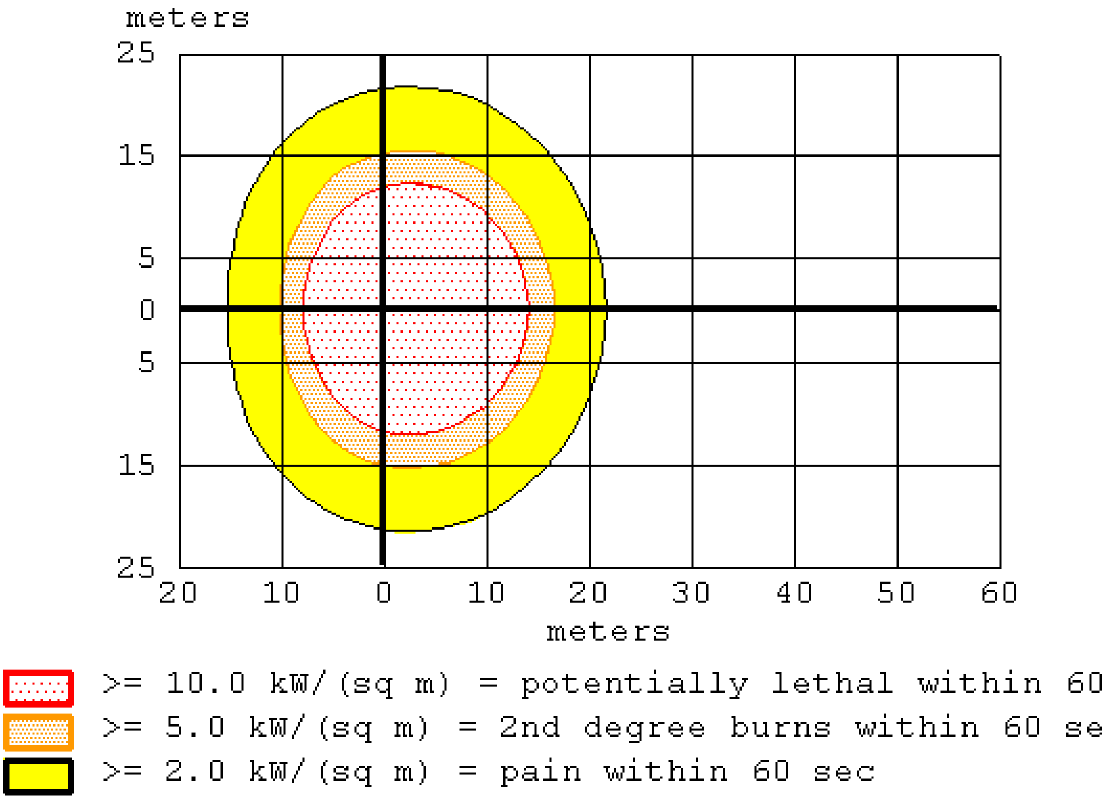
Toxic Threat Zone:



THREAT ZONE:
Model Run: Heavy Gas
Red : 402 meters --- (500 mg/ (cu m) = TEEL-3)
Orange: 899 meters --- (100 mg/ (cu m) = TEEL-2)
Yellow: 899 meters --- (100 mg/ (cu m) = TEEL-1)

SC# 10: Release of HSD from Pipeline from Vijaywada to Hyderabad

Pool Fire:



THREAT ZONE:

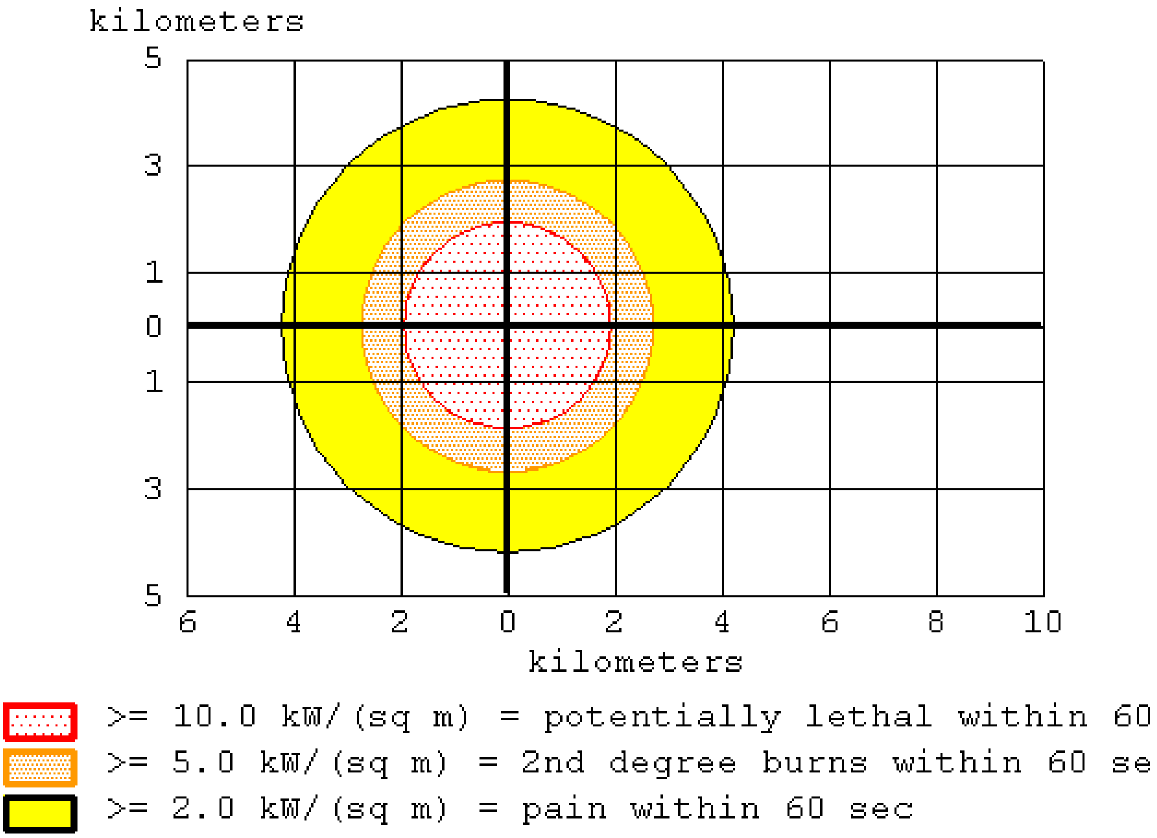
Threat Modeled: Thermal radiation from pool fire

Red : 14 meters --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)

Orange: 17 meters --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)

Yellow: 22 meters --- (2.0 kW/ (sq m) = pain within 60 sec)

BLEVE :



THREAT ZONE:

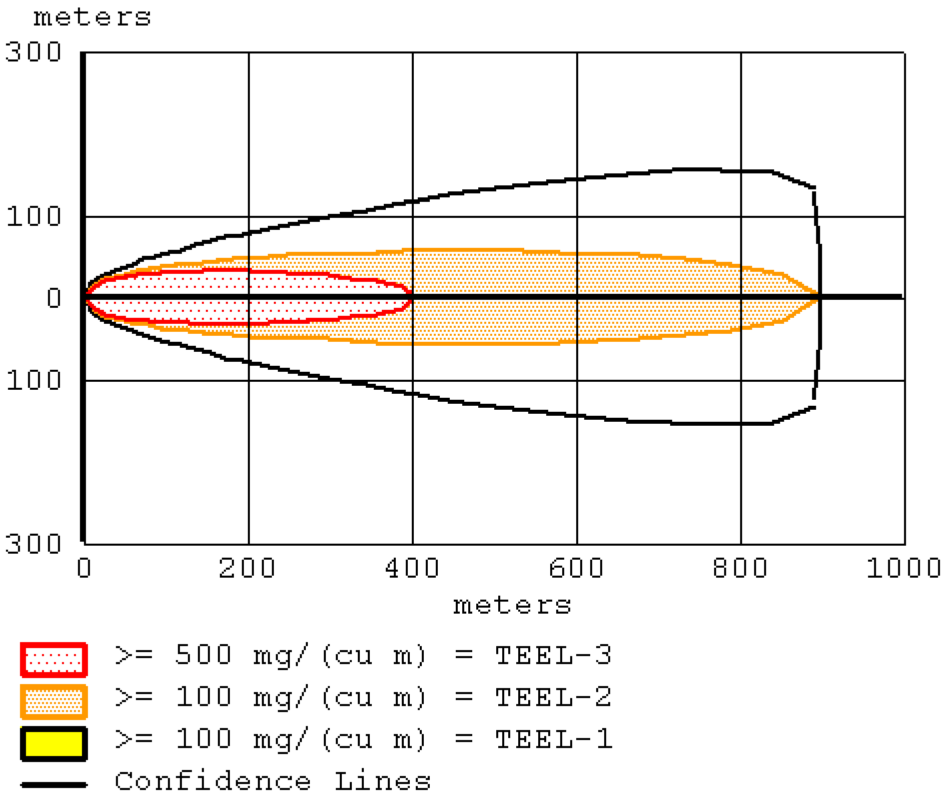
Threat Modeled: Thermal radiation from fireball

Red : 1.9 kilometers --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)

Orange: 2.7 kilometers --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)

Yellow: 4.2 kilometers --- (2.0 kW/ (sq m) = pain within 60 sec)

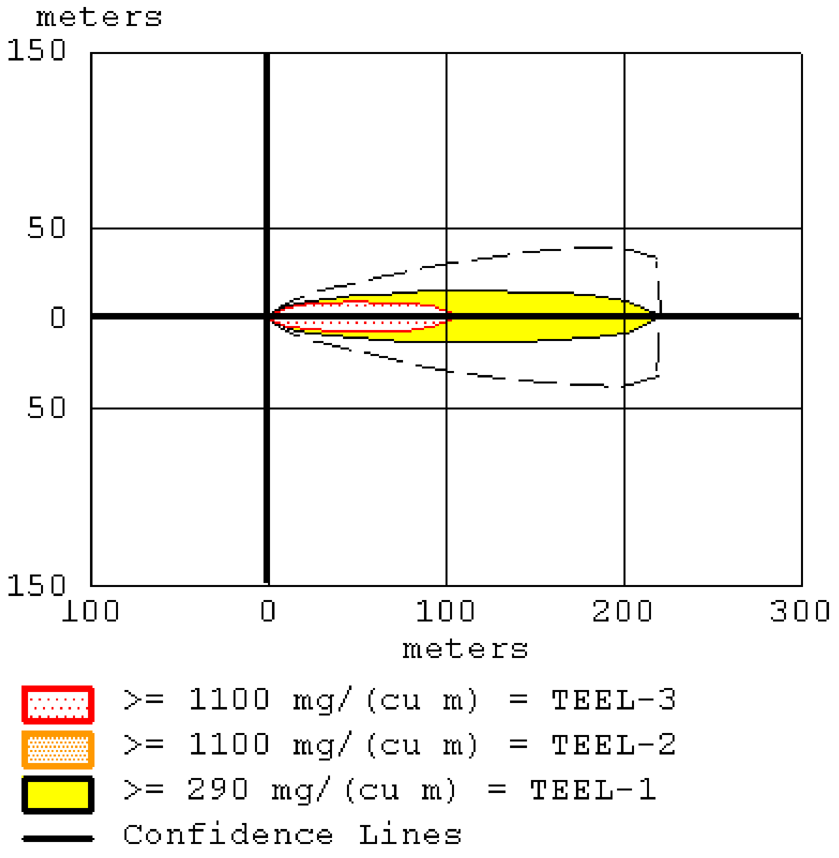
Toxic Threat Zone:



THREAT ZONE:
Model Run: Heavy Gas
Red : 402 meters --- (500 mg/ (cu m) = TEEL-3)
Orange: 899 meters --- (100 mg/ (cu m) = TEEL-2)
Yellow: 899 meters --- (100 mg/ (cu m) = TEEL-1)

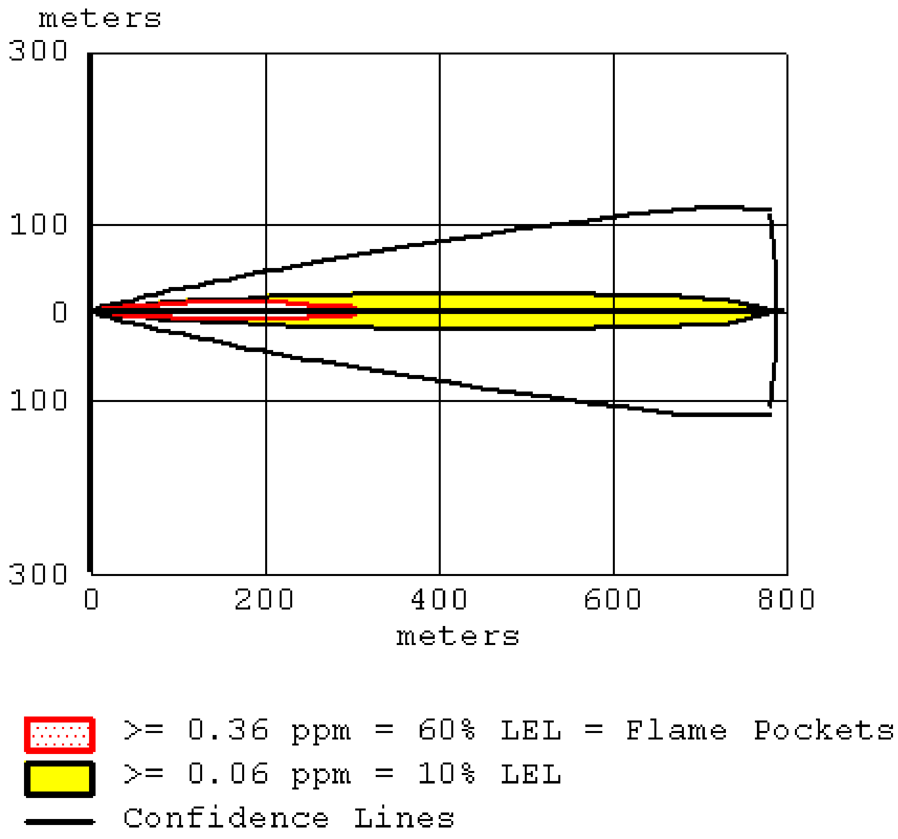
SC#11: Release of SKO from Pipeline from Paradip to Berahmpur

Toxic Threat Zone



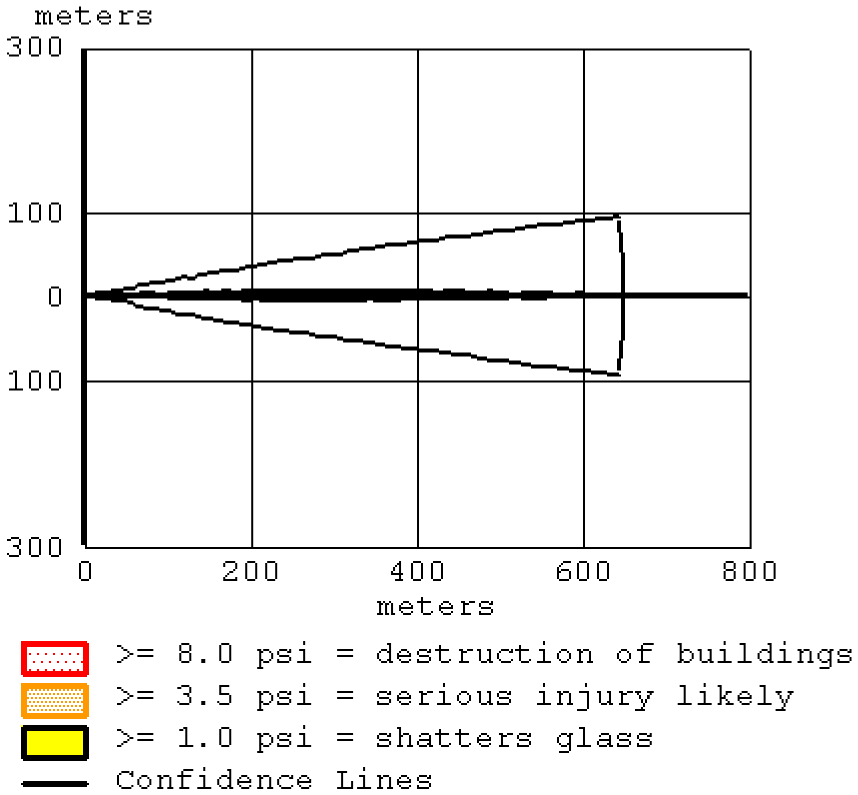
THREAT ZONE:
Model Run: Heavy Gas
Red : 108 meters --- (1100 mg/ (cu m) = TEEL-3)
Orange: 108 meters --- (1100 mg/ (cu m) = TEEL-2)
Yellow: 222 meters --- (290 mg/ (cu m) = TEEL-1)

Flammable Area of Vapour Cloud



THREAT ZONE:
Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : 312 meters --- (0.36 ppm = 60% LEL = Flame Pockets)
Yellow: 789 meters --- (0.06 ppm = 10% LEL)

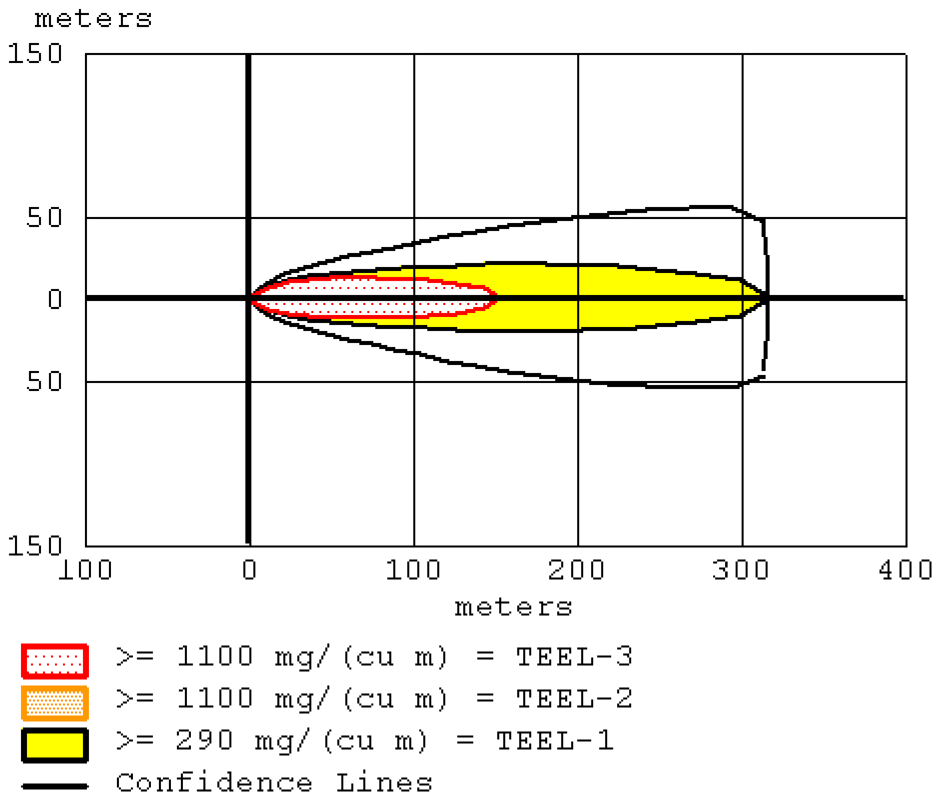
Vapor Cloud Explosion (ignited by spark or flame)



THREAT ZONE:
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Heavy Gas
Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)
Orange: 650 meters --- (3.5 psi = serious injury likely)
Yellow: 650 meters --- (1.0 psi = shatters glass)

SC#12: Release of SKO from Pipeline from Berahmpur to VIZAG

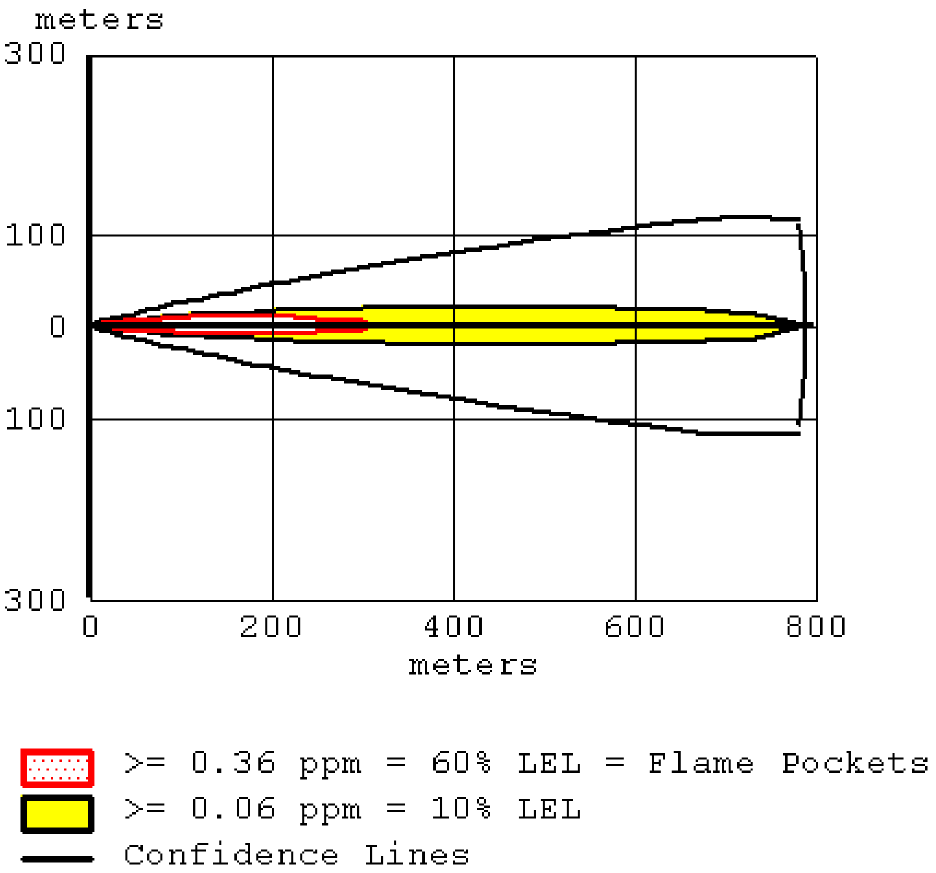
Toxic Threat Zone :



THREAT ZONE:

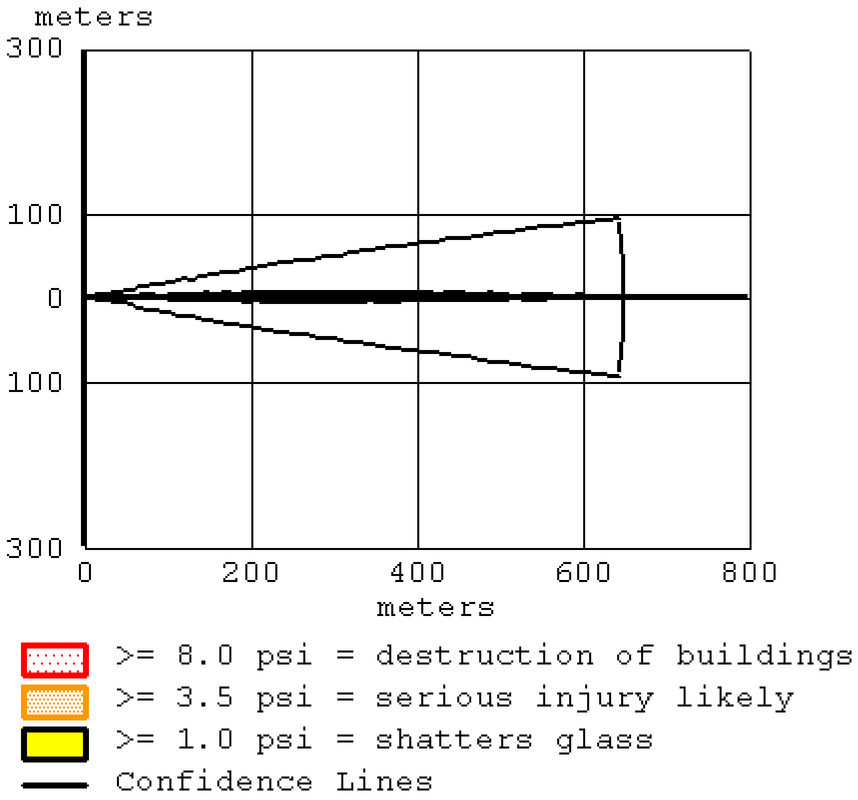
Model Run: Heavy Gas
Red : 153 meters --- (1100 mg/ (cu m) = TEEL-3)
Orange: 153 meters --- (1100 mg/ (cu m) = TEEL-2)
Yellow: 317 meters --- (290 mg/ (cu m) = TEEL-1)

