

# DISASTER MANAGEMENT & EMERGENCY RESPONSE

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# What is emergency

“Emergency” means a situation or scenario which has the potential to cause serious danger to persons, environment or damage to property and which tends to cause disruption inside and / or outside the premises and may require the help of outside resources.



# What is Disaster

“Disaster” means an occurrence of such magnitude as to create a situation in which the normal patterns of life within an industrial complex are suddenly disrupted and in certain cases affecting the neighborhood seriously with the result that the people are plunged into helplessness and suffering and may need food, shelter, clothing, medical attention protection and other life sustaining requirements.



# What is Disaster

We have experienced many big disasters in past like one of the biggest chemical disaster like Bhopal wherein uncontrolled release of MIC (Methyl Iso Cyanate) have taken millions of life, effect of which is being experienced till today. If we could have prepared for tackling the disasters like situations Sunami (natural disaster) or earthquakes (Latur, Bhuj) , then we could have saved lives & loss would have been minimized.



# BHOPAL GAS TRAGEDY

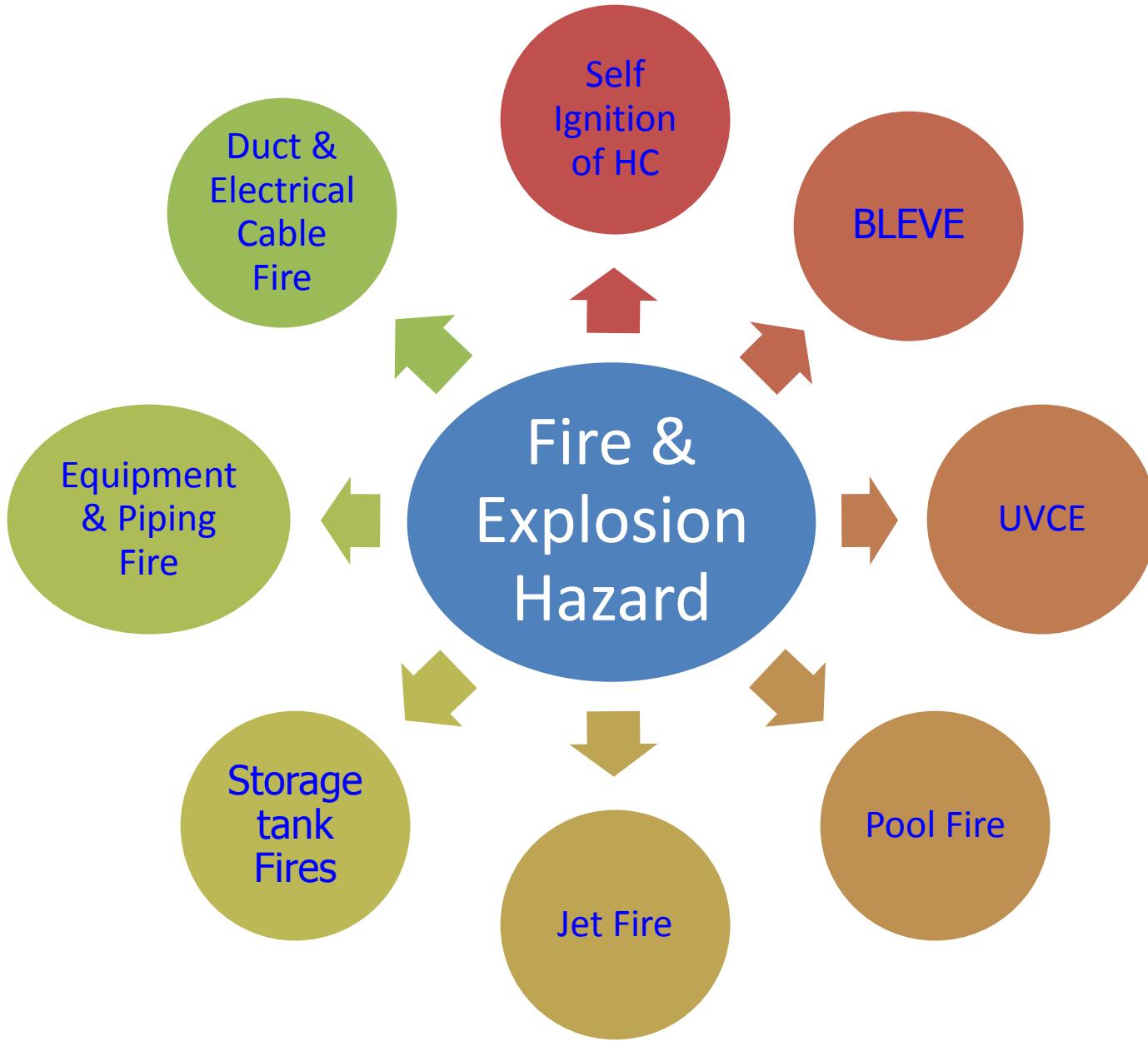


# What is Disaster

Therefore need of the hour is to have emergency preparedness of every industry and organization in place. Being refiners, we have the biggest potential hazards of fire & explosion as we produce lightest product of LPG to heaviest cut bitumen & risk associated in producing them is also very high.