Flammable Area of Vapour Cloud



THREAT ZONE:
Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : 312 meters --- (0.36 ppm = 60% LEL = Flame Pockets)
Yellow: 789 meters --- (0.06 ppm = 10% LEL)

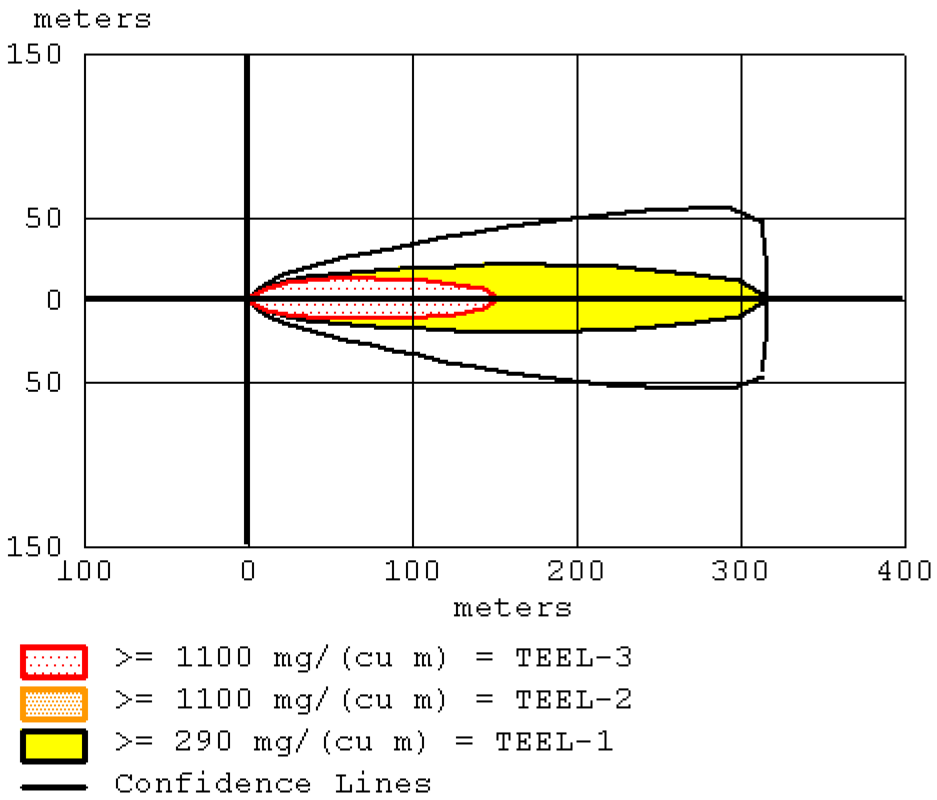
Vapor Cloud Explosion (Ignited by Spark)



THREAT ZONE:
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Heavy Gas
Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)
Orange: 650 meters --- (3.5 psi = serious injury likely)
Yellow: 650 meters --- (1.0 psi = shatters glass)

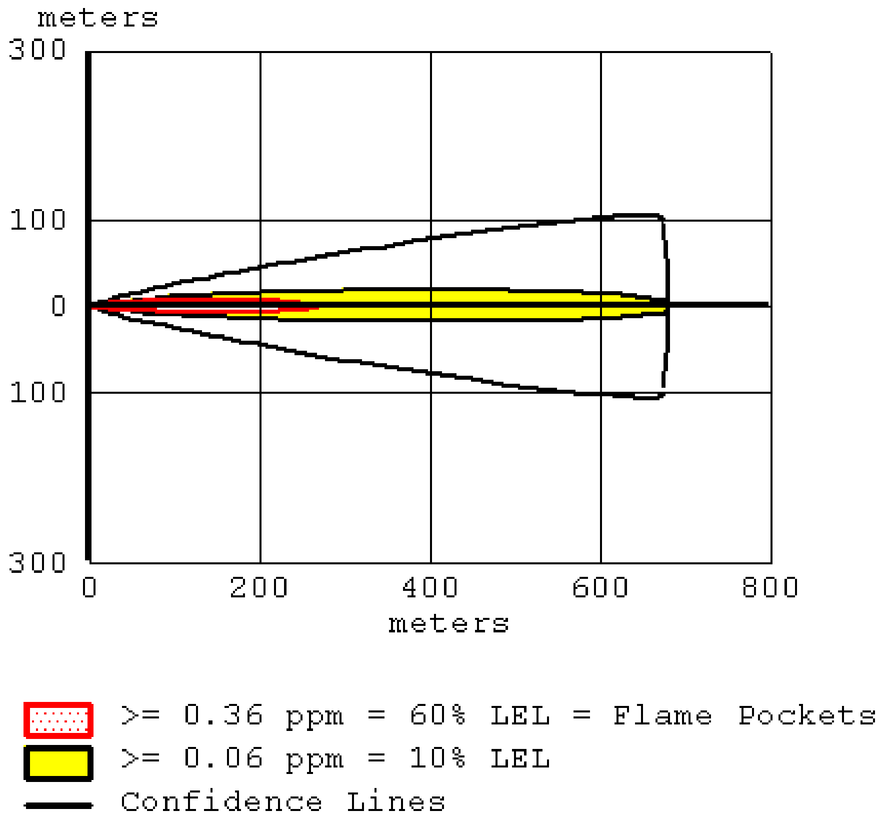
SC#13: Release of SKO from Pipeline from VIZAG to Rajamundry

Toxic Threat Zone



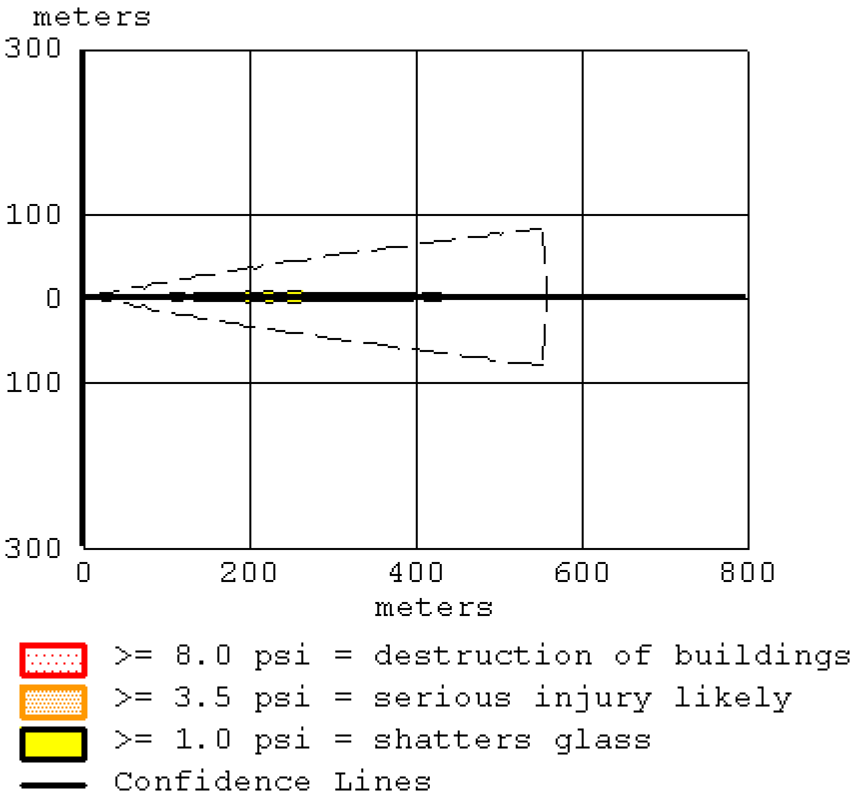
THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : 27 meters --- (10.0 kW/ (sq m) = potentially lethal within 60 sec)
Orange: 33 meters --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec)
Yellow: 46 meters --- (2.0 kW/ (sq m) = pain within 60 sec)

Flammable Area of Vapour Cloud



THREAT ZONE:
Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : 268 meters --- (0.36 ppm = 60% LEL = Flame Pockets)
Yellow: 683 meters --- (0.06 ppm = 10% LEL)

Vapour Cloud Explosion (ignited by Spark)

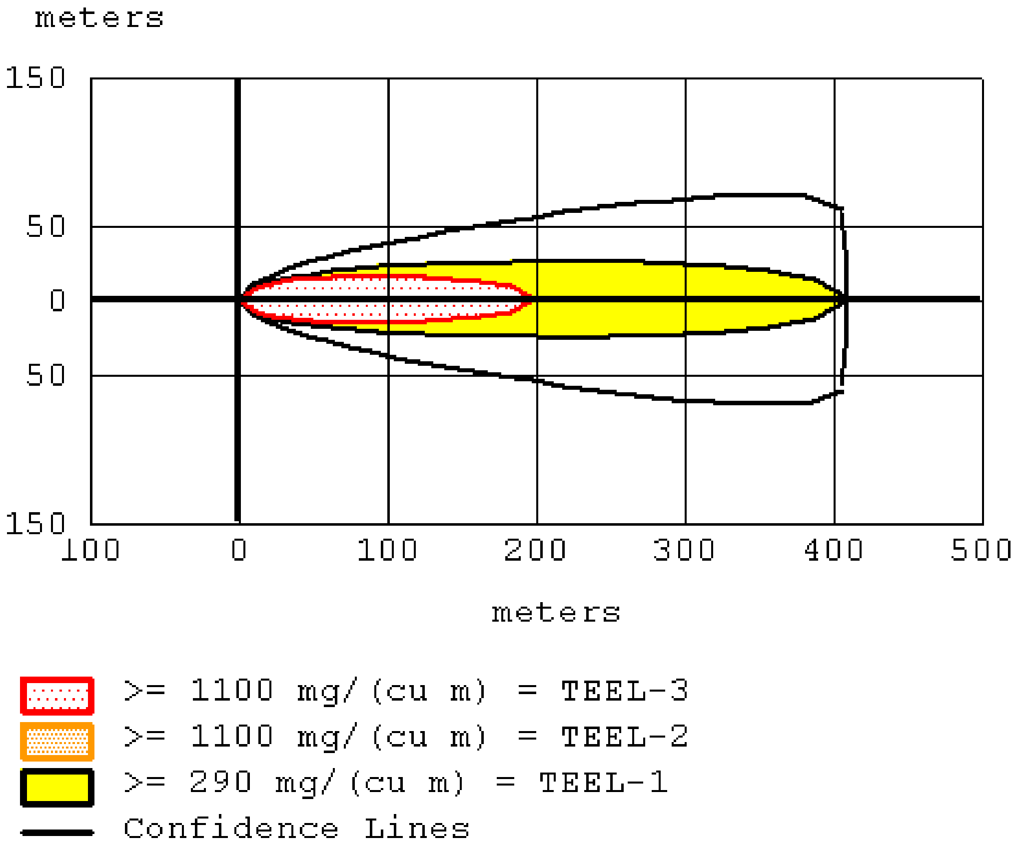


THREAT ZONE:

Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Heavy Gas
Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)
Orange: 558 meters --- (3.5 psi = serious injury likely)
Yellow: 558 meters --- (1.0 psi = shatters glass)

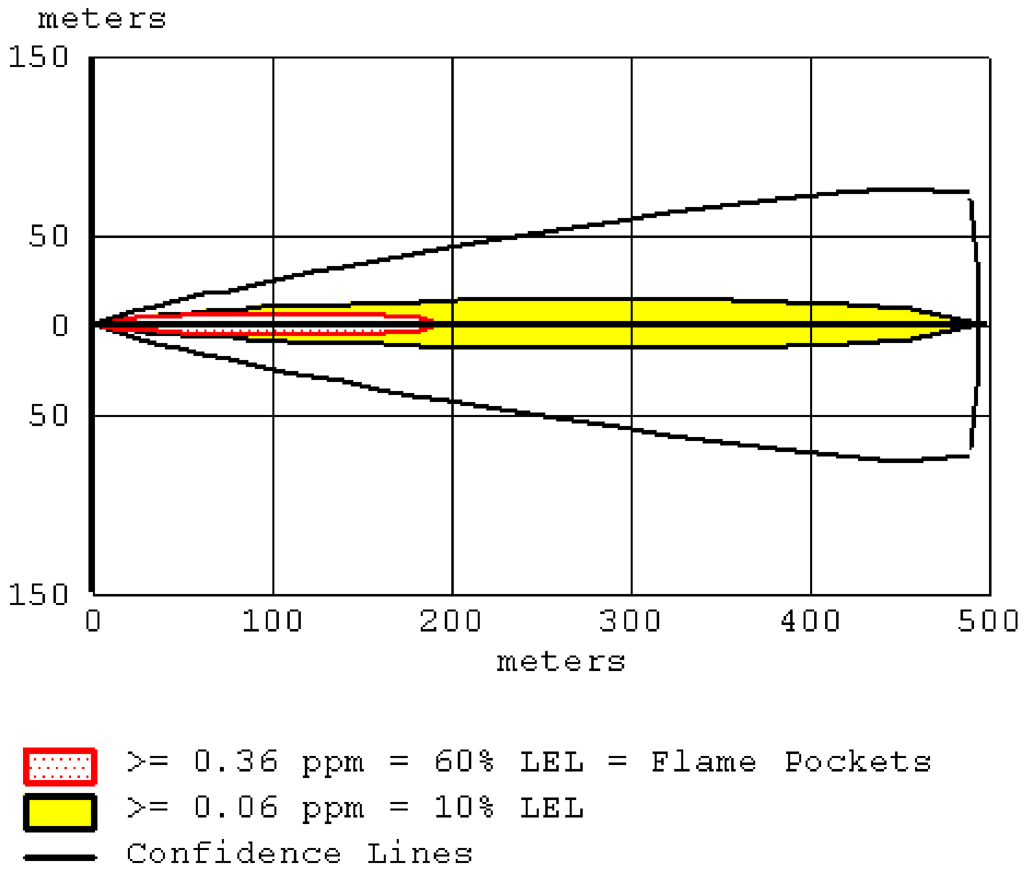
SC#14: Release of SKO from Pipeline from Rajamundry to Vijaywada

Toxic Threat Zone:



THREAT ZONE:
Model Run: Heavy Gas
Red : 199 meters --- (1100 mg/ (cu m) = TEEL-3)
Orange: 199 meters --- (1100 mg/ (cu m) = TEEL-2)
Yellow: 410 meters --- (290 mg/ (cu m) = TEEL-1)

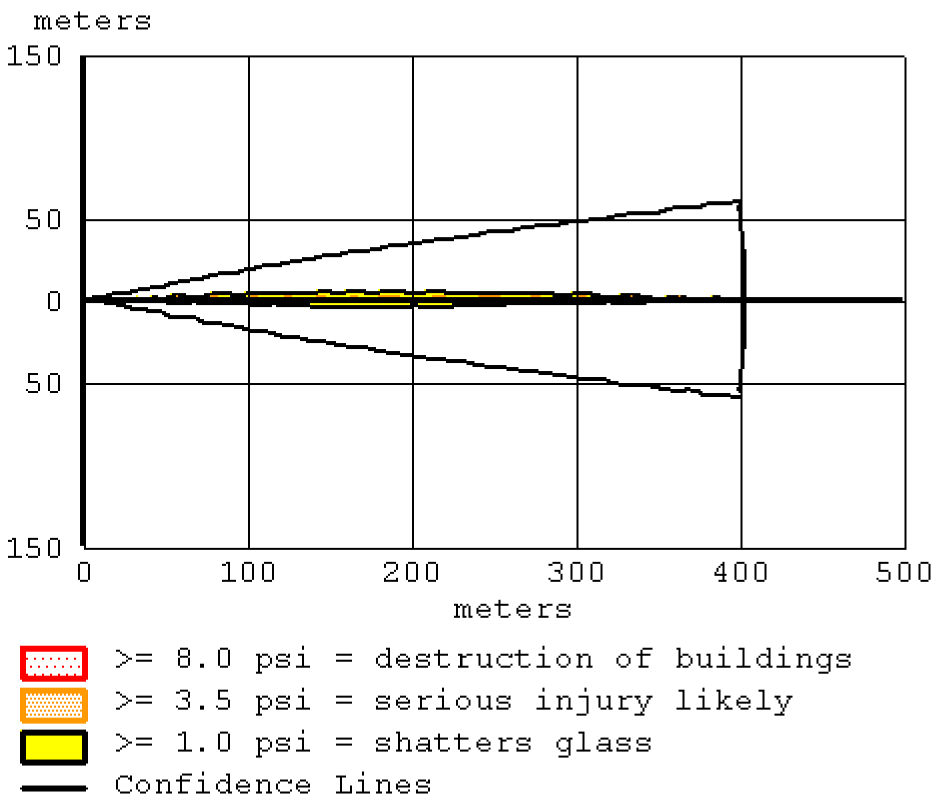
Flammable Area of Vapour Cloud



THREAT ZONE:

Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : 193 meters --- (0.36 ppm = 60% LEL = Flame Pockets)
Yellow: 494 meters --- (0.06 ppm = 10% LEL)

Vapour Cloud Explosion (ignited by Spark)

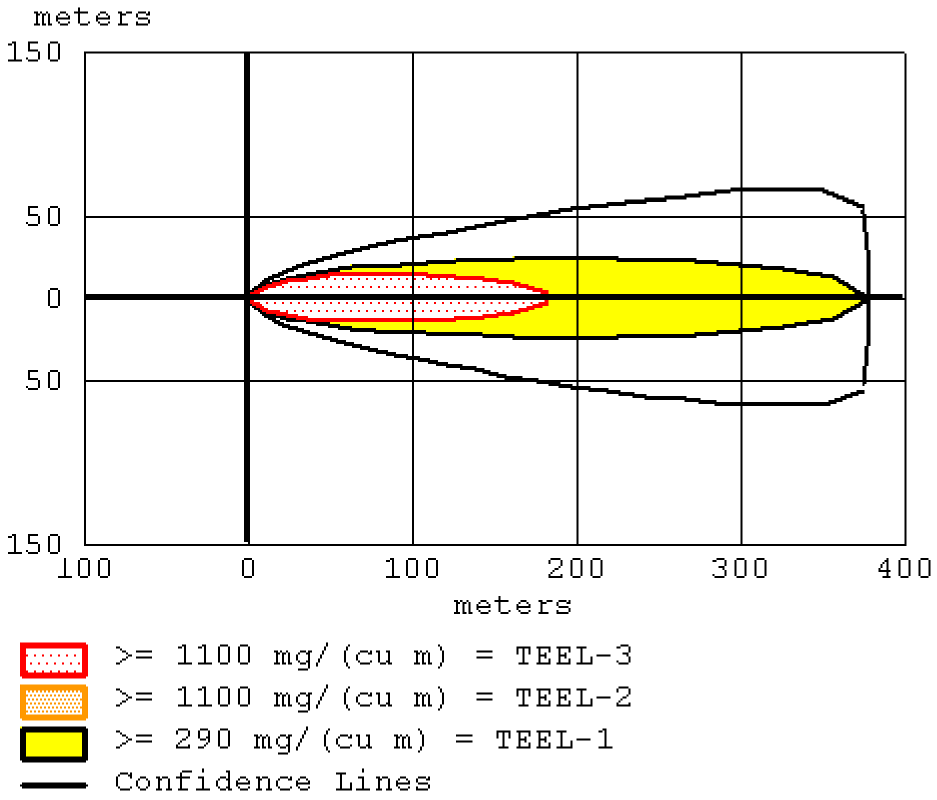


THREAT ZONE:

Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Heavy Gas
Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)
Orange: 404 meters --- (3.5 psi = serious injury likely)
Yellow: 404 meters --- (1.0 psi = shatters glass)

SC# 15: Release of SKO from Pipeline from Vijaywada to Hyderabad

Toxic Threat Zone:



THREAT ZONE:

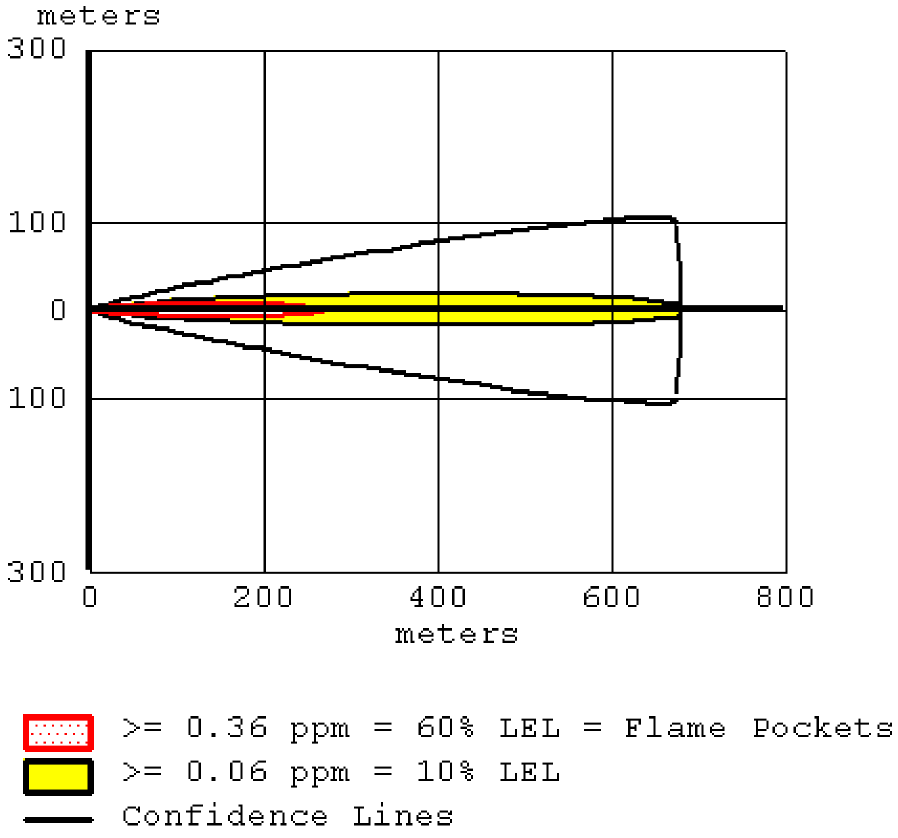
Model Run: Heavy Gas

Red : 183 meters --- (1100 mg/ (cu m) = TEEL-3)

Orange: 183 meters --- (1100 mg/ (cu m) = TEEL-2)

Yellow: 379 meters --- (290 mg/ (cu m) = TEEL-1)

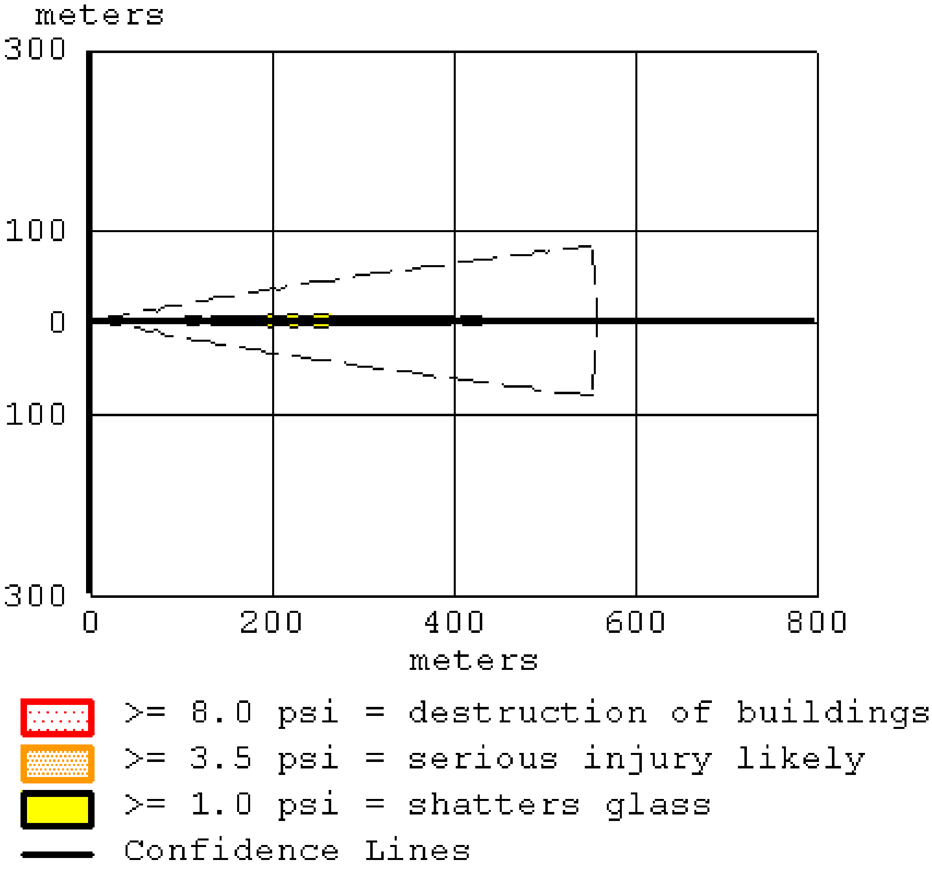
Flammable Area of Vapour Cloud



THREAT ZONE:

Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : 268 meters --- (0.36 ppm = 60% LEL = Flame Pockets)
Yellow: 683 meters --- (0.06 ppm = 10% LEL)

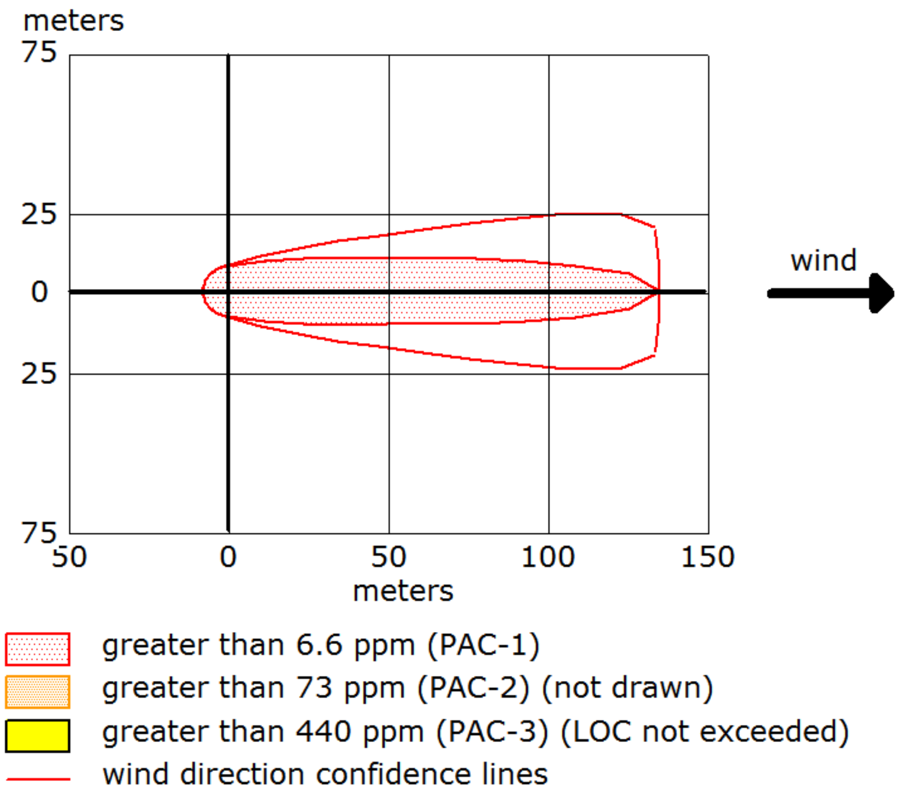
Vapour Cloud Explosion (ignited by Spark)



THREAT ZONE:
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Heavy Gas
Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)
Orange: 558 meters --- (3.5 psi = serious injury likely)
Yellow: 558 meters --- (1.0 psi = shatters glass)

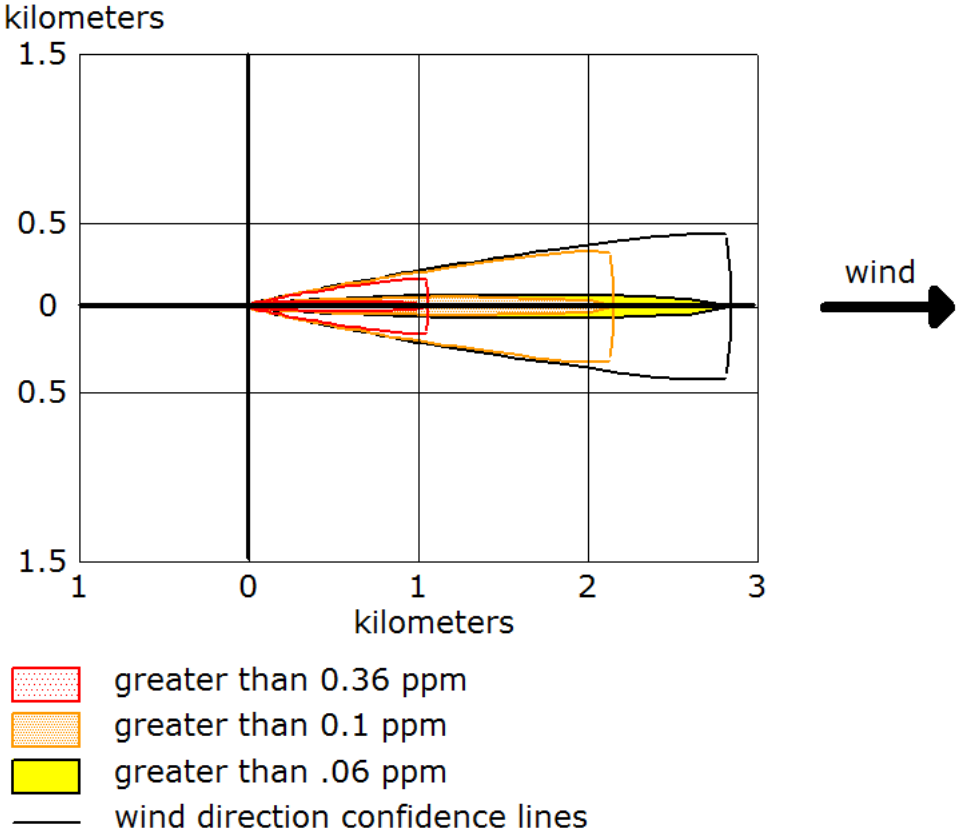
SC# 16: Release of ATF from Pipeline from Paradip to Berhampur

Toxic Threat Zone:



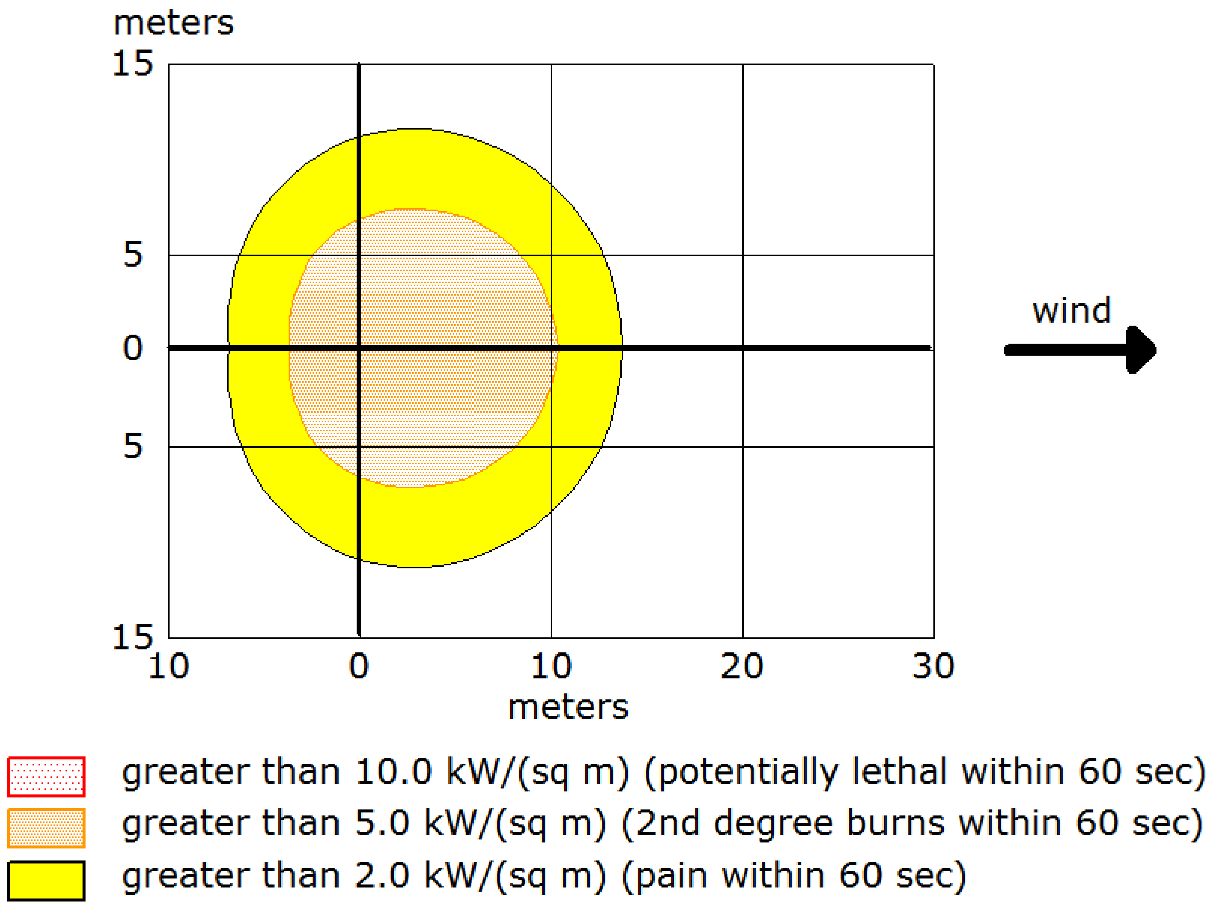
THREAT ZONE:
Model Run: Heavy Gas
Red : 135 meters --- (6.6 ppm = PAC-1)
Orange: 10 meters --- (73 ppm = PAC-2)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
Yellow: LOC was never exceeded --- (440 ppm = PAC-3)

Flammable Area of Vapour Cloud



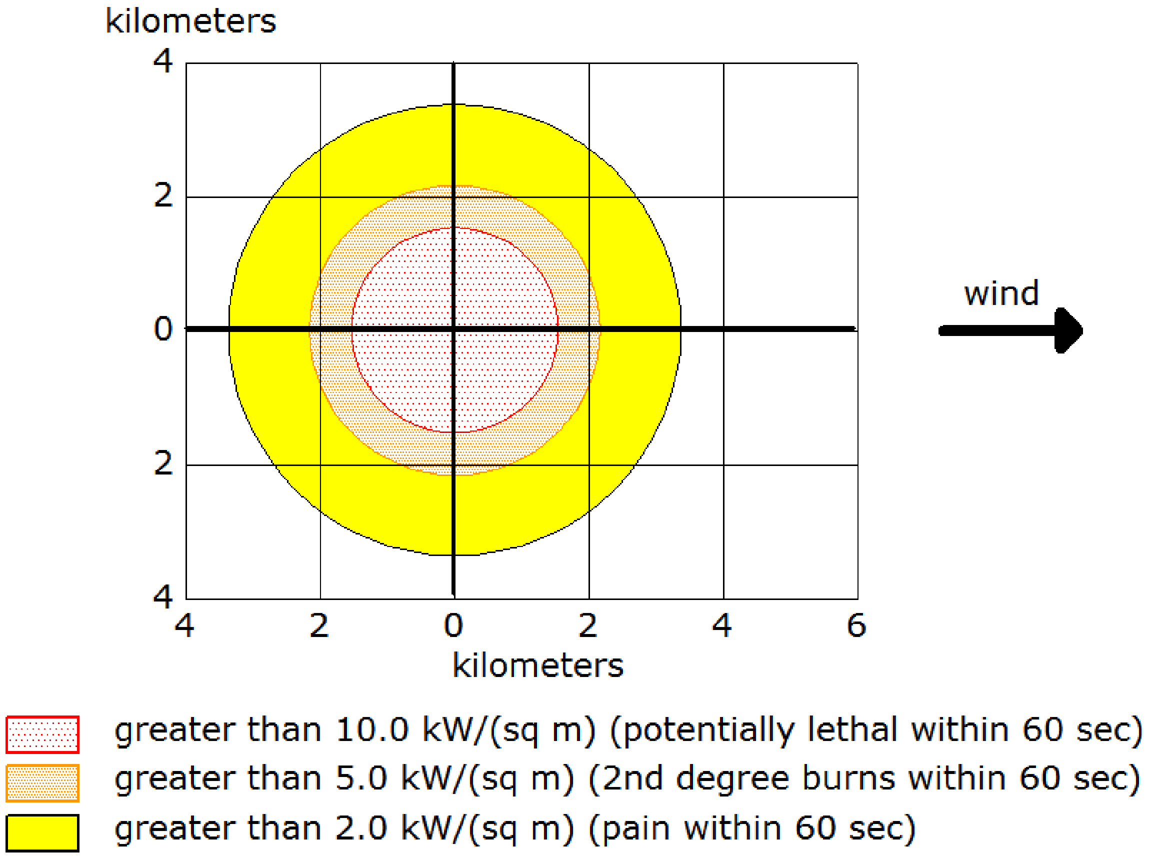
Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : 1.1 kilometers --- (0.36 ppm)
Orange: 2.2 kilometers --- (0.1 ppm)
Yellow: 2.9 kilometers --- (.06 ppm)

POOL Fire



THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : less than 10 meters(10.9 yards) --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 10 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 14 meters --- (2.0 kW/(sq m) = pain within 60 sec)

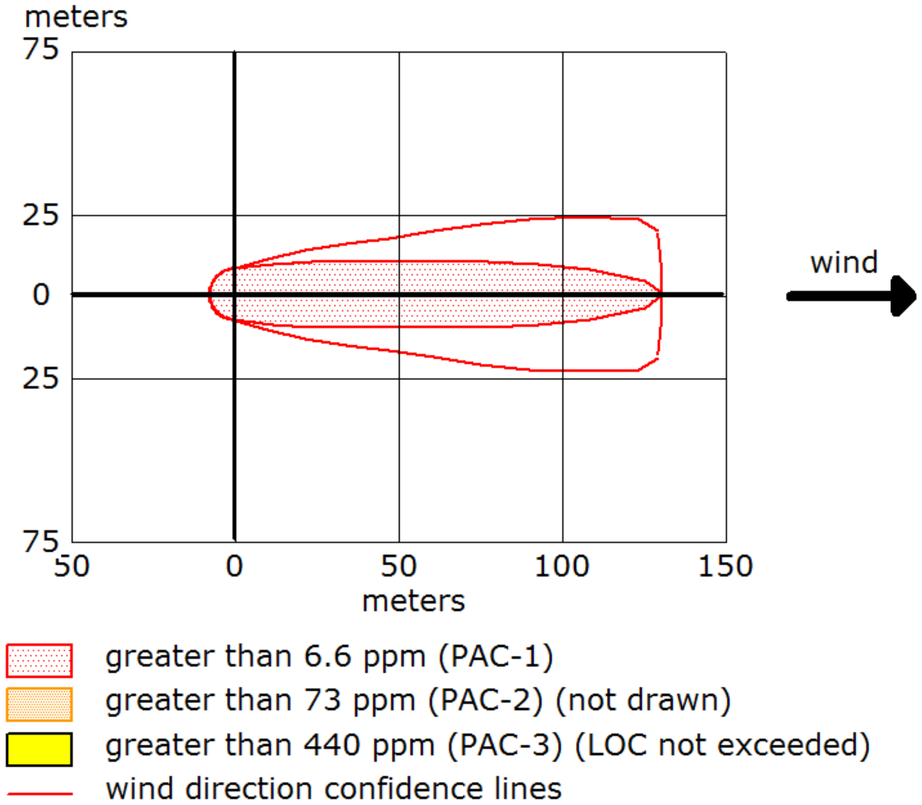
BLEVE :



THREAT ZONE:
Threat Modeled: Thermal radiation from fireball
Red : 1.5 kilometers --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 2.2 kilometers --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 3.4 kilometers --- (2.0 kW/(sq m) = pain within 60 sec)

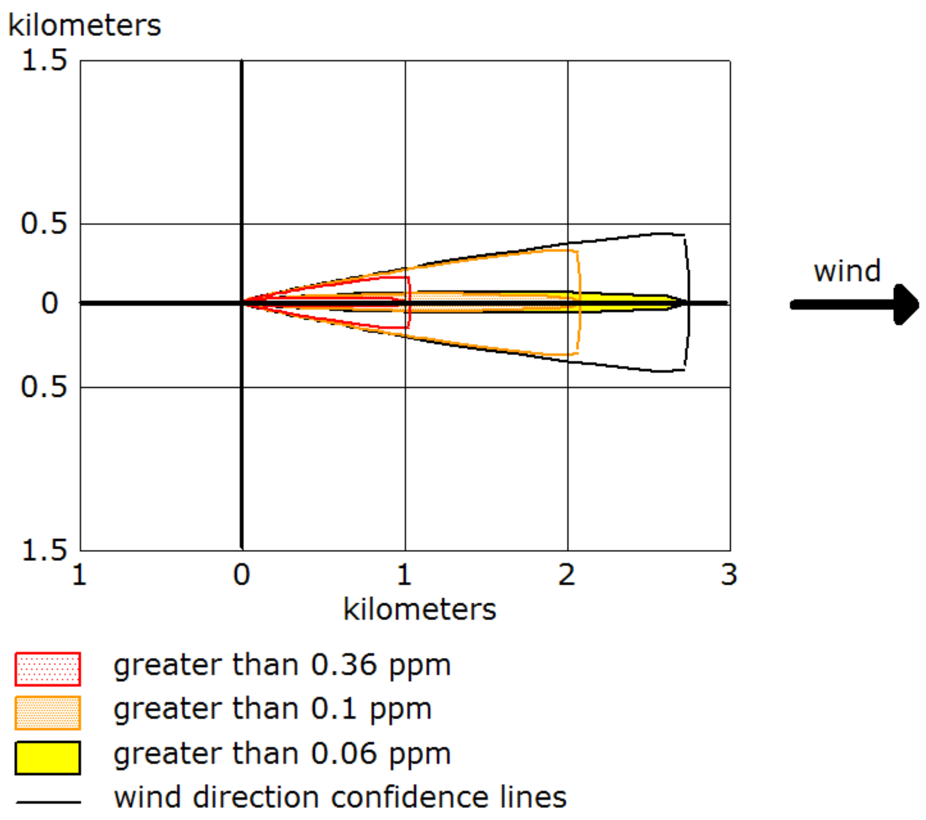
SC# 17: Release of ATF from Pipeline from Berhampur to Vizag

Toxic Threat Zone:



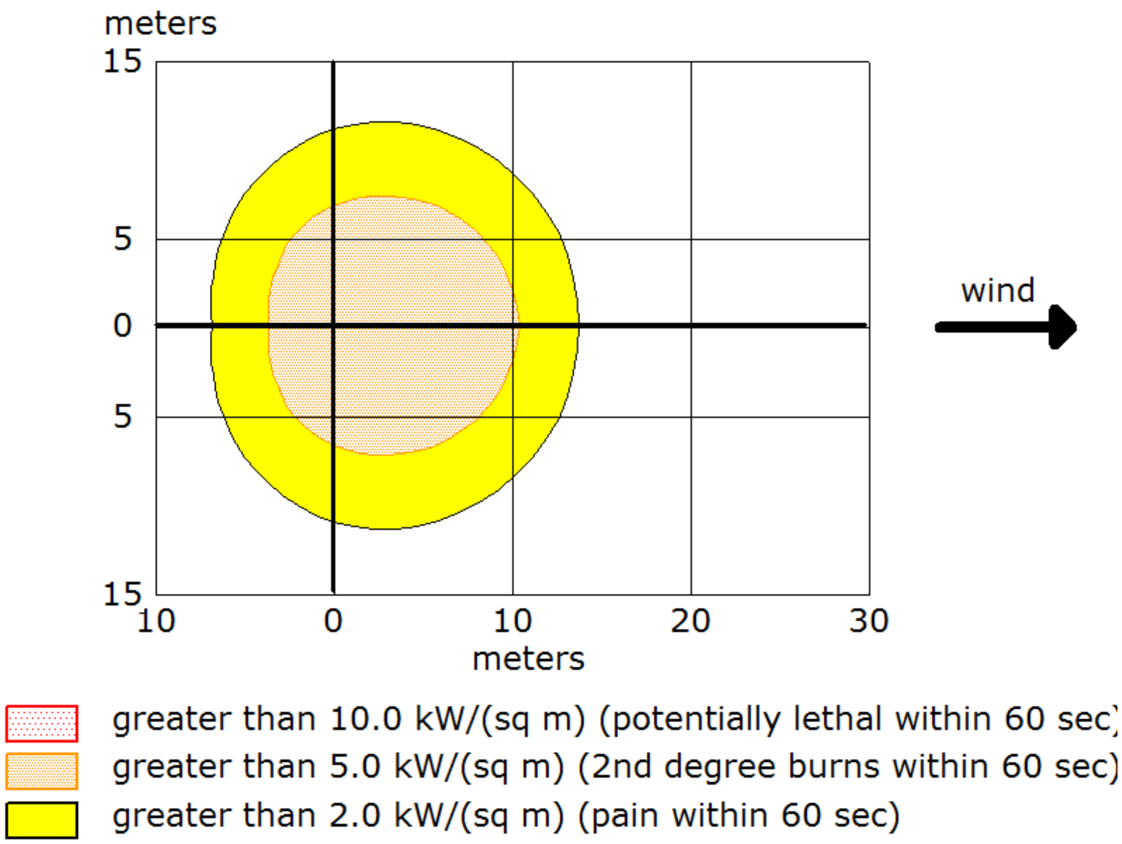
Threat Zone
Model Run: Heavy Gas
Red : 131 meters --- (6.6 ppm = PAC-1)
Orange: less than 10 meters(10.9 yards) --- (73 ppm = PAC-2)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
Yellow: LOC was never exceeded --- (440 ppm = PAC-3)

Flammable Area of Vapour Cloud



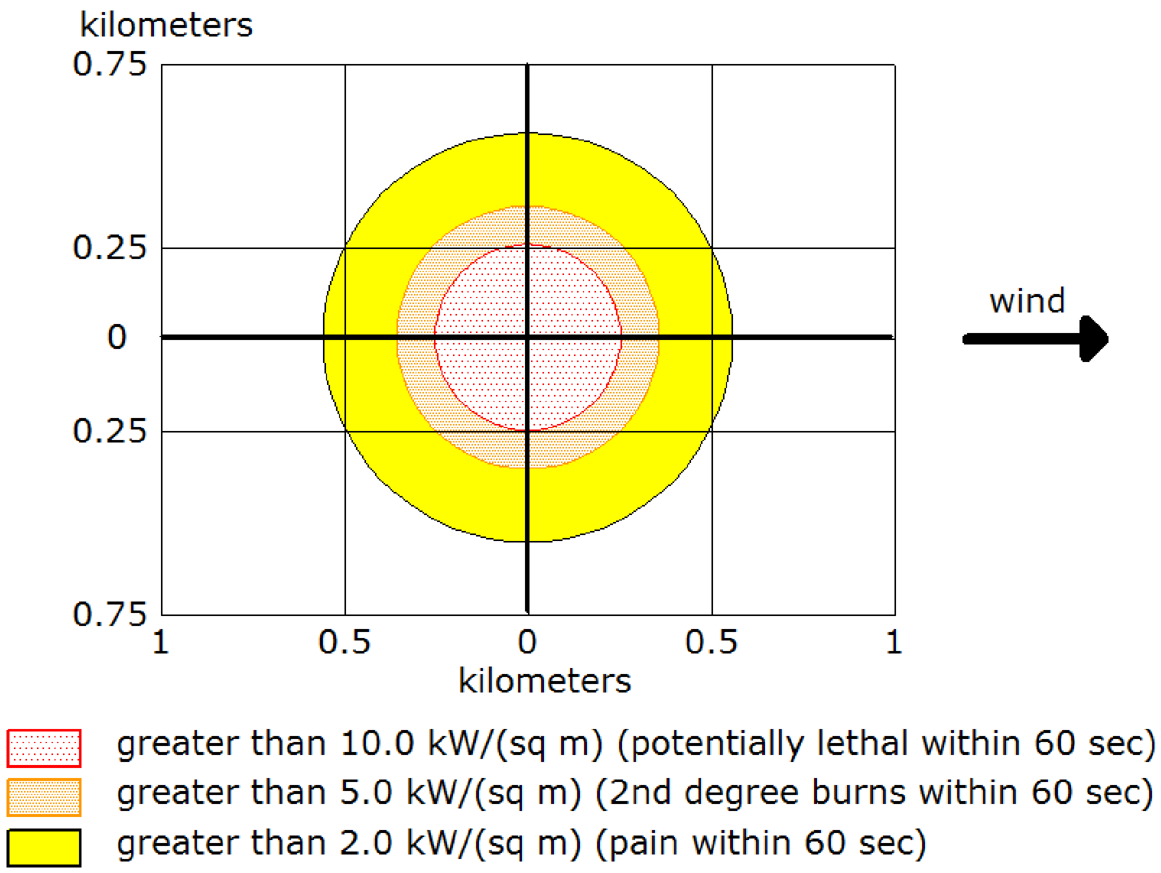
Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : 1.0 kilometers --- (0.36 ppm)
Orange: 2.1 kilometers --- (0.1 ppm)
Yellow: 2.8 kilometers --- (0.06 ppm)