# FIRE & EXPLOSION HAZARD



# Pool Fire

A Pool fire is a fire on a stationary liquid surface such as a pool of liquid hydrocarbon. We have inventory of storage tank (208 Nos.) and 60000 M3 capacity.

Jaipur fire is a live example of pool fire. It started with flash fire followed by prolonged pool fire in which the contained MS/Diesel product started burning engulfing the entire surface of the liquid.



# Jet Fire

A jet fire occurs when a hydrocarbon release from a pressurized source is ignited close to the source of the release. It is, for all practical purposes, a jet of flame that will last as long as the supply of fuel lasts under pressure and whose radiation & effect zone. Depends as much upon the fuel as on the pressure at which it is released. In addition to damage inflicted by thermal radiation, the flame can also cut through metal, if it were to impinge upon the metallic surface, setting off a domino effect.



# Jet Fire



Gaseous Fire ( Hydrogen /Lighter Hydrocarbon) in  
pressurized condition



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# Unconfined Vapour Cloud Explosion (UVCE)

A flash fire is a sheet of flame that moves through a cloud of gaseous or vaporized hydrocarbons, without any accompanying shock waves. It rarely lasts for more than a few seconds and causes little damage to equipment & installations but is fatal to individuals, in its path.

UVCE is similar to flash fire except that in addition to the flame front, a pressure front, generated by the fire, moves through the cloud, at speeds of 100m/s or greater.



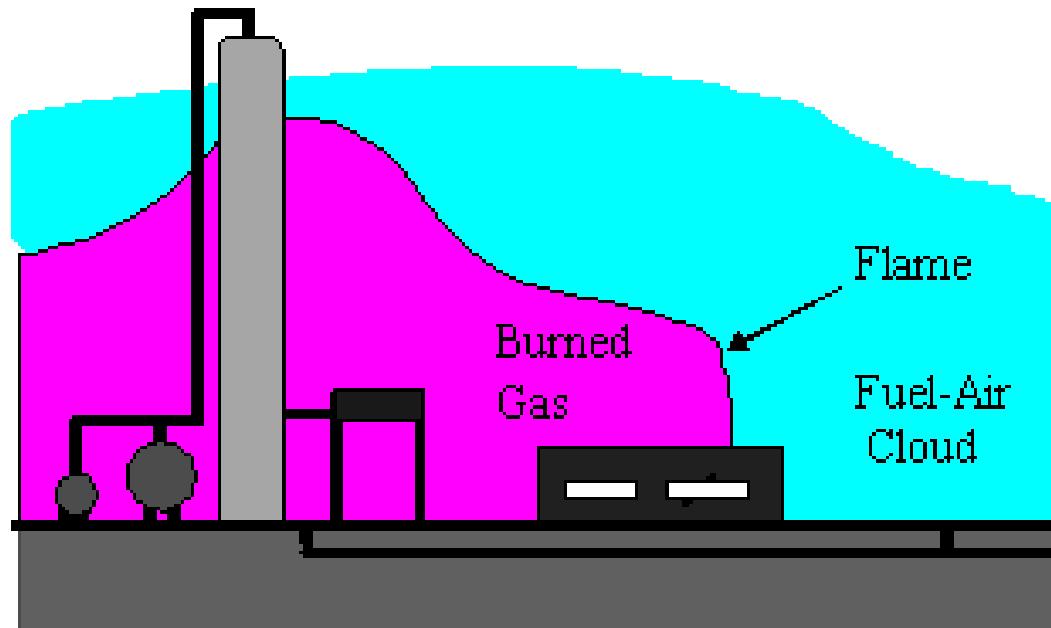
# Unconfined Vapour Cloud Explosion (UVCE)

The Flixborough disaster was an explosion at a chemical plant close to the village of Flixborough , England.

At 16:53 on 1 June 1974, the temporary bypass pipe (containing cyclohexane at 150°C (302°F) and 10 bar ruptured, possibly as a result of a fire on a nearby 8 inch (20 cm) pipe which had been burning for nearly an hour. Within a minute, about 40 tonnes of the plant's 400 tonne store of cyclohexane leaked from the pipe and formed a vapour cloud 100–200 metres (320–650 feet) in diameter. The cloud, on coming in contact with an ignition source (probably a furnace at a nearby hydrogen production plant) exploded, completely destroying the plant. Around 1,800 buildings within a mile radius of the site were damaged.