POOL Fire



THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : less than 10 meters(10.9 yards) --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 10 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 14 meters --- (2.0 kW/(sq m) = pain within 60 sec)

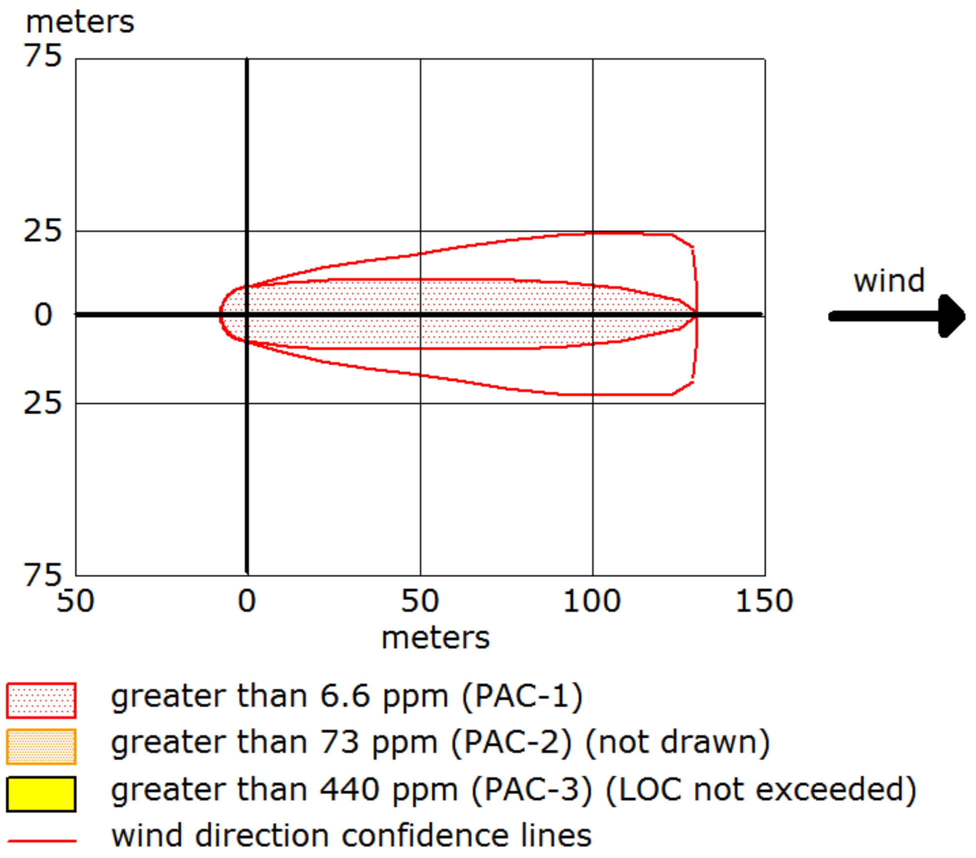
BLEVE :



THREAT ZONE:
Threat Modeled: Thermal radiation from fireball
Red : 254 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 359 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 560 meters --- (2.0 kW/(sq m) = pain within 60 sec)

SC# 18: Release of ATF from Pipeline from Vizag to Rajamundhry

Toxic Threat Zone:



THREAT ZONE:

Model Run: Heavy Gas

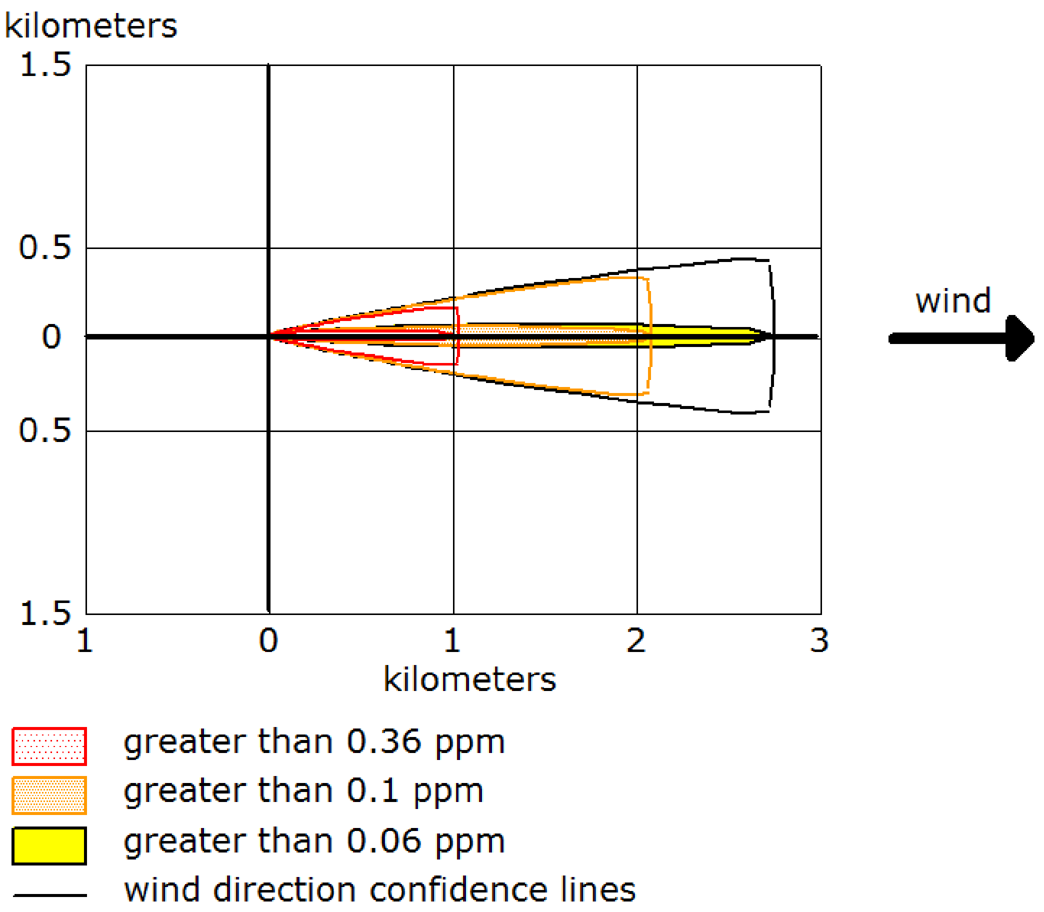
Red : 131 meters --- (6.6 ppm = PAC-1)

Orange: less than 10 meters(10.9 yards) --- (73 ppm = PAC-2)

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

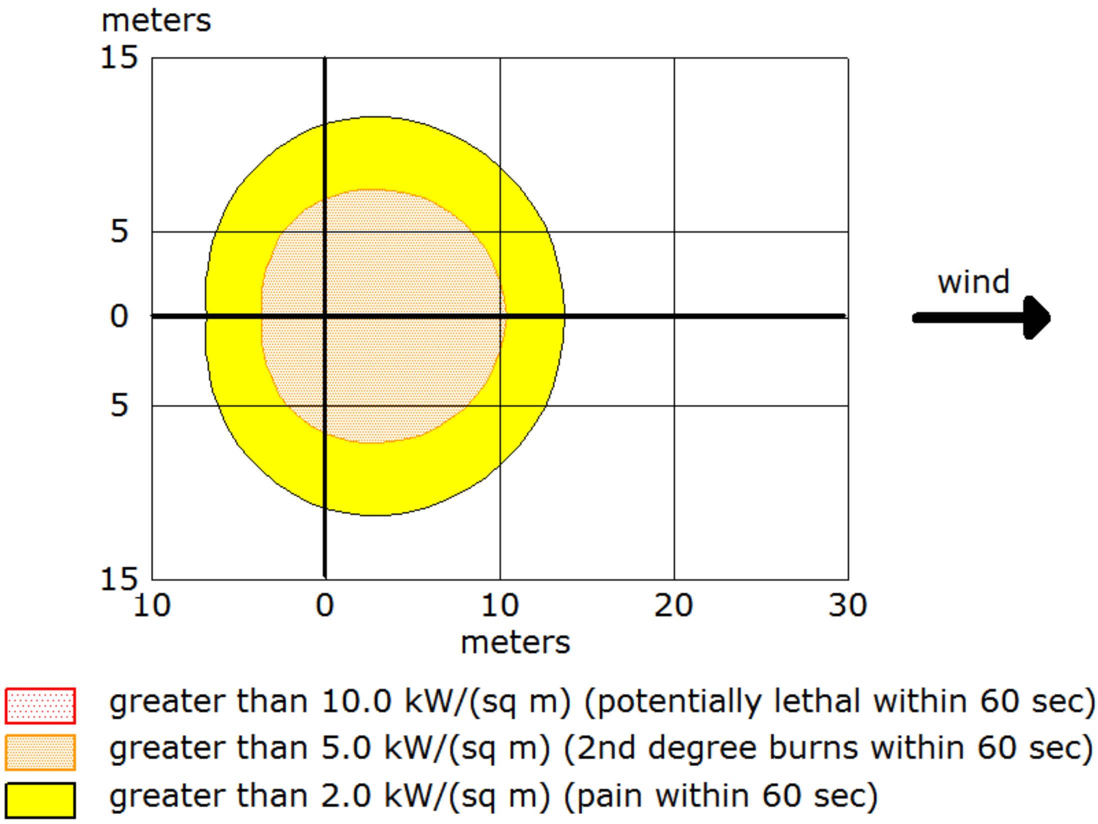
Yellow: LOC was never exceeded --- (440 ppm = PAC-3)

Flammable Area of Vapour Cloud



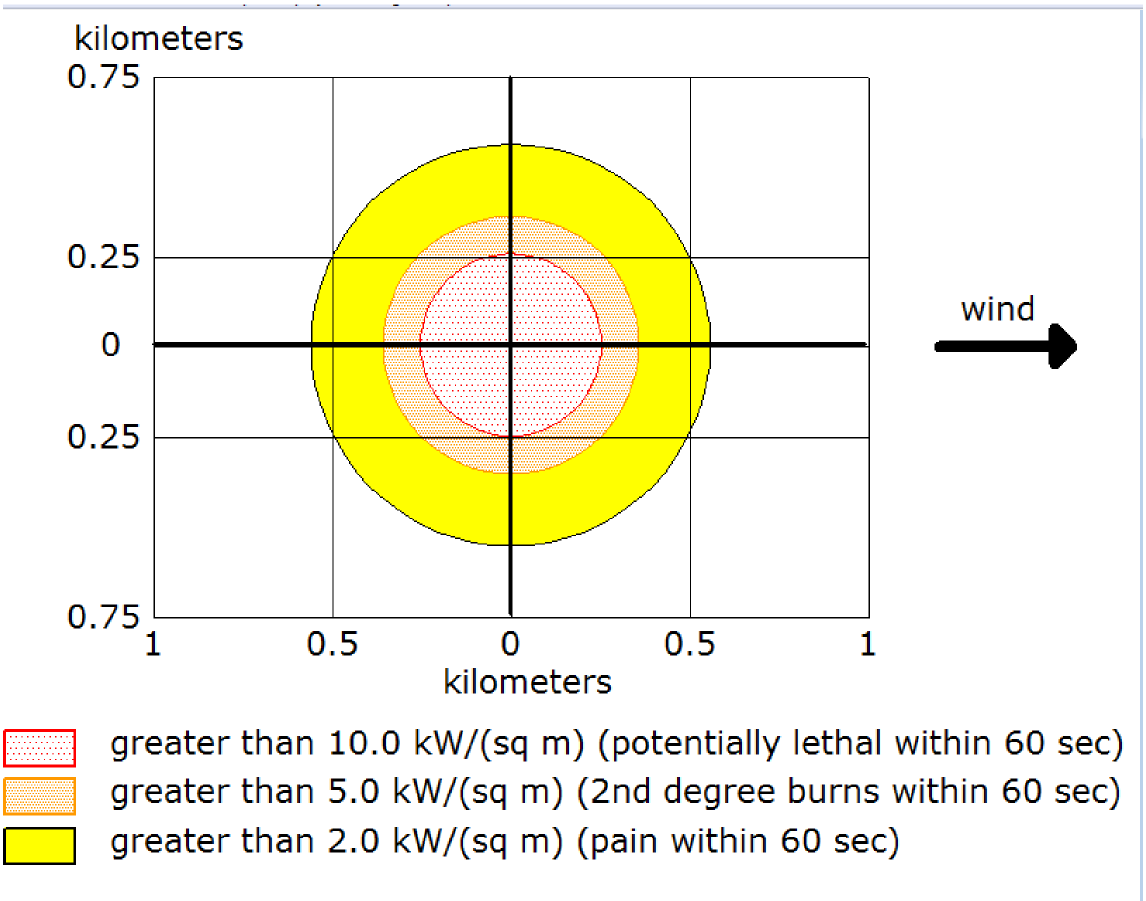
THREAT ZONE: (HEAVY GAS SELECTED)
Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : 1.0 kilometers --- (0.36 ppm)
Orange: 2.1 kilometers --- (0.1 ppm)
Yellow: 2.8 kilometers --- (0.06 ppm)

POOL Fire



THREAT ZONE:
Threat Modeled: Thermal radiation from pool fire
Red : less than 10 meters(10.9 yards) --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 10 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 14 meters --- (2.0 kW/(sq m) = pain within 60 sec)

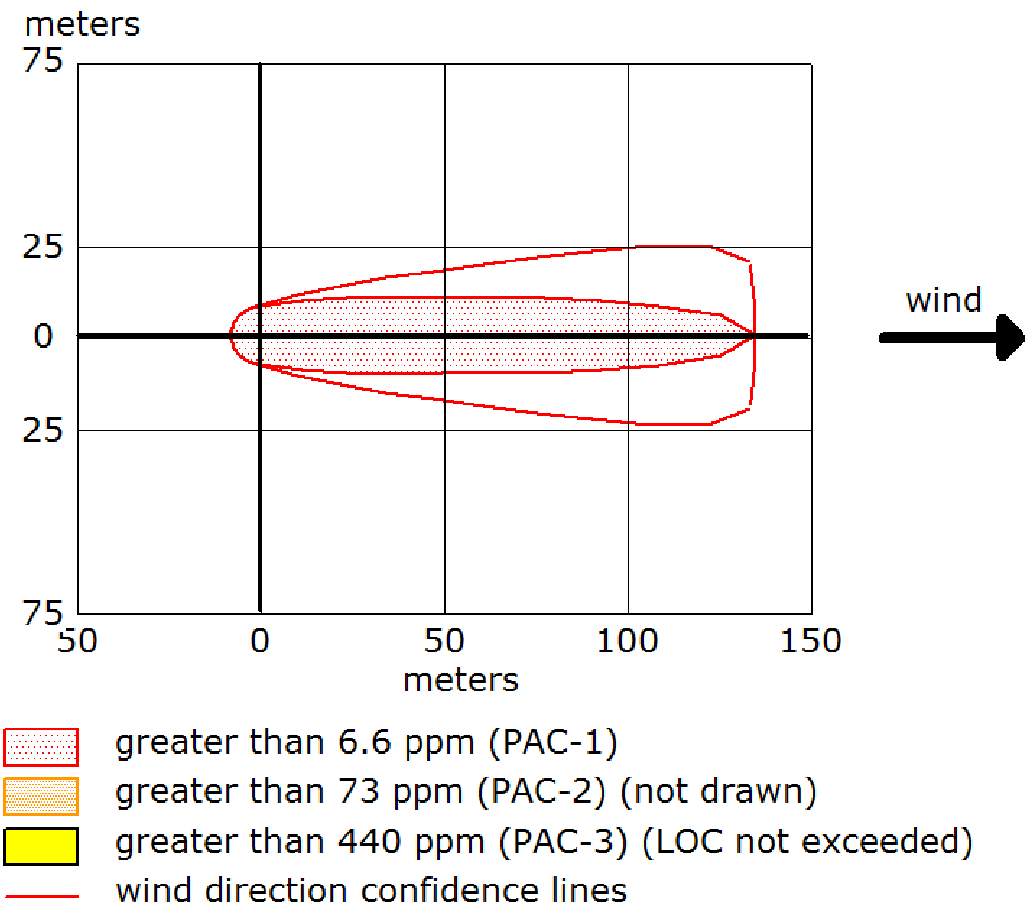
BLEVE :



THREAT ZONE:
Threat Modeled: Thermal radiation from fireball
Red : 254 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 359 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 560 meters --- (2.0 kW/(sq m) = pain within 60 sec)

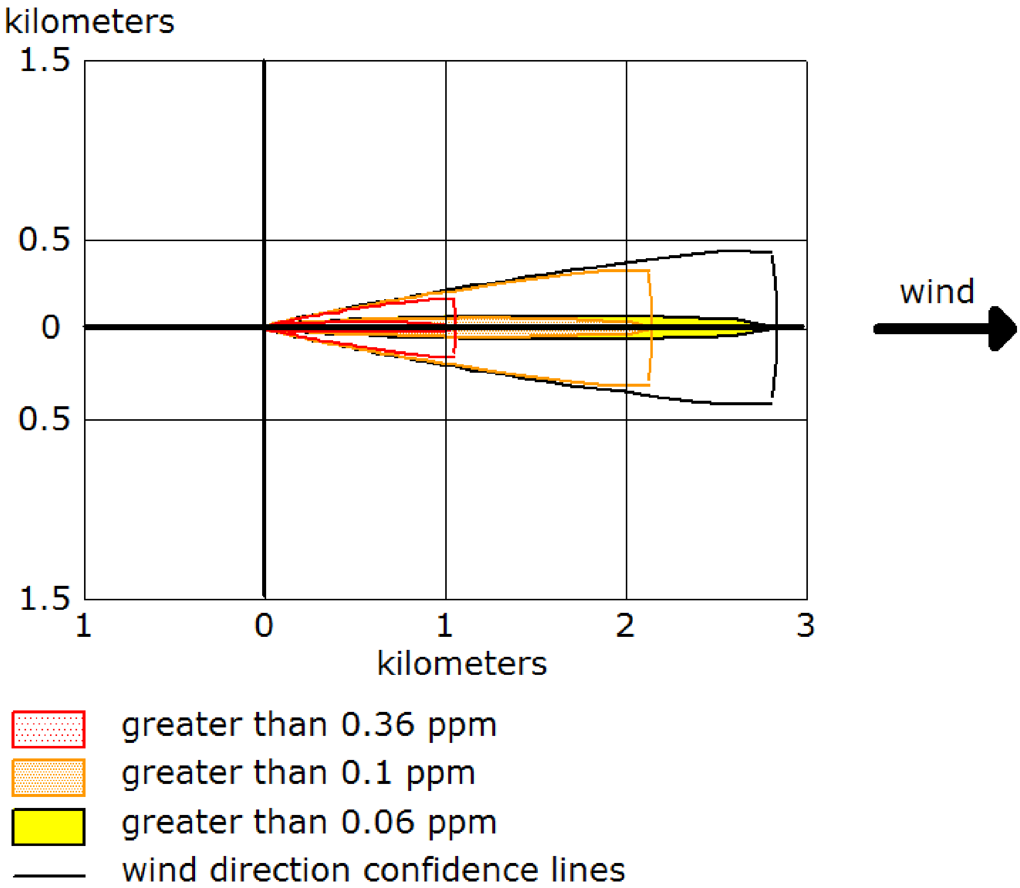
SC# 19: Release of ATF from Pipeline from Rajamundhry to Vijaywada

Toxic Threat Zone:



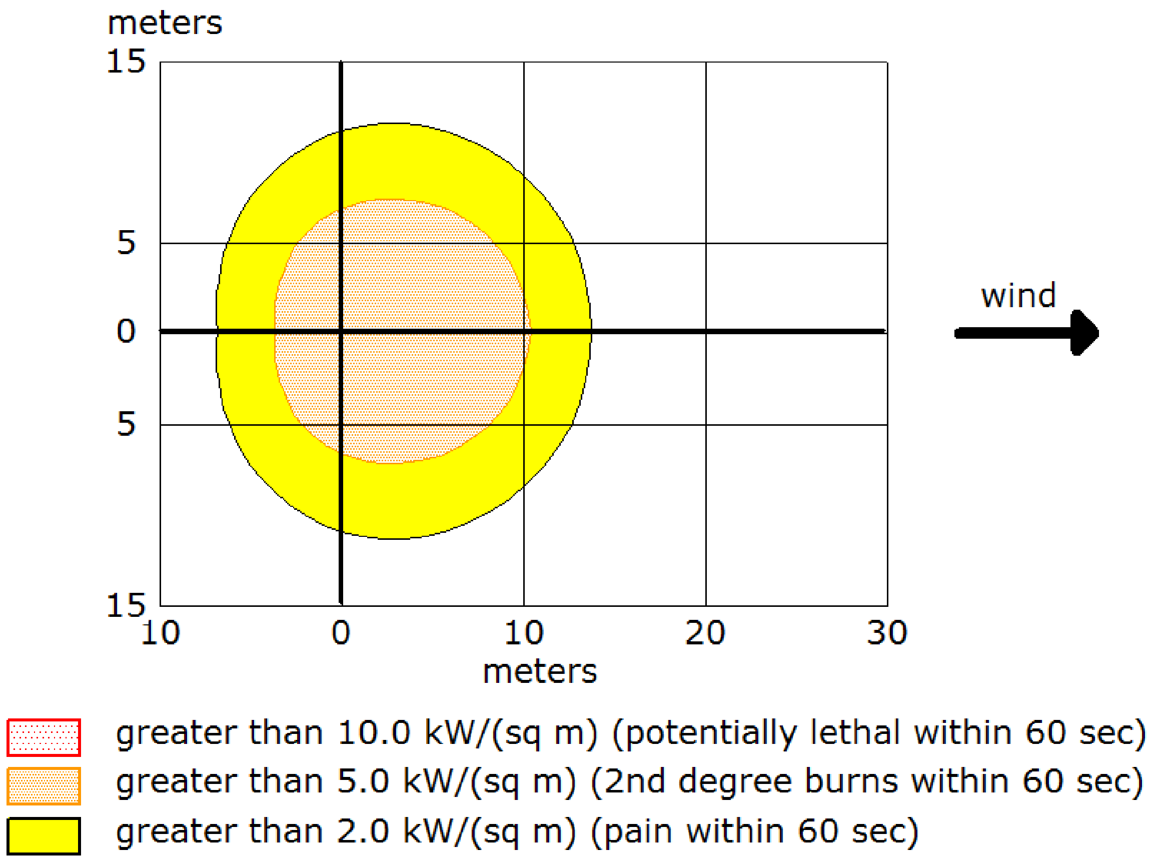
THREAT ZONE: (HEAVY GAS SELECTED)
Model Run: Heavy Gas
Red : 135 meters --- (6.6 ppm = PAC-1)
Orange: 10 meters --- (73 ppm = PAC-2)
Note: Threat zone was not drawn because effects of near-field patchiness

Flammable Area of Vapour Cloud



THREAT ZONE: (HEAVY GAS SELECTED)
  Threat Modeled: Flammable Area of Vapor Cloud
  Model Run: Heavy Gas
  Red   : 1.1 kilometers --- (0.36 ppm)
  Orange: 2.2 kilometers --- (0.1 ppm)
  Yellow: 2.8 kilometers --- (0.06 ppm)