# Unconfined Vapour Cloud Explosion



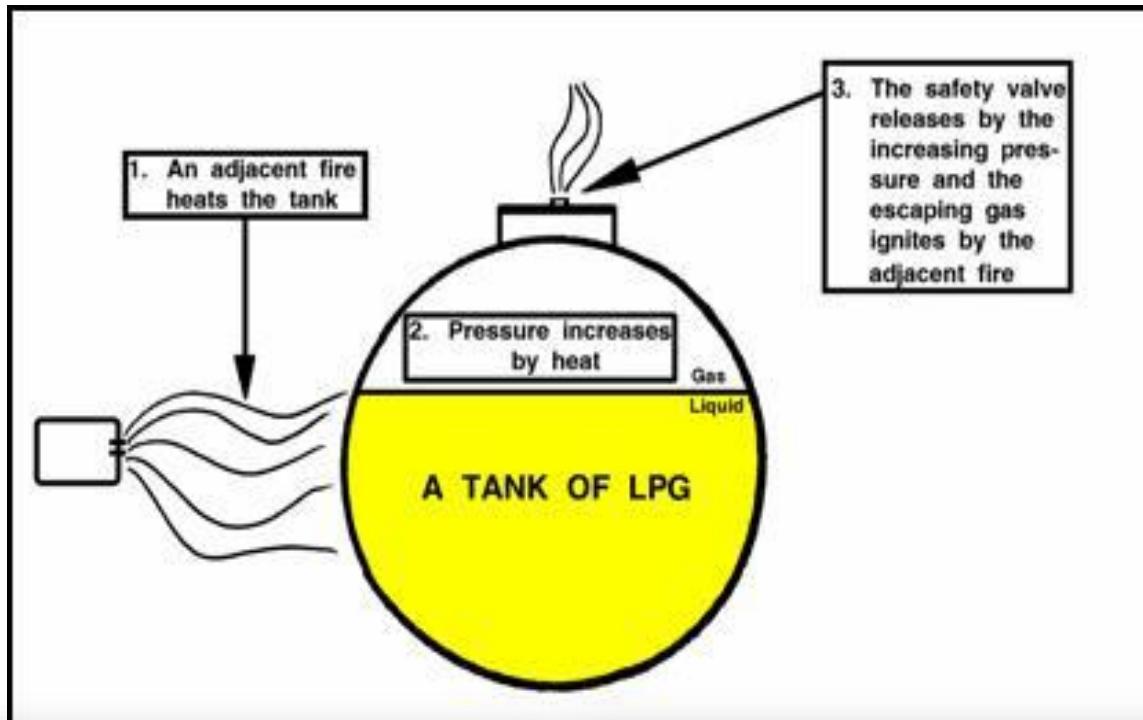
Unconfined Vapour Cloud Explosion

# Boiling Liquid Expanding Vapour Explosion (BLEVE)

A BLEVE occurs when a liquefied, or occasionally a liquid, hydrocarbon is contained in a vessel exposed to an external fire. The fire weakens the shell of the vessel, while also causing the hydrocarbon to boil, thereby pressurizing the vessel. Once the vessel's pressure exceeds the thresholds limit of the metal, the shell would fail spilling the rest of the hydrocarbon, which would then undergo an explosion or the fireball.



# Boiling Liquid Expanding Vapour Explosion (BLEVE)



Boiling Liquid Expanding Vapour Cloud Explosion

# What is On-site emergency

**“On Site Emergency” means an emergency that takes place in an installation and the effects are confined to the Installation premise’s involving only the people working inside the plants and to deal with such eventualities is the responsibility of the Occupier and is mandatory. It may also require help of outside resources.**



# What is Off-site emergency

“Off Site emergency” means an emergency that takes place in an installation and its effects extends beyond the premises or the emergency created due to an accident, catastrophic incidents, natural calamities, etc. It no longer remains the concern of the installation management alone but also becomes a concern for the general public living outside and to deal with such eventualities will be the responsibilities of district administration.



# CLASSIFICATION OF EMERGENCIES

## LEVEL - 1

- Can be contained within site
- Managed safely & effectively
- No impact on offsite



# CLASSIFICATION OF EMERGENCIES

## LEVEL – 2

- May not be safely & effectively managed
- May not be contained within site
- Outside support needed
- May impact nearby facilities



# CLASSIFICATION OF EMERGENCIES

## LEVEL – 3

- Offsite impact
- Catastrophic in nature
- Likely to affect Population / Property / Environment



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IndianOil

## STATUTORY REQUIREMENT

- **EPA -Environment Protection Act – 1986**
- **Manufacture, storage & import of hazardous chemicals.**
- **Hazardous waste management**
- **Factories Act**
- **Bio medical waste**
- **Public Liability Insurance rule**
- **Explosive Act (1983)**
- **Gas Cylinder Rules (2004)**
- **SMPV Rules 2004**