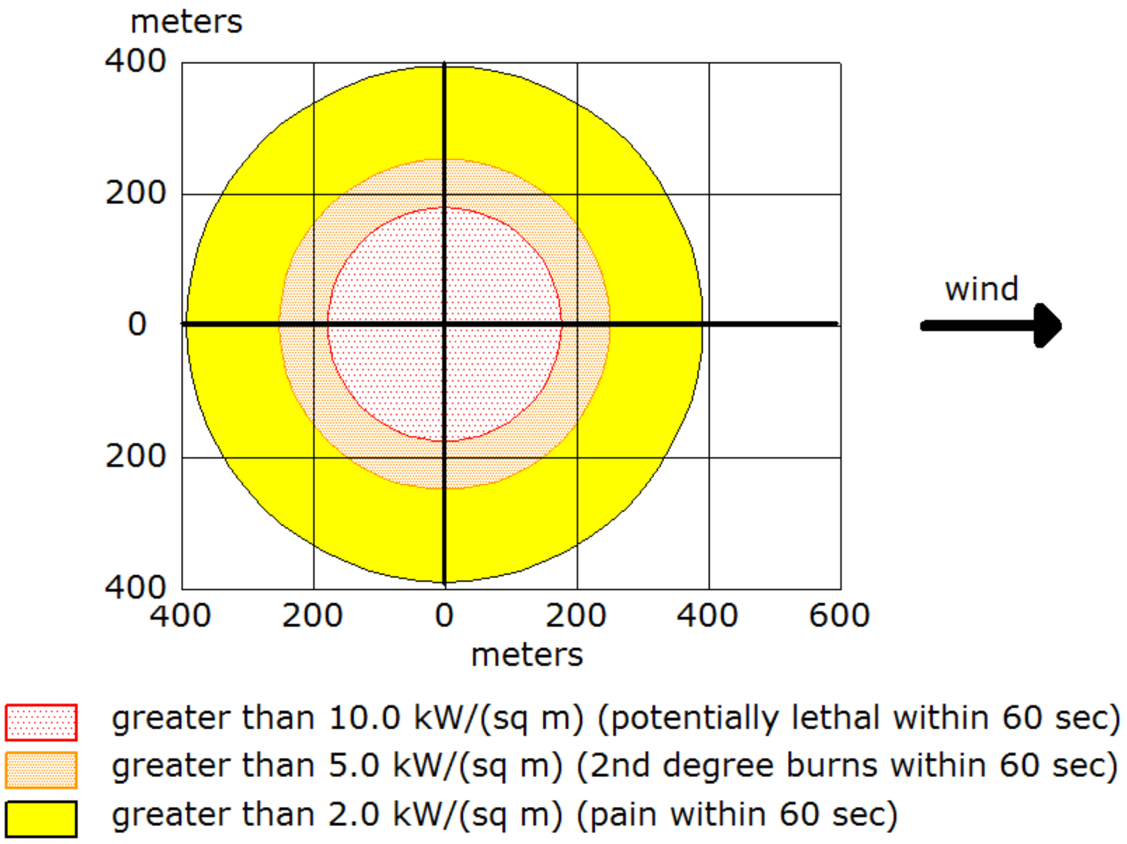
POOL Fire



THREAT ZONE:

Threat Modeled: Thermal radiation from pool fire
Red : less than 10 meters(10.9 yards) --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 10 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 14 meters --- (2.0 kW/(sq m) = pain within 60 sec)

BLEVE:



THREAT ZONE:

Threat Modeled: Thermal radiation from fireball

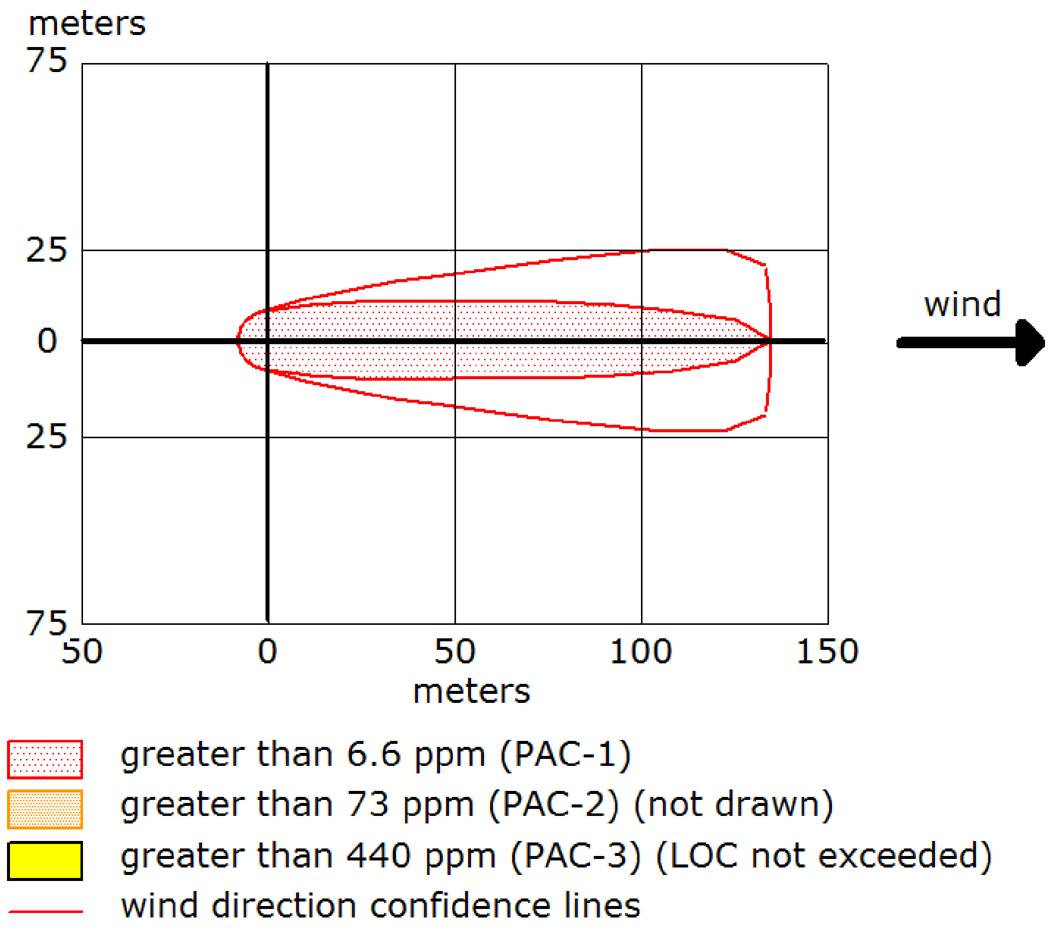
Red : 177 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)

Orange: 250 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)

Yellow: 391 meters --- (2.0 kW/(sq m) = pain within 60 sec)

SC# 20: Release of ATF from Pipeline from Vijaywada to Hyderabad

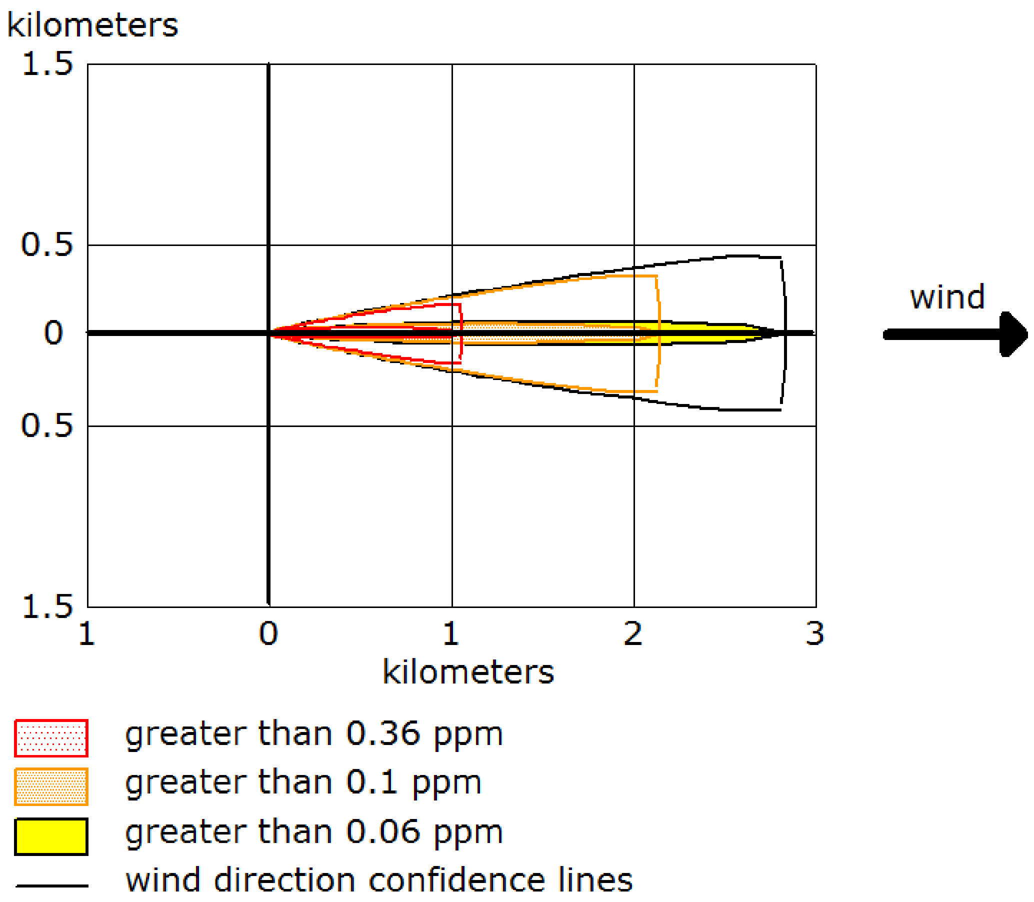
Toxic Threat Zone:



THREAT ZONE: (HEAVY GAS SELECTED)

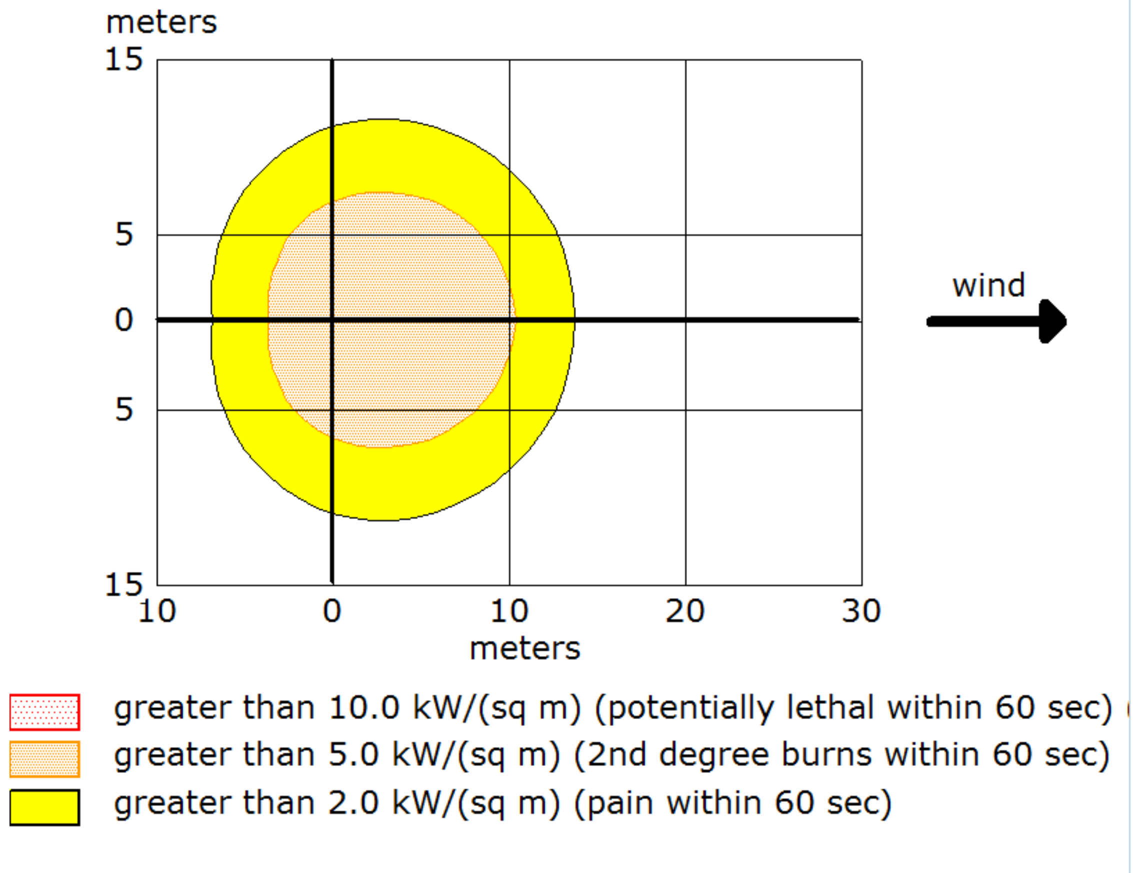
Model Run: Heavy Gas
Red : 135 meters --- (6.6 ppm = PAC-1)
Orange: 10 meters --- (73 ppm = PAC-2)
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.
Yellow: LOC was never exceeded --- (440 ppm = PAC-3)

Flammable Area of Vapour Cloud



THREAT ZONE: (HEAVY GAS SELECTED)
Threat Modeled: Flammable Area of Vapor Cloud
Model Run: Heavy Gas
Red : 1.1 kilometers --- (0.36 ppm)
Orange: 2.2 kilometers --- (0.1 ppm)
Yellow: 2.8 kilometers --- (0.06 ppm)

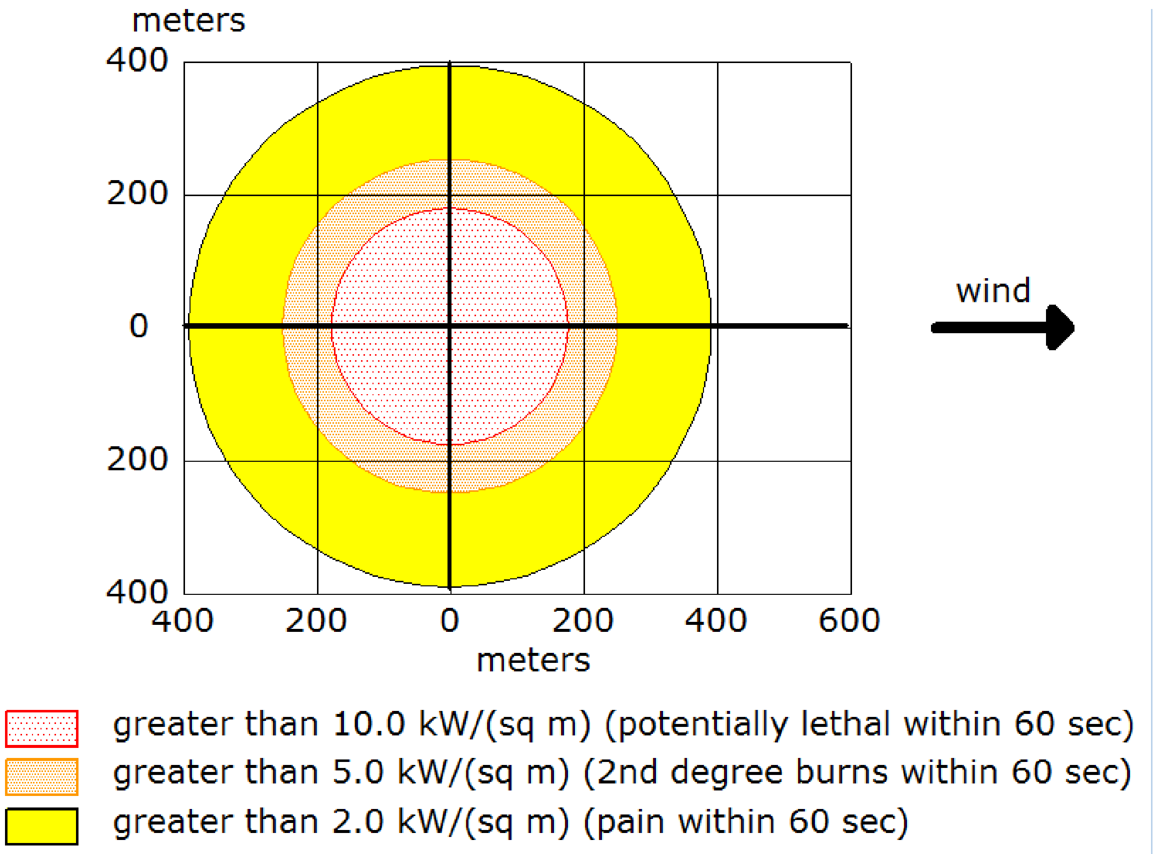
POOL Fire



THREAT ZONE:

Threat Modeled: Thermal radiation from pool fire
Red : less than 10 meters(10.9 yards) --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 10 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 14 meters --- (2.0 kW/(sq m) = pain within 60 sec)

BLEVE



THREAT ZONE:

Threat Modeled: Thermal radiation from fireball
Red : 177 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)
Orange: 250 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)
Yellow: 391 meters --- (2.0 kW/(sq m) = pain within 60 sec)

5.5 COMPARISON AGAINST RISK ACCEPTANCE CRITERIA

A risk analysis provides a measure of the risks resulting from a particular facility or activity. It thus finds application as a decision making tool in situations where judgment has to be made about the tolerability of the risk posed by an existing/proposed activity. However, risk analysis produces only numbers, which themselves provide no inherent use. It is the assessment of those numbers that allows conclusions to be drawn and recommendations to be developed. The normal approach adopted is to relate the risk measures obtained to risk acceptance criteria. Risk criteria, if they are to be workable, recognizes the following:

- There is a level of risk that is so high that it is considered unacceptable or Intolerable regardless of the benefits derived from an activity.
- There is also a level of risk that is low enough as to be considered negligible.
- Levels of risk in between are to be considered tolerable subject to their being reduced As Low As is Reasonably Practicable (ALARP). (The meaning of ALARP is explained in the following sub-section.)

The above is the formulation of the, now well-established, three tier structure of risk criteria and risk control.

The risk criteria simply attempt to establish whether risk is “tolerable”. Below is a list of words generally in use and their meaning.

ACCEPTABLE RISKS: Since risks in general are unwelcome no risk should be called “acceptable”. It might be better to say that the activity may be acceptable generally, but the risks can only ever be tolerable.

TOLERABLE RISKS: are risks the exposed people are expected to bear without undue concern. A subtle difference is made out here between Acceptable Risks and Tolerable Risks though these terms are sometimes used interchangeably.

NEGLIGIBLE RISKS: are risks so small that there is no cause for concern and there is no reason to reduce them.

5.5.1 The ALARP Principle

The ALARP (As Low As is Reasonably Practicable) principle seeks to answer the question “What is an acceptable risk?” The definition may be found in the basis for judgment used in British law that one should be as safe as is reasonably practicable. Reasonably practicable is defined as implying “that a computation must be made in which the quantum of risk is placed on scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time, or trouble) is placed on the other, and that, if it be shown that there is a gross disproportion between them – risk being insignificant in relation to the sacrifice – the defendants discharge the onus upon them”

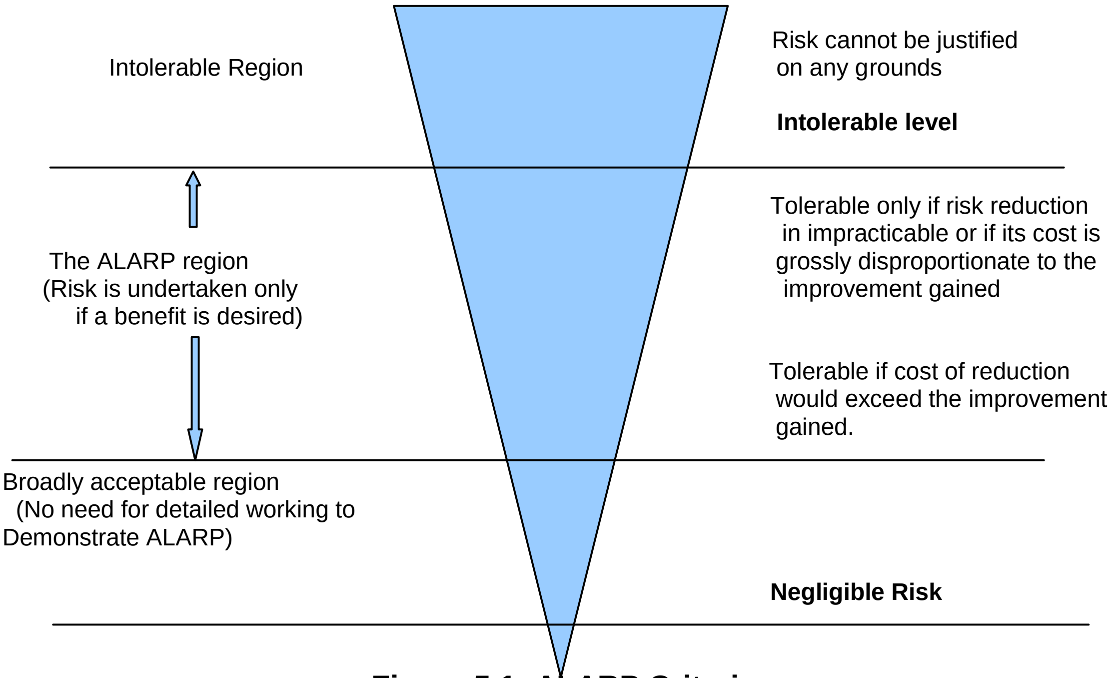


Figure 5.1: ALARP Criteria

In this chapter results of Risk Summation are presented as following:

- Risk of fatality in terms of Individual Risk levels
- Risk to environment in terms of cumulative frequency versus released Quantity and annual oil spill rate.

5.5.2 Quantification of Risks – Individual & Societal

The results of Risk Analysis are often reproduced as Individual Risk. Individual Risk is the probability of death occurring as a result of accidents at a fixed installation or a pipeline route expressed as a function of the distance from such an activity.

There are as yet no specified risk acceptance criteria in our country for Individual Risk levels. A review of risk acceptance criteria in use in other countries indicates the following:

- For fixed installations Official Individual Risk Criteria have been developed by various countries and the review indicates that Individual Risk of fatality to the members of the public outside the pipeline boundaries may be adopted as higher as **10^{-5} per year** (in populated areas) for intolerable risk and lower than **10^{-6} per year** for negligible risk. The region in between is the so-called ALARP region where risk is acceptable subject to its being As Low As Reasonably Practicable (the ALARP principle).

- For Transportation facilities, the Risk tolerability criteria as set in the ACDS Transport Hazards Report published by the HSE of the UK adopts fatality risk 10^{-3} per year as 'intolerable' while fatality risk of 10^{-6} per year is adopted as 'broadly acceptable'. The ALARP principle then implies that if the fatality risk from a particular transport activity lies between 10^{-6} per year and 10^{-3} per year, then efforts should be made to reduce to it to as low a level as reasonably practicable.

The risk of failure (Event Probability) has been estimated taking into consideration the following parameters:

- **Basic Failure Frequency for the event**
- **Ignition Probability (the smaller the cloud, the smaller the ignition Probability)**

The individual risks from an activity are the result of the cumulative risks connected with all possible scenarios.
In case of product pipeline, the Individual Risk Contours run close to the pipeline and Installations. The distance from the pipeline to Individual Risk contour of 10^{-5} per year from all scenarios varies from a minimum of 0 m to a maximum of 90 m from the pipeline. Individual Risk of 10^{-6} per year from all scenarios will be maximum of 300. Therefore, the individual risk for the pipeline is tolerable as it lies within ALARP region.

The individual risk level of 10^{-5}/ yr to public from the pipeline will be within the boundary necessary for ALARP.

The ALARP figure for Individual Risk of fatalities for Paradip- Hyderabad pipeline shown in **Figure-5.2**.

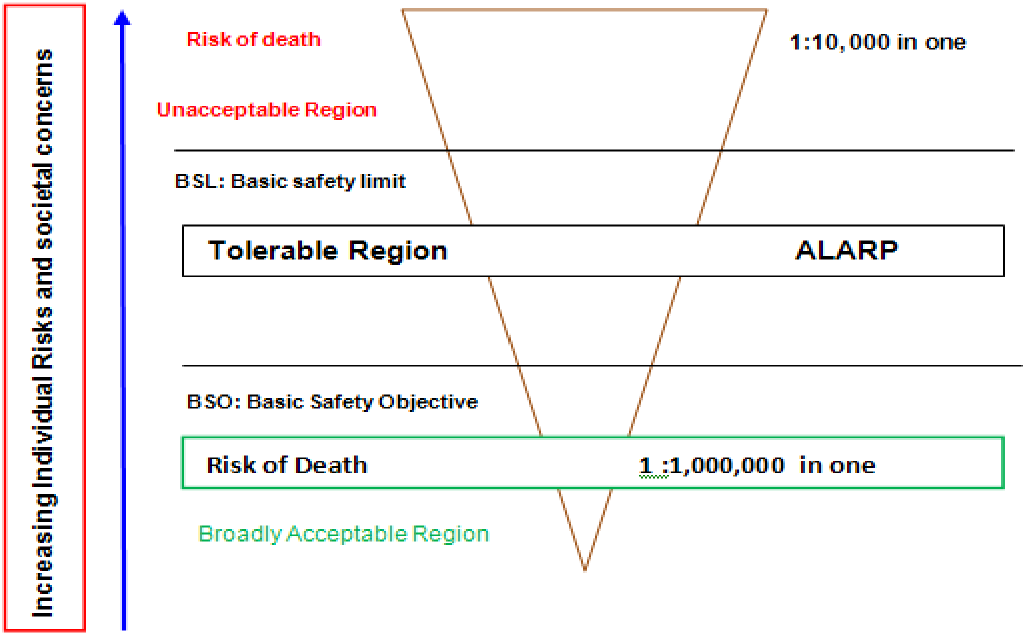


Figure-5.2: ALARP Figure for Individual Risks of Fatalities

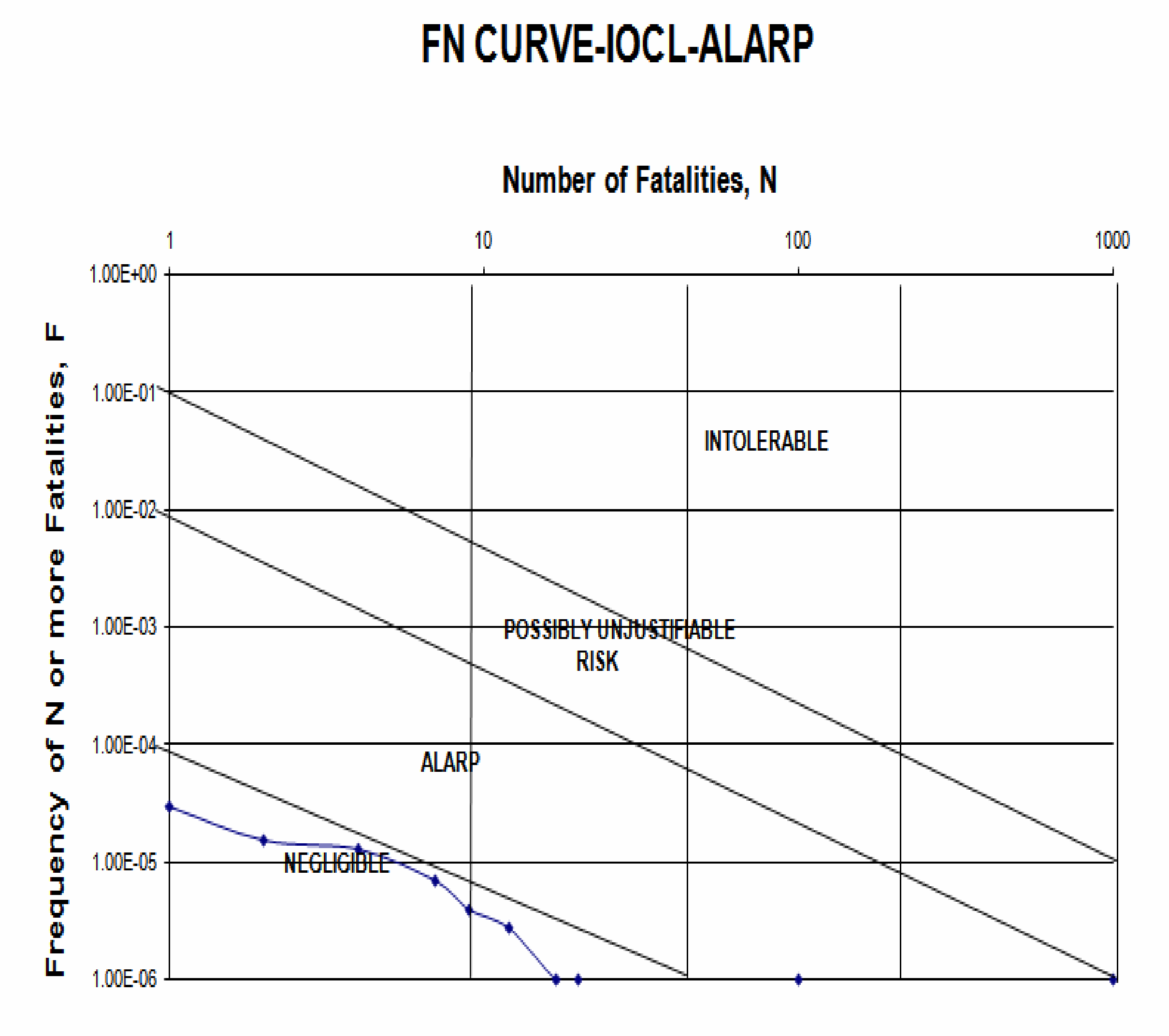


Figure- 5.3 Societal Risks of Fatalities

5.5.3 Findings of Risk Summation

The individual and societal risks of the pipeline facilities are tolerable as it lies within ALARP region. The individual risk from the stations is tolerable, as it is below the criterion of individual risk not to exceed 10^{-5} per year in populated areas, and FN curve societal risks lie within the ALARP zone.

Chapter-6: Risk Reduction Recommendations

From the Calculations, the following emerge:

1. The proposed pipeline is near the road and railway track, damage distances for the worst case could affect road and rail transport, hence close co-ordination with the concerned authorities is required at the time of emergency

2. In addition to fixed foam, mobile system foam activation could save the day-stocks of foam equipment are important as is advanced fire fighting training in use of mobile and fixed foam systems is imperative (which has been done).

3. Pipeline, Pump loading line failures and Hose failures etc. again have possibility of causing major damage- great care is necessary, as the vicinity could have a lot of persons as possible victims. Supervision by staff, hoses maintenance and following strict procedures is essential for preventing escalation of such incidents of high frequency and low outcome.

4. The pipeline should be subjected to quality control through pressure testing during construction and operation phase. The pipeline should be monitored and controlled from Station control Centre (SSC).

5. Warning signs should be placed at road crossings and other appropriate locations as required.

6. Temporary traffic control should be established where necessary at road crossing and junctions.

7. Green belt should be developed in and around the pipeline area as it is an effective way to check pollutants and their dispersion in to the surrounding areas.

8. Corrosion inhibitor chemical should be injected in the pipeline during its operation to prevent internal corrosion.

6.1 STORAGE AND HANDLING OF PETROLEUM FLUIDS – GENERAL PRECAUTIONS

Two main aspects of fire protection are prevention and loss limitation

Fire Prevention

Fire prevention is the first requirement in fire safety. Since for a fire to start, fuel, oxygen and heat must be represented, effective fire prevention simply boils down to manipulation of these constituents, so that a fire cannot start.
Where flammable fluids in the open storage area, are concerned, fuel and oxygen are immediately present. Only thing lacking to start a fire is heat. The flash point of many of the petroleum fluids is below 0^oC, which means that at any temperature above 0^oC, these gases can generate enough vapors to form, a flammable mixture in air, which will catch fire if exposed to a spark, flame or other source of ignition.

So, strictly from fire preventing point of view,

1. The working temperature must be kept as low as possible
2. Supply of atmospheric oxygen must be cut off
3. All sources of ignition must be eliminated
4. The area must be well ventilated so that even though there is enough vapor to form flammable mixture with air, the vapor will be dispersed quickly (rapid air entrainment) preventing a build-up of a destructive explosive mass .

Unfortunately, on an industrial scale, of the above, the first two are relatively difficult to attain and third one can only be partially attained as stringent restrictions such as complete elimination are seldom economically feasible.

Oxygen: It is difficult to manipulate the oxygen concentration in a working area, particularly since a concentration of oxygen below normal to keep fires from starting, would also be too low to support human life.

Heat: Can be manipulated to render a set-up fire safe to an extent. It is important to note that for a fire to start, it is often necessary to heat to a sufficient degree only a very small quantity of fuel and oxygen mixture. Once a small fire is started, it supplies enough heat to ignite more fuel and oxygen mixture and so on quickly becoming a large fire. Small fires should therefore not be neglected. This heat may be provided by various sources of ignition, which therefore has to be eliminated. The essence of modern day fire prevention is to rapidly detect a small fire and extinguish it before it assumes menacing proportions requiring major fire equipment and skilled personnel mobilization.

Sources of ignition:
In petroleum tank storage farms, it is very important to recognize the ignition sources and make sure that they are kept away from potential vapour or gas sources to the most feasible extent. Some of the most common ignition sources are:
Open flames: At or near flammable gases installation it is necessary to check for such sources as burners, matches, lamps, welding torches, lighting torches, broken gas or oil lines.
Precautions:
- Ample isolations must be obtained by means of partitions.
- Partitions should be substantial enough to contain fire, if one starts.
- sprinkler or other fire fighting mechanism should be ready to put out the fire
- Fire resistant construction should be chosen.

***Electrical sources*:** Electric power supply and generating equipment, heating equipment, lighting equipment. There are recognized standards these should be carefully observed while installing electrical equipment in flammable fluid storage area. Most motors, switches and other electrical devices powered by generated electricity are potential fire hazard. These should be:

- located outside areas where flammable vapors are present or
- enclosed and sealed so that vapor or gas cannot reach the arcs or sparks in the device or
- Enclosed in a housing that is strong enough and tight enough to ensure that

any explosion within the enclosure will be contained without releasing flames or hot gases to the outside. Such enclosures are called explosion proof.

- Enclosed in a housing that is pressurized with clean air to prevent migration of outside atmosphere into it.

***Static electricity*:** Discharges of static electricity can be an ignition source and precautions against accumulating hazardous charges must be taken. For static electricity to be an ignition source there must be :

- a mechanism for accumulating charges, generally on a conductive material that is insulated from its surroundings
- a spark gap between charged conductor and a conductor at some other electrical potential
- A flammable vapor or gas-air mixture in this spark gap, at the time the spark jumps across the gap.

Lightning is also a form of static electricity and special means to avoid its ignition hazards should be taken
Bonding and grounding are effective solutions, especially in a petroleum depot.

***Sparks*:** from mechanical tools and equipment, hot ashes from smoking unprotected extension lights, boilers and furnaces, back fire from gasoline/diesel engines are all potential causes of fire. Smoking prohibition should be ensured and implemented strictly.

***Hot surfaces*:** Flammable liquid and gases can be ignited by contact with hot surfaces, such as glowing electrical elements or other exposed surfaces that are very hot. If hot surfaces are covered with insulation, it can become an ignition source at substantially low temperatures. Care should be taken that material whose auto ignition temperature is lower than the temperature sometimes reached by the operating equipment, be kept at a safe distance from such equipment. This particularly applies to mobile construction related equipment used for modifications.

***Friction*:** Friction sparks are a form of hot surface. Friction from rubbing or striking objects or defective equipment can result in heating or sparks that could ignite flammable vapors. Steel hand and mechanical tools such as hammers, shovels and wrenches are likely source of sparks. In area where flammable vapors are possible, non sparking tools should be used.

***Spontaneous ignition*:** Many fires are caused by spontaneous heating of materials, accelerated by external heat. Wherever flammable gas is handled, it is important to pay particular attention to good housekeeping and ventilation.

6.2 FIRE PROTECTION

When the vapor is given off by a petroleum fuel being ignited, burning will continue as long as there is a continuous supply of vapor and air sufficient to provide a flammable mixture. To extinguish the fire, depriving the combustion zone of either vapor or air is important. Various fire fighting media are available, some time tested and used successfully and some new ones being the subject of much R and D work. The more common ones are described below.

Water

Water as a fire extinguishing agent:
The primary function of water as a fire extinguishing agent is as a coolant. Maximum cooling effect is obtained when the water is in the form of a fine spray or fog which cools the flames and the burning surface. If the temperature of the burning surface is cooled below its flash point, the fire will be extinguished. Though gases with very low flash points cannot be cooled by this method, for heavy gases, water spray or fog is a very effective and cheap fire extinguishing agent.

Water as protection for tanks exposed to heat:

When a tank/Pipe line which contains flammable gases is exposed to radiant heat or direct flames, the two main consequences are:-

- The part of the tank/Pipeline which is not wetted by the contents may be so weakened by flame lick that it will buckle and possibly fracture

- The rate of vaporization of the gases increases as a result of the heating of the part of the tank/pipeline wetted by the contents and the tank/pipeline will be subjected to dangerous overpressure if not provided with suitable arrangements for relieving internal pressure.

Cooling water, preferably in the form of spray, applied to the part of the tank by its contents must therefore have priority in any bulk storage depot.

Foam

Foam for fighting gas fires is of three main types:
- Chemical foam
- Mechanical foam (protein base)
- Detergent foam

Case Study- Foam application

One of the eye opening Petroleum fires was that which occurred in the Union Oil Tank Farm during the early hours of 24th September 1977 due to a thunderstorm in a Chicago suburb called Romeoville. The Tank involved was initially a 190 feet dia by 53 feet high cone roof tank (tank 413) storing Diesel. This tank exploded and its fragments struck another tank (tank 115) containing gasoline in a 100 feet dia by 40 feet height floating roof tank. Other fragments traveled north and struck another gasoline tank (tank 312), again a floating roof tank of size 180 feet dia and 40 feet high. Tank 413 and 115 were ignited immediately. The surface area was totally involved. Fire developed in the seal area of tank 312 and persisted for several hours until the roof sank and the entire surface area became involved. The two largest tanks were full whereas the smallest was about half full.

Fire fighters confronted two and then three tanks on fire- critically exposed were a Butane-butylenes sphere (tank 432) located almost west of tank 413. The cooling of the sphere was initiated immediately. Winds luckily were favorable for fire fighting operations.

Union Oil was a mutual aid member and resources were hence easily mobilized from nearby industries and authorities, who sent in huge quantities of foam proportioning systems to supplement Union Oils reserves.

Initial efforts were directed at cooling exposed tanks and preventing further spread of fire whilst Union Oil staff started pumping out oil from the burning tanks. Huge quantities of foam were going to be required to fight the fire over an area of over 62,000 square feet burning area- for this, National Foam was contacted to supply immediately. Tank 115 was selected as the first to put out as it was endangering a piperack. Some areas of the big tanks were not accessible to fire fighting.

Foam subsurface injection through a 24 inch suction line of tank 413 after quickly fabricating a manifold for attaching foam makers was carried out after due calculations. This was partly successful. Examination of tank 413 revealed a split in the 24 inch line from where diesel was leaking out and feeding a fire in the diked area. During subsurface injection, a foam truck water pumps cavitated. Also, two attempts to direct foam streams over the top rim from ground failed. Also, despite all efforts, foam supplies got exhausted and arrived later, by which time the fire had spread again. A further attempt using a combination of subsurface and topside application was made, with a subsurface injection rate of 2000 gpm and topside rate 1000 gpm, but foam was discharging out of a water bottom created by the previous subsurface attempt- it was then discontinued. Foam from monitors was increased and the fire eventually extinguished. Also, in the end, tank 312 burned itself out.

Lessons to be learnt include:-

- Subsurface injection may be effective for large cone roof tanks if equipment is fully ready. If attack is delayed and shell plates become deformed, it may be difficult.

- Review need for large quantities of foam- quick arrangements may be necessary.

- Logistics of maneuvering such large foam quantities need to be addressed as consumption could go to one and half drums per minute.

- Water reserve back ups are essential and need to be planned- 4 hours may not be enough.

- Good mutual aid planning can prove vital, as in this case.

- Check radio frequencies of Mutual aid members and fire brigades as 2 way communication could be critical when multi agencies are involved in fire fighting efforts.

- Designation of a fire control centre for emergencies.

- Water supplies were critical - make up was done by boats of the Chicago Fire Service from a canal.

6.3 SAFETY MANAGEMENT SYSTEM (SMS)

The failure probabilities largely depend upon how effectively Safety is being managed. This in turn necessitates formal documented Safety Management System (SMS), one that is effective. The features of a Safety Management System are described below.

Analysis of industrial accidents and disasters has clearly shown that these are not simply a consequence of direct technical failure or operator tasks carried out incorrectly. The underlying causes may be deeply routed in management aspects of the organization. In some cases, the incidents could have been prevented with a formal Safety Management System (SMS). In other situations, a safety management system was in place, but did not prevent the occurrence of the incident. This suggests the need for a wider application of “best practice” safety management system in industry. Moreover it raises the question of the quality of such systems.

Safety, Health and Environment (SHE) should be a function reporting at the highest management level. There is nothing unusual about this suggestion since such is the practice followed by renowned multi-nationals.

SHE management comprises of a number of elements. For the sake of completeness, as an example, the contents of the SHE programme covered in the current practice are given below:

6.4 SMS ELEMENTS

- Management leadership, commitment and accountability
- Risk Analysis, Assessment and Management
- Facilities design and construction
- Process and facilities information and documentation
- Personnel safety
- Health
- Personnel
- Training
- Operation and Maintenance procedures
- Work permits
- Inspection and Maintenance
- Reliability and Control of defeat of critical systems & devices
- Pollution prevention
- Regulatory compliance
- Product stewardship
- Management of change
- Third party services
- Incident reporting, analysis and follow-up
- Emergency preparedness
- Community awareness

- Operations integrity assessment and improvement

These elements cannot be used as such. They need to be converted into workable procedures. The twenty one elements listed above for illustration, embrace over 100 distinct requirements with corporate guideline for each. These system and procedures should detail at least the following:

- Objectives and scope (What is required to be achieved)?
- Tools and procedures (How is it going to be achieved)?
- Resources and responsibilities (Who is responsible? Does he have commensurate resources?)
- Plans and measurement (How is the performance going to be measured?)
- System of monitoring and control (Audit procedures)

6.5 MOCK DRILL EXERCISES

Mock drill should be conducted every month and Onsite Mock drills should be conducted once in six months. Exercises or Drills have two basic functions, namely training and testing. While exercises do provide an effective means of training in response procedures, their primary purpose is to test the adequacy of the emergency management system and to ensure that all response elements are fully capable of managing an emergency situation.

Mock drills are best means of accomplishing the following goals and objectives:

1. To reveal weaknesses in the plans and procedures before emergencies occur.

2. To identify deficiencies in resources (both in manpower and equipment).

3. To improve the level of co-ordination among various response personnel, departments and agencies.

4. To clarify each individual’s role and areas of responsibility.

Chapter-7: HAZOP Review

7.1 INTRODUCTION

HAZOP analysis is a systematic technique for identifying hazards and operability problems throughout an entire facility. It is particularly useful to identify unwanted hazards designed into facilities due to lack of information, or introduced into existing facilities due to changes in process conditions or operating procedures.

7.2 HAZOP PROCESS

A block flow diagram of the HAZOP process is given below. The following terms are being used in the HAZOP process.

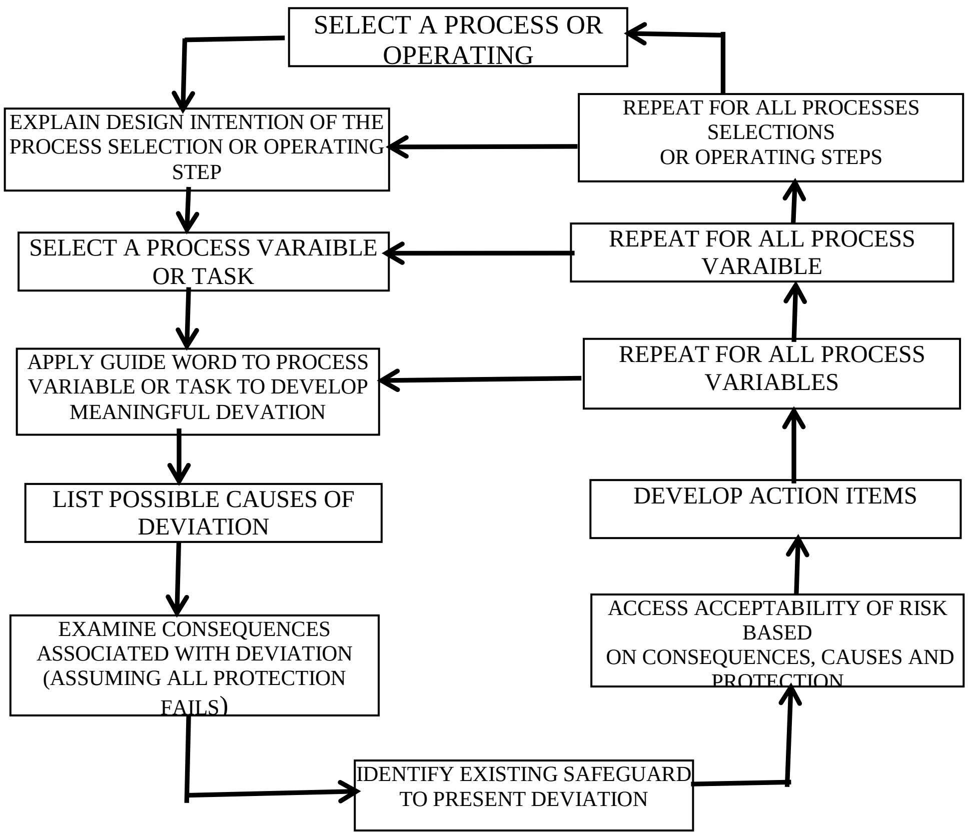


Figure-7.1: HAZOP Process

Design intent: the way a process is intended to function.

Deviation: a departure from the design intend discovered by systematically applying guide words to process parameters.

Guide word: simple word such as “high” pressure, “high” temperature, “leak” etc. that are used to modify the design intent and to guide the stimulate the brainstorming process for identifying process hazards.

Cause: the reason why a deviation might occur.

Consequence: The result of a deviation.

Safeguard: Engineered system or administrative controls that prevent the cause or mitigate the consequences of deviations.

Hazard category: An assessment of the hazard risk of the operation.

Recommendations: recommendations for design changes, procedural changes, or for further study.

7.3 HAZOP MATRIX

Table-7.1: HAZOP Matrix

Guide word / Process-variable	No	Low	High	Part of	Also	Other than	Reverse
Flow	No flow	Low flow	High flow	Missing ingredients	Impurities	Wrong material	Reverse flow
Level	Empty	Low level	High level	Low interface	High interface	-	-
Pressure	Open to atmosphere	Low pressure	High pressure	-	-	-	Vacuum
Temperature	Freezing	Low temp.	High temp.	-	-	-	Auto refrigeration
Agitation	No agitation	Poor mixing	Excessive mixing	Irregular-mixing	Foaming	-	Phase separation
Reaction	No reaction	Slow reaction	"Runaway reaction"	Partial reaction	Side reaction	Wrong reaction	Decom-position
Other	Utility failure	External leak	External rupture	-	-	Start-up Shutdown Maintenance	-

7.4 HAZOP CRITICALITY ANALYSIS

Criticality- Combination of severity of an effect and the probability or expected frequency of occurrence. The objective of a criticality analysis is to quantify the relative importance of each failure effect, so that priorities to reduce the probability or to mitigate the severity can be taken.

Formula for Criticality analysis:

Cr = P X B X S
Cr: criticality number
P: probability of occurrence in a year
B: conditional probability that the severest consequence will occur
S: severity of the severest consequence
Values for P, B and S:

Table 7.2: Values for HAZOP Critically Analysis

Categories					
Probability **P**		Cond. Probabil **B**		Severity **S**	
Very rare	1	Very low	1	Low	1
Rare	2	Low	2	Significant	2
Likely	3	Significant	3	High	3
Frequent	4	high	4	Very high	4

7.4.1 Probability (P) very rare - less than once in 100 years; rare - between once in 10 y and once in 100 y; likely - between once a year and once in 10 years; frequent - more frequent than once a year.

7.4.2 Conditional probability (B) very low - less than once every 1000 occurrences of the cause; low - less than once every 100 occurrences of the cause; significant - less than once every 10 occurrences of the cause; high - more than once every 10 occurrences of the cause.

7.4.3 Severity (S) low- no or minor economical loss/small, transient environmental damage; Significant- considerable economic losses/considerable transient environmental damage/slight non-permanent injury; high- major economic loss/considerable release of hazardous material/serious temporary injury; very high- major release of hazardous material/permanent injury or fatality.

For the proposed product pipeline from Paradip- Hyderabad,

Cr = Rare x Low x Low

Cr = 2 x 2 x 1

Cr = 4

Therefore, Combination of severity of an effect and the probability or expected frequency of occurrence for the Project is Low as it can be seen by its value as compared to the highest value of criticality which will be 64.

7.5 FAULT TREE ANALYSIS

Graphical representation of the logical structure displaying the relationship between an undesired potential event (top event) and all its probable causes

- Top-down approach for failure analysis
- Starting with a potential undesirable event - top event
- Determining all the ways in which it can occur
- Mitigation measures can be developed to minimize the probability of the undesired event.

7.5.1 Fault Tree can help to

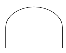
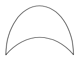
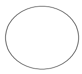
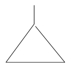
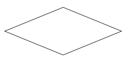
The following are the benefits of fault tree analysis.

- Quantifying probability of top event occurrence
- Evaluating proposed system architecture attributes
- Assessing design modifications and identify areas requiring attention
- Complying with qualitative and quantitative safety/reliability objectives
- Qualitatively illustrate failure condition classification of a top-level event
- Establishing maintenance tasks and intervals from safety/reliability assessments.

7.5.2 Fault tree construction

The following gates are used while construction of fault tree for a given process. The meaning and purpose of these are given in the below table.

Table-7.3: Fault Tree Construction

	**AND gate** The AND-gate is used to show that the output event occurs only if all the input events occur
	**OR gate** The OR-gate is used to show that the output event occurs only if one or more of the input events occur
	**Basic event** A basic event requires no further development because the appropriate limit of resolution has been reached
	**Intermediate event** A fault tree event occurs because of one or more antecedent causes acting through logic gates have occurred
	**Transfer** A triangle indicates that the tree is developed further at the occurrence of the corresponding transfer symbol
	**Undeveloped event** A diamond is used to define an event which is not further developed either because it is of insufficient consequence or because information is unavailable

7.5.3 Guidelines for developing a fault tree

Following guidelines are to be kept in mind while developing fault tree

- Classify an event into more elementary events.
- Replace an abstract event by a less abstract event.
- Identify distinct causes for an event.
- Couple trigger event with ‘no protective action’.
- Find co-operative causes for an event.
- Pinpoint a component failure event.

Below diagram shows the fault tree for the Project.

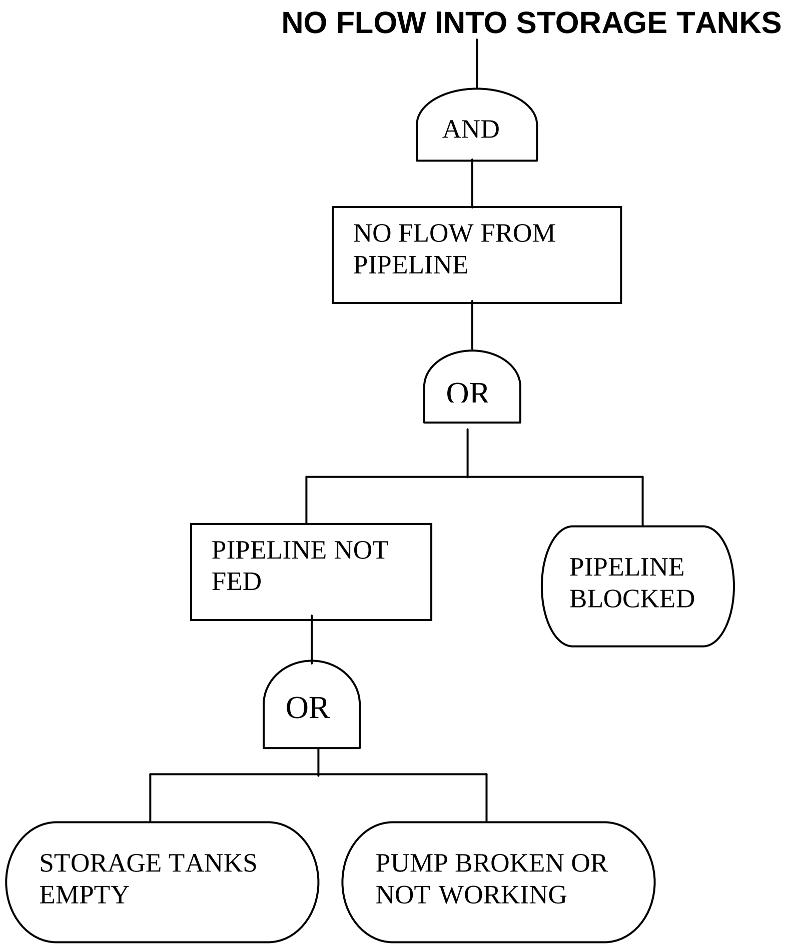


Figure-7.2: Fault Tree for the Project

7.5.4 Consequence event tree – instantaneous rupture

Below tree shows the consequence event tree for the Project.

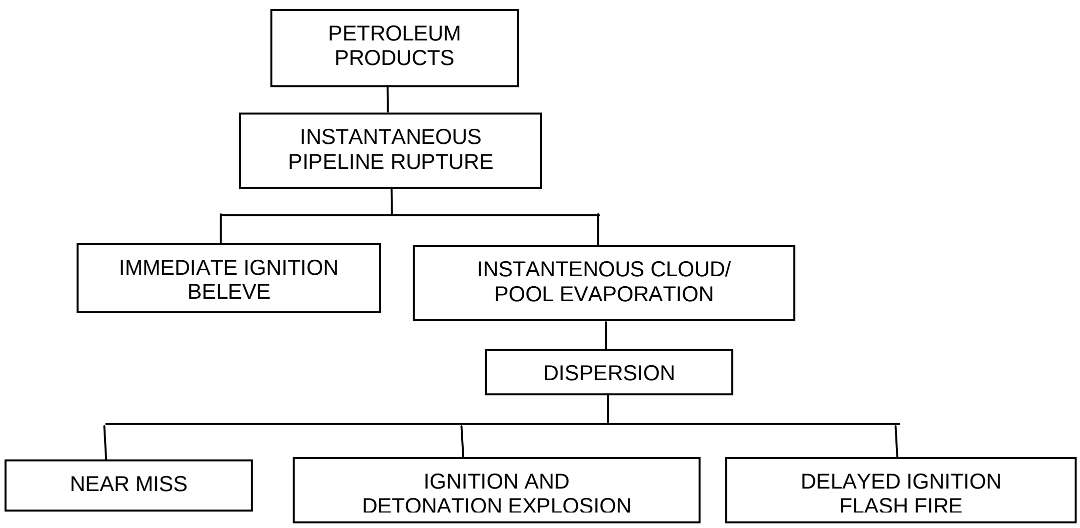


Figure-7.3: Consequence event Tree

7.6 RISK MATRICES

The risk matrix approach is comprised of three separate matrices. For each hazard, the following matrices are used:

1. Consequence Matrix
2. Frequency Matrix
3. Risk Matrix

7.6.1 Consequence Matrix

The first risk term to be considered is the consequence associated with a given hazard.

Fires and Explosions

The topic of fire analysis and control is covered by a wide range of standards from bodies such as the National Fire Protection Agency.

The fire and health hazards are categorized based on NFPA (National Fire Protection Association) classifications, described below.

Table-7.4: Hazard Identification for Product at the Project

S. No	PETROLEUM PRODUCT	N_h	N_f	N_r
1.	MS	1	3	0
2.	HSD	0	2	0
3.	SKO	0	2	0
4.	ATF	0	2	0

N_h NFPA health hazard factor
N_f NFPA flammability hazard factor
N_r NFPA reactivity hazard factor

Gas Releases

If a facility releases a toxic or flammable gas it is important to know how far the plume will travel, what the concentration gradient within the plume will be, and what impact various concentrations of gas are likely to have on human health. The effect of a release depends on a plethora of factors such as the density of the gas, the amount released, weather conditions at the time of the release, and the roughness of the ground surface.

Representative Consequence Matrix

A representative consequence matrix is shown in Table 7.5 which identifies three consequence categories: worker safety, public safety, environmental impact; each of these is divided into four levels of seriousness. There are no rules as to how many levels should be selected, nor does any major regulatory body insist on a particular size of matrix.

However, many companies choose four levels; three levels do not provide sufficient flexibility and differentiation, but five levels imply a level of accuracy that is probably not justified — estimates of hazard consequences are usually very approximate. Table 7.5 also provides some examples of the values assigned to each level of consequence for each category. Once more, there are no rules regarding these levels; company will select values that are most appropriate for its own circumstances.

The Representative consequence matrix for the Project comes under Low Category.

Table-7.5: Representative Consequence Matrix

	Worker Safety	Public Safety	Environment
Low 1	Report-able or equivalent	None	None
Moderate 2	Hospitalization or long time injury	Minor medical attention	Report to agencies
Severe 3	Single disabling injury	Hospitalization or serious injury	Remediation required
Very Severe 4	Fatality or multiple serious injuries	Fatality or multiple serious injury	Business threatening

7.6.2 Frequency Matrix

Once the predicted consequences of an identified hazard have been ranked, then some estimate as to the frequency with which the hazard may occur. A representative frequency matrix is shown in Table 7.6. Once more, four value levels are provided. As with consequence values, three levels is probably too coarse, but five levels or more implies accuracy that probably cannot be justified.

The frequency level matrix for the project comes under Medium Category (Conceivable — has never happened in the facility being analyzed, but has probably occurred in a similar plant somewhere else).

Table-7.6: Frequency Levels Matrix

	Frequency	Comments
Low	< 1 in 1000 years	Essentially impossible
Medium	1 in 100 years to 1 in 1000 years	Conceivable — has never happened in the facility being analyzed, but has probably occurred in a similar plant somewhere else.
High	1 in 10 years to 1 in 100 years	Might happen in a career.
Very High	> 1 in 10 years	It is likely that the event has occurred at the site if the facility is more than a few years old.

7.6.3 Risk Matrix

Having determined consequence and frequency values, the overall risk associated with the hazard is determined using a risk matrix as given in below **Table-7.7.**

Table 7.7: Risk Matrix

		Consequence			
		Low	Moderate	Severe	Very Severe
Frequency	Low	D	D	C	B
	Medium	D	C	B	B
	High	C	B	B	A
	Very High	B	B	A	A

A — requires prompt action: money is no object, and the option of doing nothing is not an option. An 'A' risk is urgent. If the A-level risk represents an emergency situation, management must implement Immediate Temporary Controls (ITC) while longer-term solutions are being investigated.

B — Risk must be reduced, but there is time to conduct more detailed analyses and investigations. Remediation is expected within say 90 days. If the resolution is expected to take longer than this, then an Immediate Temporary Control must be put in place to reduce the risk.

C — the risk is significant. However, cost considerations can be factored into the final action taken, as can normal scheduling constraints, such as the availability of spare parts or the timing of plant turnarounds. Resolution of the finding must occur within say 18 months.

D — requires action, but is of low importance. The decisions as to what values to assign the different letters, and which letters go in which boxes vary according to the company, the technology being used, and past experience of incidents.

The Overall Risk matrix for the Project comes under D Category (Low), which means requires action, but is of low importance. The decision depends upon the technology being used, and past experience of incidents.

Indian Oil

DISASTER MANAGEMENT PLAN (DMP)

FOR

PROPOSED PRODUCT PIPELINE FROM PARADIP TO HYDERABAD

M.2014 **January, 2014**

MANTEC CONSULTANTS PVT. LTD.

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TABLE OF CONTENTS

Chapter-1: Introduction

1.1 BACKGROUND

Disaster Management planning is an integral and essential part of loss prevention strategy. Although a great deal of efforts and money is spent to reduce the scale and probability of accidents, there always remains a finite but small possibility that disaster may occur. Effective action has been possible due to existence of pre-planned and practiced procedures for dealing with emergencies.

This disaster management plan sets out the procedures and measures to be taken into account in the event of loss of containment and consequence thereof in the Proposed product pipeline from Paradip to Hyderabad.

1.2 TYPES OF EMERGENCIES

The type of emergency primarily considered here is the major emergency which may be defined as one which has the potential to cause serious danger to persons and/or damage to property and which tends to cause disruption inside and/or outside the site and may require the co-operation of outside agencies.

Emergency is a general term implying hazardous situation both inside and outside the Pipeline route. Thus the emergencies termed “on-site” when it confines itself within the Pipeline route even though it may require external help and ‘offsite” when emergency extends beyond its proposed route. It is to be understood here, that if an emergency occurs near the pipeline route and could not be controlled properly and timely, it may lead to an “off-site” emergency.

An emergency in the Proposed Pipeline project can arise due to certain undesired incidents resulting in fire, explosion or vapour cloud of petroleum gases.

1.2.1 Definition of On-Site Emergency and Off-site Emergency

An On-site emergency is one where the consequences of an undesired incident remain confined within the boundaries of the facility. Emergencies at the Proposed product pipeline from Paradip to Hyderabad shall be On-Site Emergencies if the consequences remain confined to the route of the proposed pipeline and to the boundaries of the terminals falling on the route.

An emergency, which is likely to develop or has developed such as to pose a threat to members of public outside the facility boundary, is termed as an off-site emergency. All mainline emergencies shall be Off-site emergencies. Emergencies at the proposed product pipeline from Paradip to Hyderabad project shall be Off-Site Emergencies, if the consequences exceed the boundaries.

1.2.2 Classification of Emergencies

Emergencies have been broadly classified into three levels:

Level 1 : The incident at Paradip- Hyderabad pipeline project confined to a small area and does not pose an immediate threat to life or property.

Level 2 : An incident at Paradip- Hyderabad pipeline project involving a greater hazard or larger area which poses a potential threat to life or property.

Level 3 : An incident at Paradip- Hyderabad pipeline project involving a severe hazard or a large area which poses an extreme threat to life or property.

1.2.3 Priority in Emergency Handling

The general order of priority for involving measures during the course of emergency would be as follows:

- Safeguard life
- Safeguard environment
- Safeguard property

1.3 SPECIFIC OBJECTIVES OF THE DISASTER MANAGEMENT PLAN

The internal resources in the installation like dispatch, intermediate stations may be inadequate to deal with the on site situation and will require the support of outside services. It can provide resources to supplement the internal resources and deal with the situation "off-site". They would, however, find it in some situation difficult to operate effectively in isolation from the internal resources. The objective must be therefore to make the most effective use of the combined resources to:

- Safeguard Pipeline and outside resident people.
- Minimize damage to property and the environment.
- Initially contain and ultimately bring the incident under control.
- Identify casualties.
- Provide for needs of casualties.
- Provide authoritative and factual information for the news media.
- Secure safe rehabilitation of the affected area.
- Preserve relevant records and equipment for the subsequent enquiry into the circumstances and cause of the incident.
- Restore the facilities at the earliest.

The main objectives of the Disaster Management Plan would be:

- Ensure that loss of life and injuries to persons are minimized
- Damage to environment is minimized
- Property loss is minimized
- Relief and rehabilitation measures are effective and prompt
- Minimize the outage duration of the facilities.

The above objectives are sought to be achieved through some of the following measures:

- Providing information to all concerned on the estimated consequences of the events that are likely to develop as a result of the emergency;
- Mobilizing on-site resources;
- Calling up assistance from outside agencies;
- Initiating and organizing evacuation of affected workmen;
- Providing necessary first aid and other medical services that may be required;
- Collecting data on the latest developments, other information and requirements.

1.4 LEGAL AUTHORITY AND RESPONSIBILITY

1.4.1 On Site Emergency Planning

The provisions of the Hazardous Chemicals Rules, Section 41 B(4) of the Factories Act, 1948 (as amended) requires that every occupier is to draw up an on-site emergency plan with detailed disaster control measures and to educate the workers employed. The obligation of an occupier of hazardous chemicals installation to prepare an emergency plan is also stipulated in Rule 13 of the 'Manufacture, Storage and Import of Hazardous Chemicals Rule's, 1989 and amended.

1.4.2 Off-Site Emergency Planning

Under the 'Manufacture, Storage and Import of Hazardous Chemicals Rules' preparation of 'Off-site Emergency Plan' is covered in Rule No.14. The duty of preparing and keeping up to date the 'Off-site Emergency Plan' as per this rule is placed on the District Emergency Authority. Also, occupiers are charged with the responsibility of providing the above authority with such information, relating to the industrial activity under their control, as they may require for preparing the off-site emergency plan.

Off-site emergency response needs actions by various Government agencies over which the operating company has no control. IOCL's role and responsibility is to provide material, manpower, and knowledge support under the overall charge of the off-site control administration.

1.5 STRUCTURE OF THE DISASTER MANAGEMENT PLAN

This Disaster management plan basically comprises of the following elements:

1 Identification of hazards and risk analysis
2 Organizational Structuring, Duties and Responsibilities
3 Response Procedures
4 Infrastructure and Resources

Identification of hazards and Scenarios

The release-consequence scenarios have been summarized in Chapter 2, of DMP. Basis for selection of release scenarios for response planning has also been discussed.

Organizational Structuring, Duties and Responsibilities

The organization structuring, duties and responsibilities for IOCL has been described in Chapter 3 of DMP.

Response Procedures

The response procedures have been covered in Chapter 4 of this document.

Off site Emergency Plan

The organizational aspects, duties and responsibilities of various civic authorities for an Off-site emergency response have been briefly described in Chapter 5.

Infrastructure and Resources

These have been documented in Appendix 1.

Chapter-2: Selection of Scenarios for Emergency Planning

2.1 INTRODUCTION

The primary step in any disaster management planning is identification and assessment of the principal hazards like for instance the hazards due to fire & explosion. It is the most important step without which the whole exercise of emergency planning turns out to be meaningless.

Operation experience, past histories and criteria review will help in identifying the vulnerable points and possible hazards. These are then assessed by applying the appropriate risk analysis methods.

In this Chapter, the findings of the risk analysis study have been summarized. The basis for selection of scenario for emergency planning has also been discussed. The accident scenarios for planning response procedures and carrying out mock drill are suggested.

2.2 HAZARD IDENTIFICATION & SELECTION OF SCENARIOS

The hazards include:

- Pool Fire
- BLEVE
- Toxic Threat Zone
- Vapour cloud explosion

The causes of the leakage can be divided into following categories:

- Mechanical failure
- Operational failure
- Natural hazards
- Third party activity

At the pumping station, failure of any of the equipment such as pipeline, valves, flanges, filter etc. can result in loss of containment. The new Proposed Paradip-Hyderabad pipeline project is divided into appropriate isolated sections i.e. sections that can be promptly isolated from each other in case of emergency.

The outcome cases considered for each release case are as follows:

- Immediate ignition resulting in jet fire
- Delayed ignition resulting in toxic threat zone / vapour cloud explosion

The following damage criteria for 1% fatality distances have been used:

- Fires : heat radiation 12.7 kW/m^2 during 20 sec
- Explosions: overpressure 0.1 bar.

For emergency plan following effect – distances were calculated:

- 10 kW/m^2 -high damage risk
- 3 kW/m^2 -low damage risk
- 1 kW/ m^2 -no damage risk

2.3 SUGGESTED ACCIDENT SCENARIOS FOR EMERGENCY PLANNING

Based on the risk analysis study and discussion on basis for scenario selection for emergency planning, the accident scenarios for planning response procedures and carrying out mock drill are suggested as follows.

For Pump Stations

- In most cases the leak will be contained within the boundary wall, therefore, for jet fire scenarios the consequences are not likely to go beyond the boundary limits.
- A vapour cloud can be formed except for unstable weather conditions such as typical day-time conditions.
- Line rupture downstream of pump, release of Oil, formation of flammable vapour cloud and possibility of delayed ignition resulting in vapour cloud explosion/flash fire/toxic threat.

For pipeline

- For Pipeline, the 1% fatality distance (12.7 kW/m^2) for clothed human body and exposure duration of 10 seconds extends. Calculations indicate that there are no possibilities of explosive mass from fixed pool area.

The response procedures have been detailed in Chapter 4 for various planning topic. These response procedures should be reviewed for the scenarios selected for planning. Mock Drills should be conducted regularly, and based on the results of mock drills the response procedures should be updated and/or other accident scenarios included for planning.

2.4 MOCK DRILL EXERCISES

Exercises or Drills have two basic functions, namely training and testing. While exercises do provide an effective means of training in response procedures, their primary purpose is to test the adequacy of the emergency management system and to ensure that all response elements are fully capable of managing an emergency situation.

Because drills and exercises simulate actual emergency situations, they are the best means of accomplishing the following goals and objectives:

1. To reveal weaknesses in the plans and procedures before emergencies occur.
2. To identify deficiencies in resources (both in manpower and equipment).
3. To improve the level of co-ordination among various response personnel, departments and agencies.
4. To clarify each individual's role and areas of responsibility.

The four types of drills and exercises to test the adequacy of the plan are: (1) orientation exercises, (2) tabletop exercises, (3) functional drills, and (4) full-scale exercises. Each of these should be designed to evaluate individuals' responses to various degrees of simulated emergency conditions in order to test the adequacy of procedures.

Chapter-3: Organization-Duties & Responsibilities

3.1 INTRODUCTION

In case of an emergency at any Terminal/pipeline route, the On-site Emergency Plan of the pipeline will come into action.

Effective emergency plan requires that, in the event of an accident, nominated functionaries be given specific responsibilities, often separate from their day-to-day activities.

The emergency organization follows the usual pattern of the hierarchy. The senior-most functionary available during an emergency at the plant takes charge as **Chief Emergency Coordinator (CEC)** and will locate himself at the designated Primary Command Post. The senior most functionaries for each emergency service will act as coordinator and shall report at the Primary Command Post unless otherwise instructed by the Chief Coordinator.

The senior most person (operations) in the shift is designated as the **Site Incident Controller (SIC)**. The SIC takes charge of the incident site and takes the overall command. He is supported by other Key persons representing various emergency services. **Key persons** are personnel available at the site on round the clock basis. It is to be appreciated that the Key Persons remain the front line fighters. The role of various **coordinators** is to assess the situation from time to time, take appropriate decisions in consultation with the CEC and to provide timely resources to the Key Persons to fight the emergency.

Emergency planning also requires coordination with Head Office, Regional Office and other stations around the proposed pipeline. The main functionary at head office has been designated as **Crisis Coordinator (HO)**. The main functionary at Regional office has been designated as **Crisis Coordinator (RO)**.

Duties and responsibilities of various emergency functionaries have been described in following sub sections. The organizational aspects, duties and responsibilities of various civic authorities for an Off-site emergency response have been given in Chapter 5.

In sub section 3.3 below, names of the designated coordinators for each station/ and head office/ regional office have been listed.

3.2 DUTIES AND RESPONSIBILITIES FOR FUNCTIONARIES

The duties and responsibilities of the functionaries are given below:

3.2.1 Crisis Coordinator (HO)

i. To establish emergency control center at Head Office.
ii. To supply manpower from Head office as required by CEC.
iii. To arrange mobilization of material and equipment from other units and outside agencies as required by CEC.

iv. To contact crisis cell of the ministry and inform about the incident, magnitude of disaster, combating operations and number of casualties if any.

v. To approve release of information to press, TV and Government agencies.

3.2.2 Crisis Coordinator (RO)

i. To establish emergency control center at Regional Office.

ii. To supply manpower from Regional office as required by CEC.

iii. To coordinate with other stations and outside agencies, to arrange mobilization of material and equipment as required by CEC.

3.2.3 Chief Emergency Coordinator (CEC)

He will report at the command post and will assume overall responsibility of the works and its personnel. His duties are:

i. To assess the magnitude of the situation and decide whether a major emergency exists or is likely to develop, requiring external assistance. To inform District Emergency Authority (DEA). (i.e. District Collector) in case on-site emergency escalates into off-site emergency.

ii. To exercise direct operational control over areas in the station other than those affected.

iii. To assess the magnitude of the situation and decide if personnel need to be evacuated to identify safe places.

iv. To continuously review in consultation with the other coordinators.

v. To liaise with senior officials of Police, Fire Brigade, and Factories Inspectorate and pass on information on possible effects to the surrounding areas outside the factory premises.

vi. To liaise with various coordinators to ensure casualties are receiving adequate attention and traffic movement within the Terminal/ pipeline route is well regulated.

vii. To arrange for a log of the emergency to be maintained in control room.

viii. To release authorized information to press through the media officer designated.

ix. To control rehabilitation of the affected persons and the affected areas after the emergency.

x. To obtain assistance from Mutual Aid partners.

3.2.4 Site Incident Controller

He will take overall control of handling the emergency at site. His first task will be the isolation of the source of containment loss to the extent possible. Simultaneously, in case of fire, he will organize appropriate fire response to get the situation under control and to prevent escalation.

On arrival at the site he will assess the scale of emergency and judge if a major emergency exists or is likely to develop and will inform the control room accordingly asking for assistance and indicating the kind of support needed. His duties and responsibilities include:

i. To coordinate the activities of other key persons reporting at the incident site, under his overall command.
ii. To direct all operations within the affected areas giving due priorities for safety of personnel and to minimize damage to environment, plant and property.
iii. To provide advice and information to Fire & Safety personnel and other fire services as and when they arrive.
iv. To ensure that all non-essential workers and staff within the affected area are evacuated to appropriate assembly points and those areas are searched for casualties.
v. To organize rescue teams for any casualties and to send them to safe areas/medical centre for first aid and medical relief.
vi. To setup communication points and establish contact with control room.
vii. To seek additional support and resources as may be needed through the control room.
viii. To seek decision support from the control room for decisions such as activation of mutual aid plan etc.
ix. To preserve all evidence so as to facilitate any inquiry into the cause and circumstance, which caused or escalated the emergency. (to arrange photographs, video etc.)
x. To arrange for a head count after the emergency is over with respect to the personnel on duty in the affected areas.

3.2.5 Fire and Safety Function

The main responsibilities of fire and safety functionary are:

i. To immediately take charge of all fire fighting operations upon sounding of the alarm.
ii. To instruct the telephone operator to immediately inform all essential personnel not residing within the audible range of the emergency siren.
iii. To guide the fire fighting crew and provide logistics support for effectively combating the fire.
iv. To barricade the area at appropriate locations in order to prevent the movement of vehicular traffic.
v. To assist in rescue and first aid operations.
vi. To operate the Mutual Aid Scheme and call for additional external help in fire fighting via the control room.
vii. To organize relieving groups for fire fighting.

viii. To inform the CEC and give "All Clear" signal when the fire emergency is over.

3.2.6 Engineering Function (Maintenance)

The engineering functionary will perform the following duties:

i. To report at the control room.

ii. To mobilize the team from Maintenance Department to assist the Site Incident Controller.

iii. To arrange isolation of electric lines from distribution points/substations as required by the Site Incident Controller by calling the electrical engineers/ electricians.

iv. To provide all other engineering support as may be required.

3.2.7 Media Function

He will, under the direction of the CEC co-ordinate the following:

i. To liaise with various media and release written statements to the press through prior concurrence of CEC.

ii. To handle media interviews with various media. Make arrangements for televising the information about the incident, if public interest warrants.

iii. Inform State and Central Governments and statutory bodies of the nature and magnitude of the incident, the number of casualties etc.

iv. To locate himself such that media personnel/third parties do not need to go past the pump stations security gates and that adequate communication links exist.

v. Media personnel often insist on visiting the incident scene. To escort media team(s) if the CEC approves such visits.

3.2.8 Communication Function

Communication functionary should perform the following duties:

i. To ensure all available communication links remain functional.

ii. To quickly establish communication links between incident site and the control room.

iii. To ensure that previously agreed inventory of various types of communication equipment is maintained in working condition and frequent checks carried out and records maintained.

iv. To maintain voice record of significant communications with timings received/passed from the primary control room.

3.2.9 Medical Function

The medical functionary will perform the following:

i. To arrange for the First Aid team to treat the affected personnel.

ii. To arrange for treatment in the hospital.

iii. To liaise with the local medical authorities and hospitals, if the casualties are more and the situation demands treatment at more/other medical centers.

iv. To liaise with the Transport coordinator for transporting the victims to various hospitals. To arrange for ambulances.

v. The Medical Coordinator should ensure the upkeep of agreed medical supplies, antidotes and equipment that should always be kept in stock for treating victims of burns.

vi. To liaise with the Media coordinator for release of news to the press.

3.2.10 Transport Function

The Transport functionary shall perform the following duties

i. Arrange for Transport of victims to Hospital/Dispensaries

ii. Mobilize all available vehicles available at the pump station for emergency use, along-with the drivers.

iii. Arrange for the duty rotation of the drivers to meet with the emergency situation.

iv. To direct refueling of vehicles, if not topped up.

v. To arrange for vehicles from Other Sources.

vi. To liaise with the CEC for evacuation of personnel and transportation of victims.

3.2.11 Security Function

The Security functionary shall perform the following duties:

i. To control traffic movement in/out of the pipeline route. To instruct plant security personnel to maintain law and order and prevent unnecessary gathering of personnel not required to be present at the scene of emergency.

ii. To instruct security personnel, who could be spared, to assist Fire & Safety Coordinator in fire fighting or evacuation of personnel.

iii. To request for external help/local authorities, if needed, through control room.

3.2.12 Materials Function

The Materials functionary will ensure:

i. Availability of materials required by the Site Incident Controller.

ii. Issue of materials from warehouse round-the-clock during the emergency period.

iii. Emergency procurements from local dealers or from neighboring industries.

iv. Transportation of Materials from warehouse to the incident site in Co-ordination with Transport Coordinator.

3.2.13 Finance Function

The Finance functionary shall arrange for:

i. Release of finance as directed by the CEC.
ii. Assist Material Coordinator for emergency procurement.
iii. Liaise with Insurance Company personnel.

3.2.14 Welfare Function

i. Ensure that Casualties receive adequate attention and to arrange additional help (compensation, etc.) if required and inform the relatives.

3.2.15 Mainline Search Party Leader

The mainline search party leader shall perform the following functions:

i. Lead the search of the location of leak
ii. Assess the magnitude of the leak and give feed back to CEC for further assistance / mobilization.
iii. Act as Site Incident Controller (until the SIC designated by CEC reaches the incident site).
iv. Arrange to isolate the section of the mainline where leak is detected.

3.3 LIST OF NAMES OF FUNCTIONARIES

List of name of various functionaries with designation and telephone numbers are given below for head office, regional office and pump stations.

3.3.1 Head Office/ Regional Office

Type of Coordinator	Name	Designation	Telephone Numbers	
			Office	Residential
Crisis Coordinator (HO)				
Crisis Coordinator (RO)				

3.3.2 Pump Station

Type of Coordinator	Name	Designation	Telephone Numbers			
			Office		Residential	
			P&T	UHF	P&T	UHF
Chief Emergency (CEC)						
Fire & Safety						
Engineering						
Media						
Communication						
Medical						
Transport						
Security						
Materials						
Mainline Search party leader						

Chapter-4: Emergency Response Procedures

4.1 BACKGROUND

Since the proposed Paradip- Hyderabad will be transferring of products like MS, HSD, SKO which are inflammable in nature, due care is taken in its operation to avoid any mishap which may result in loss of material or loss of life. As such, emergency situation related to pumping operation or storing is a remote possibility.

The main emergencies associated with the pipeline route are as follows:

- Leakage of tanks/pipe due to steam or circumferential weld failure or attempted sabotage.
- Rupture/burst of tanks/pipeline

The above situations need immediate attention to avoid the following unwanted situations:

- Leakage resulting in huge losses from tanks/pipes
- Spreading of the inflammable products in the vicinity
- Induction of fire hazards in the vicinity
- Pollution of river/canal water, cultivated fields and habitats
- Prolonged disruption in pumping operation.

The designated Primary Command Post where the Chief Coordinator assisted by other designated co-coordinators shall assemble on notification of emergency are as follows:

Pump Stations	*
Head Office	*
Regional Office	*

The Field Command Post is to be promptly established near the scene of accident. It shall be the nearest office/place having communication facilities to be manned continuously.

The response planning topics covered in this chapter are as follows:

1. Initial Notification of Release
2. Establishment and Staffing of Command Post
3. Formulation of Response Objectives and Strategy at the incident site
4. Ensuring Health and Safety at Incident Scenes
5. Evacuation
6. Fire Response
7. Health Care

8. Personal Protection
9. Public Relations
10. Spill Containment and Clean-up
11. Documentation and Investigative Follow-up
12. Training

In **Chapter-2**, the accident scenarios for planning response procedures and carrying out mock drill are suggested based on the risk analysis study.

However, it has to be appreciated that no two emergency scenarios are going to be alike since the escalation process depends upon a large number of variables including the response actions. It is therefore, not only impossible but also dangerous to lay down clear-cut responses applicable to all situations. For each emergency situation spot decisions will need to be taken often under high stress conditions.

4.2 INITIAL NOTIFICATION OF RELEASES

1. In case of emergency in pump station/ terminal

Any person noticing a fire, explosion or the release of hazardous materials should shout "LEAK" or "FIRE" and immediately inform the control room.

Action by Individual Employee at the time of emergency

When You Notice
FIRE
or
LEAKAGE

Please DO (√)

- Immediately inform the control room.
- Act to control the incident as per the instructions.
- Reach the assembly point.

Please DO NOT (x)

- Get panicky or spread rumors.
- Approach control room without work.
- Engage telephone or loudophone continuously.

4.3 ESTABLISHMENT & STAFFING OF FIELD COMMAND POST

i. Quickly establish a field command post near the scene of incident. The minimum that is necessary is a continuously manned communication system close to the incident site.

ii. It is the responsibility of the response personnel at the Field Command Post to restrict the entry or movement of people into the Hazard zone. The first step of a response action must be restriction of access to the spill site and other hazardous areas.

iii. Security and access control at Field Command Post and Primary Command Post need to be provided

4.4 FORMULATION OF RESPONSE OBJECTIVES AND STRATEGY AT THE INCIDENT SITE

i. It is the responsibility of the CEC to decide on the appropriate response strategy specific to the situation prevailing. It is important to assess each particular incident before taking action.

ii. CEC in consultation with the Site Incident Controller will formulate realistic response objectives. The assessment should be based on resource requirement i.e., trained personnel and protective gear.

General

Upon completion of the incident assessment, command personnel will be in a better position to determine whether their response strategy should be defensive or offensive in nature. A defensive posture is best taken when intervention may not favorably affect the outcome of the incident, or is likely to place emergency response personnel in significant danger, and/or may possibly cause more harm than good. An offensive posture (i.e., one requiring response personnel to work well within the boundaries of hazard zones) is best taken when intervention is likely to result in a favorable outcome without exposing personnel to undue danger and without causing new and potentially more severe problems. In all cases, of course, actions to protect the public and environment outside the immediate leakage or discharge area and/or to contain the hazard from a safe distance can be initiated regardless of whether a defensive or offensive response strategy is chosen at the actual incident site

4.5 ENSURING HEALTH AND SAFETY AT INCIDENT SCENES

The results of hazard analysis will be used to identify the vulnerable zone. Based on incident-specific factors, the exact size and configuration of hazard control zones will be determined. The Hazard Control Zones have been defined below.

The CEC will formulate safe operating procedures for a site safety and health program that addresses the following.

- The use of appropriate protective gear and equipment
- Limiting the number of personnel in the “Hot” and “Warm” hazard control zones.
- Utilizing the most experienced personnel for the most hazardous tasks.
- Positioning a backup team in the “Warm Zone” in case it is needed to assist or rescue personnel in the “Hot Zone”.
- Providing medical surveillance for personnel before and after “Hot” and “Warm” Zone operations.
- Monitoring (visually and through communications contact) the welfare of personnel operating within the “Hot” and “Warm’ Zones.
- Ensuring that all personnel understand their assignments.
- Ensuring that responders do not ingest contaminants through eating, drinking,

or inhaling.
- Replacing fatigued personnel with "fresh" personnel.
- Adjusting hazard control zones to reflect changing conditions.

Hazard Control Zones
- Hot Zone" - Area of maximum hazard surrounding the damaged container(s) or fire area, which may only be, entered by specially equipped and trained response personnel.
- "Warm Zone" - Area of moderate hazard outside the Hot Zone in which properly equipped and trained backup crews standby and decontamination takes place.
- "Cold Zone" - Area outside the Warm Zone that poses minimal or negligible hazards to emergency personnel. The primary Command post, most of the deployed apparatus, and the resource staging area should be located in the Cold Zone.

4.6 EVACUATION

1. In case of an On-site emergency, the order to evacuate to a safe place will be given by the Chief Coordinator in consultation with other coordinators.

2. In case of an Off-site emergency, the order to evacuate to a safe place will be given by the District Emergency Authority in consultation with Chief Coordinator in consultation with other coordinators.

3. Accident scenarios covered in 'Risk Assessment study' can be a key source of information for evacuation planning where specific facilities are known to pose a threat. The size and shape of the vulnerable zone for selected scenarios are presented in Risk Assessment Report and have been summarized in Risk Assessment report.

4. Evacuation and shelter-in-place decisions are incident specific and must be made at the time of an actual release. Guidance obtained from consequence analysis may be considered a starting point for the decision process.

Some general guidelines in case of fire are:-

Only Personnel in close vicinity and affected by heat radiation need be evacuated to safe distances. Non-essential personnel will usually be evacuated from the incident area and also from adjacent areas. Evacuation should be to a predetermined assembly point in a safe part of the complex.

1. For serious injury cases, evacuation to hospital will be carried out by the response personnel.

2. Chief Coordinator should designate one individual to record all personnel arriving at the assembly point so that the information can be passed to the Primary Command Post.

3. At the Primary Command Post, a nominated person should collect the lists of personnel arriving at the assembly points with those involved in the incident.

These should then be checked against the roll of those believed to be on-site, updated with known changes for that day. Where it is possible that missing people might have been in the area of emergency, the site incident controller should be informed and arrangements made to organize a further search.

4.7 FIRE RESPONSE

i. All available fire fighting resources will be mobilized in minimum time by head of fire fighting services at the time of emergency. The fire fighting arrangements including manpower and resources have been organized to deal with worst scenarios like the largest tank in Pump station on fire.

ii. Fire department need to be well prepared and experienced in rescuing people from fire and explosion situations.

General

Water is not suitable for extinguishing fires caused by petrochemical products, though it may be used to keep surroundings cool and prevent the spread of fire to them. Adequate number of portable dry chemical or carbon dioxide extinguishers and foam concentrate need to be stocked. The quantity of foam requirement should be such as per OISD(117/118) guidelines.

4.8 HEALTH CARE

- Requisite medical resources will be mobilized under the overall charge of the Health and Medical functionary.
- The operational response will be coordinated from the control room.

4.9 PERSONAL PROTECTION

i. Specific skills need to be developed for the safe use of protective clothing through training and experience.

ii. The CEC will arrange for rapid availability of appropriate protective clothing in the event of an emergency.

4.10 PUBLIC RELATIONS

i. CEC will designate one specific individual as the Media Officer.

ii. The designated Media Officer only will speak to media personnel. The Media officer should ensure orderly and accurate dissemination of information. The “do’s” and “don’ts” on how to deal with the media are discussed below.

iii. The CEC should understand the need to relay up-to-date “status reports” to the Media Officer on a regular basis

THINGS TO DO:

- Accommodate the media as much as possible; make the news available to them.
- Schedule news conferences and preferably avoid written releases.
- Be direct and specific.
- Have news conferences immediately after any meeting from which the media or public have been barred.
- Send a press representative to the Primary control room.
- If safety permits, allow the media to take pictures of the accident site.

THINGS NOT TO DO

- Do not permit arguments among public officials or press officials from different organizations in front of the press. Do, however, permit statements of dissenting opinions.
- Avoid giving gut opinions or conjecturing.
- Do not be evasive. If the answer to a question is not known, refer the question to someone who has the appropriate answer.
- Do not be critical in a personal manner; i.e., avoid personal remarks about other people at the accident scene.
- Do not be philosophical. These kinds of discussions are extremely susceptible to being quoted out of context.
- Do not make off-the-record comments. They may end up in print with later retractions buried in the back pages.
- Avoid friendly chats with media people. Casual comments may appear in print.
- Avoid bad or foul language.
- Do not hide from the media. They can sense this and form an unfavorable opinion of the Media Officer as a credible source of news.
- Do not answer questions beyond personal knowledge or expertise.
- Do not permit media persons to attend emergency response team meetings.

4.11 SPILL CONTAINMENT AND CLEANUP

i. Trained personnel who are at ease in handling flammable gases need to be mobilized. Plugging and stopping of leakage and containment of the gases should be attended to with great speed while taking all measures to prevent ignition.

ii. CEC will assign responsibility to one or more individuals for identifying methods of plugging or stopping leaks, assembling the materials and supplies necessary for this task and training for their use under emergency conditions. A minimum inventory of these items should be maintained at the pump station.

iii. Upon detection of hydrocarbon leakage/fire, the immediate actions to take are:
   * Isolate the system
   * Depressurize all affected equipments

iv. It is the responsibility of the CEC to identify the rapid availability of bulldozers, fire extinguishers or the earthmoving equipment capable of digging trenches, properly equipped work crews with shovels or other equipment resist gas leaks.

v. Where necessary, plan for the rapid plugging of sections of storm drains to limit the spreading of gases that have entered a drainage system.

vi. As and if necessary, arrange for rapid availability of treatment and cleanup services.

4.12 DOCUMENTATION AND INVESTIGATIVE FOLLOW UP

i. CEC will assign responsibility to a functionary for real-time and post-incident documentation of the accident and resulting response actions.

ii. The responsible person will adopt appropriate reporting forms and procedures giving detailed records of what happened and what actions were taken in response.

General:

Detailed records of what happened and what actions were taken in response can help in:-

- Attempting to recover response costs and damages from the party responsible for the incident.
- Setting the record straight where there are charges of negligence or mismanagement resulting from the incident.
- Reviewing the efficiency and effectiveness of response actions.
- Preparing for future incident responses.
- Verifying facts, actions, injuries, equipment used, etc. for the purpose of legal

proceedings, insurance claims, budget requests, and public inquiries.

4.13 TRAINING

i. Training sessions need to be provided in which personnel are briefed on their specific duties in an emergency.

ii. To provide training to all emergency responders. The concerned personnel are shown how to wear and properly use personal protective clothing and devices.

iii. Periodic drills to be conducted to test the overall efficiency and effectiveness of the emergency response plan and emergency response capabilities.

General

The types of training required for emergency response personnel with responsibilities in any or all phases of the response is based upon the types of incidents most likely to occur and the related response and planning activities. The selection of accident scenarios for emergency planning has been discussed in Risk Assessment report.

Responsibility, Frequency and Procedure for Evaluation

The CEC is responsible for evaluating the effectiveness of the on-site emergency plan. Emergency mock drill should be conducted at an interval of six months. Experts should be invited to observe the mock drill in order to know their response and opinion. The recommendations following the discussions will help to identify the loopholes in the plan and response capability of the organization. Such periodic recommendations of the mock drill should be kept in order to update the plan.

The CEC should be responsible to update their on-site emergency plan regularly. A regular review of the plan at least once in a year should be carried out to replace outdated information or to incorporate the results of mock drill.

Chapter-5: Off-Site Emergency Response

5.1 INTRODUCTION AND DEFINITION OF OFF-SITE EMERGENCY

An emergency, which is likely to develop or has developed such as to pose a threat to members of the public out side the facility boundary, is termed as an *Off-site emergency*.

This distinction needs to be clearly appreciated. Whereas the responsibility for handling an On-site emergency is clearly that of the operating company, the responsibility for an Off-site emergency response lies with the civic authorities. Off-site emergency response needs actions by various Government agencies over which the operating company has no control.

This Chapter briefly describes the organizational aspects, duties and responsibilities of various civic authorities for an Off-site emergency response. The objective is to familiarize personnel with off-site emergency organization, and their legal responsibility to enable IOCL personnel to dovetail their efforts in an effective and orderly fashion while assisting the civic authorities.

5.2 LEGAL AUTHORITY AND RESPONSIBILITY FOR OFF-SITE EMERGENCY RESPONSE LEGISLATION IN INDIA

Under the Environment (Protection) Act, 1986 the ‘Manufacture, Storage and Import of Hazardous Chemicals Rules‘ were promulgated in November, 1989 and ‘Rules on Emergency Planning, Preparedness and Response for Chemical Accidents’ in 1996.

Under the ‘Manufacture, Storage and Import of Hazardous Chemicals Rules‘ preparation of ‘Off-site Emergency Plan’ is covered in Rule No.14. The duty of preparing and keeping up to date the ‘Off-site Emergency Plan’ as per this rule is placed on the District Emergency Authority (DEA). Also, occupiers are charged with the responsibility of providing the above authority with such information, relating to the industrial activity under their control, as they may require for preparing the off-site emergency plan.

Under the ‘Rules on Emergency Planning, Preparedness and Response for Chemical Accidents’ as gazetted in notification dated 1st August 1996 Central Crisis Group (CCG), State Crisis Group (SCG), District Crisis Group (DCG) and Local Crisis Group (LCG) need to be constituted for management of chemical accidents. The Ministry of Environment and Forests is the nodal Ministry for management of chemical disasters in the country. In order to respond adequately during a major chemical emergency, a coordinated effort at local, District, State and Central levels is needed and all available resources need be mobilized to deal with the crisis in the shortest possible time with least adverse effects. The Joint Secretary in the MoEF responsible for Hazardous Substance Management is the Member Secretary of the CCG. The Group functions under the chairmanship of Union Secretary (Environment & Forests). Similarly, a SCG and the DCG has to be constituted in every State and at district levels. The LCG will be the body in the industrial pocket to deal with chemical accidents and co-ordinate efforts in planning, preparedness and mitigation of a chemical accident.

The Major Accident Hazard (MAH) installations in the industrial pockets will aid, assist and facilitate functioning of the LCG. As per the rules, the functions of the LCG are detailed below:

- Prepare local emergency plan for the industrial pocket.
- Ensure dovetailing of the local emergency plan with the district off-site emergency plan.
- Train personnel involved, in chemical accident management.
- Educate the population, likely to be affected in a chemical accident, about the remedies and existing preparedness in the area.
- Conduct at least one full-scale mock drill every six months and forward a report to the DCG.
- Respond to all public inquiries on the subject.

Similarly, the DCG, SCG and the CCG will provide expert guidance for handling major chemical accidents. The DCG and the SCG will assist the district administration and the State Government administration in the management of chemical accidents. The CCG, the apex body in the Centre will render all financial and infrastructure help as may be necessary in a state in case of an accident.

5.3 OFF-SITE EMERGENCY PLAN OBJECTIVES

The overall goal is to prevent loss of life or damage to health, promote social well being, avoid property damage, and ensure environmental safety around MAH units in the Industrial area during emergency. Its specific objectives are:

1. To establish emergency response plan in the local area
2. To provide information to the concerned members of the local area e.g. LCG members on the hazards involved in industrial operations in its neighborhood and the measures taken to reduce these risks.
3. Increase industry involvement in emergency response planning.
4. Involve LCG members in the development, testing and implementation of the overall emergency response plan.

Emergencies could arise due to different types of chemical accidents and it is not practicable to develop complete detailed response procedures for every conceivable type of emergency situation. However, advance planning can create a high order of preparedness to limit and minimize the adverse effects of an emergency caused by a chemical accident. Emergency plans are not static documents and need to be updated from lessons learnt during drills, experiences and other sources. A good communication system, training and understanding of emergency procedures, regular interaction between Government agencies and industries, education of the public and high degree of availability of emergency equipment are the key areas for effective off-site emergency preparedness.

5.4 IMPORTANT GOVERNMENT AGENCIES INVOLVED IN OFF-SITE EMERGENCY ACTIONS

In the implementation of the Off-site Emergency Plan, the district collector is designated as the DEA.

The following members of the crisis group will also invariably assist DEA:

1. Police	Warning and Advice to the Public-Security measures; Rescue & Evacuation
2. Head of Fire Services	Help the industry concerned in fire fighting operations and rescue
3. Medical Officer	Treatment of affected persons
4. Head of Civil Defense	Rescue and Evacuation operations
5. Head of Electricity Board	Ensuring uninterrupted power supply or de-energize power supply as required

5.5 RESPONSIBILITY OF DEA

In case of an offsite emergency, the On-Site Chief Emergency Coordinator located at respective stations will report the matter to the DEA or as specified in the Off-site emergency plan. The DEA will initiate the action plan to combat the emergency. The various responsibilities are:

1. Take overall responsibility for combating the offsite emergency.
2. Direct the police and fire personnel to combat the emergency.
3. Arrange, if necessary, for warning and evacuating of the public, by the Department of Police.
4. Direct the team of Doctors headed by the Medical Officer
5. Direct the Chief of Transport Corporation to arrange for transportation of victims and evacuation of people trapped within the hazard zone.
6. Direct the Electricity Board official to give uninterrupted power supply or stop etc.
7. Direct the official in-charge to provide uninterrupted water supply as required.
8. Direct the Revenue Officer and the Supply officer to provide safe shelters, food and other life sustaining requirements for the evacuees if required.
9. Nominate a press officer

5.6 RESPONSIBILITY OF CRISIS GROUP

The responsibilities of the members of the crisis group are:

- To develop an integrated response strategy based on the available information.
- To plan deployment of field units to ensure the availability of appropriate force

to deal with the situation.

- To co-ordinate the functioning of various agencies.
- To deal with crisis.
- To monitor the progress till the crisis ends.

5.7 LIST OF TELEPHONE NUMBERS OF OUTSIDE AGENCIES AROUND THE PLANT

5.7.1 District Collectors

Sl.No	Name of District	District Collector/ Magistrate	Telephone No.	
			Office	Residence
1				
2				
3				
4				
--				
--				

5.7.2 Police Stations around the Plant

Sl.No.	Address	Telephone No. of Control Room
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

5.7.3 Fire Stations around the Plant

Sl.No.	Address	Telephone No. of Control Room
1		
2		
3		
4		
5		
6		
7		

8		
9		
10		

5.7.4 Hospitals around the Plant

Sl.No.	Name of Hospital	Address	Telephone No. of Emergency Control Room
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

5.7.5 Electricity Boards

Sl.No.	Address	Designation	Telephone No. of Head	
			Office	Residence
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Appendix 1

List of Emergency Equipment

Item	
Leak Clamps Size	
Chain Pulley Blocks	
Pneumatic pumps	
Portable compressors	
Mobile generator sets	
Portable Radio Set	
Shovel	
Spade	
Tasala	
Manila Rope	
Oil Absorbent Pads	
Safety torches	
Blankets	
Others	

List of Fire Fighting Facilities and Other Resources at the Terminals

Facilities	
Foam Tenders	
Foam concentrate qty.	
Fire Extinguishers - DCP - CO_2	
Fire Water Storage Tanks	
Fire water pumps	
Communication Facility	
Water Tanker	
Ambulance Vans	
Hose Pipe	
Ladders	
Rubber Hand Gloves	
Asbestos Suits	
Breathing Apparatus/SCBA	
Any other protective equipment.	

Mutual Aid Agreements

S.No.	Name and Address of Industry	List of Equipment that can be spared in Emergency	
		Item	No.
1		Man Power	
2		Foam tender	
3		Foam trolley	
4		Fire proximity suit	
5		Fire Extinguishers	
6		Hose Pipes	
7		Portable Pumps	
8		Etc.	