# PRE-EMERGENCY PLANNING

## HAZARD IDENTIFICATION

- **MSDS of chemical & basic substances**
- **Potential impact on**
  - Downwind air quality
  - Down stream water quality
- **Possible danger to human, flora & fauna.**

**Flora - Grass, Reserve Forest, Green Belt,  
Riverine vegetation.**

**Fauna – Fishes, Mammals, Birds**



# NEIGHBOURING DETAILS

- **Address**
- **Location**
- **Site Map**
- **Population within 10 Km radius**
  - **Name of the locality / village**
  - **Area in Hectare**
  - **Estimated population**
  - **Distance from Factory premises**
  - **Direction w.r.t Factory (NE, NW etc.)**



# METEOROLOGICAL CONDITIONS

- Annual Mean Temp
- Annual Mean % Humidity
- Wind Speed
- Stability class (Pasquill stability) categorizing the amount of atmospheric turbulence
  - A - Very Unstable
  - B - Unstable
  - C - Slightly Unstable
  - D - Neutral
  - E - Stable
  - F - Very Stable



# METEOROLOGICAL CONDITIONS

- Many combination of wind speed vs stability do not occur in nature
- For risk analysis  
B – 3 m/s  
E - 1 m/s  
is widely considered.

## Wind Direction Frequencies

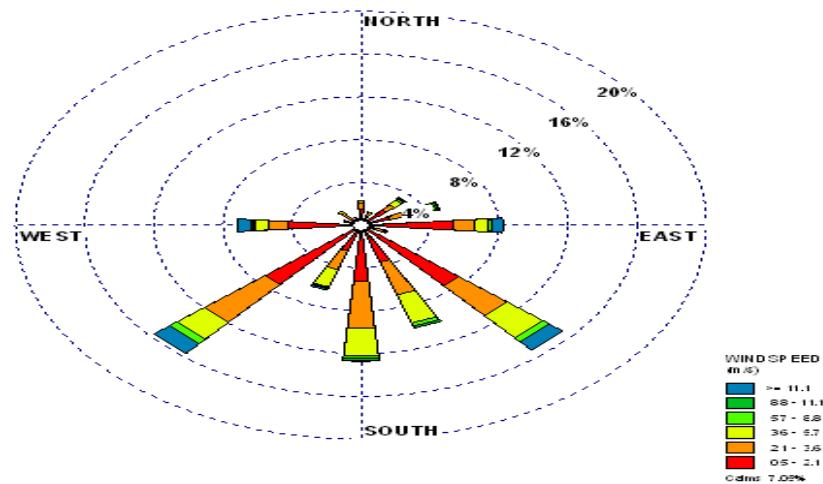
	N	NE	E	SE	S	SW	W	NW	CALM
8.30 A.M.	25	6	2	8	14	23	4	5	13
5.30 P.M.	4	2	2	14	39	13	1	1	24



# METEOROLOGICAL CONDITIONS

Wind rose shows the frequency of winds blowing *from* particular directions over a specified period. The length of each "spoke" around the circle is related to the frequency that the wind blows from a particular direction per unit time. Each concentric circle represents a different frequency, emanating from zero at the center to increasing frequencies at the outer circles e Diagram

Wind Rose Diagram



# HAZARDOUS TO FACTORY

## Explosion

Man made

Heavy leakage

Fire

Failure of critical control

Unsafe Act

Design deficiency

Inadequate maint.

## Nature's Fury

Cyclone

Flood

Earthquake

Outbreak of diseases

Excessive rain

Tsunami

## Sabotage

Extraneous

Riots/civil disorder/  
Mob violence

Terrorism

Bomb threat

War/missile hit

Abduction

Food/water  
poisoning



# RISK ANALYSIS & RISK ASSESSMENT

- Potential Failure
- Calculate material release to atmosphere
- Probability of occurrences
- Consequences of occurrence
- Ranking (based on consequences vs probability)
- Define max tolerable criterion
- Risk – ALARP (As low as reasonably practicable)



# IDENTIFICATION OF MAJOR RISK

## Raw Naphtha Surge Drum Catastrophic Rupture

**CONSEQUENCES :** Flash Fire, Pool Fire & UVCE

**Level** : 1

Wind Speed/ Pasquill stability	Flash Fire Dist. (m)	Thermal Radiation due to pool fire		
		4 kw/m <sup>2</sup>	12.5 kw/m <sup>2</sup>	37.5 kw/m <sup>2</sup>
1.5/F	159.54	56.16	22.27	Not reached
1.5/D	182.4	55.65	22.16	-do-
1.1/C	203.6	53.45	22.14	-do-



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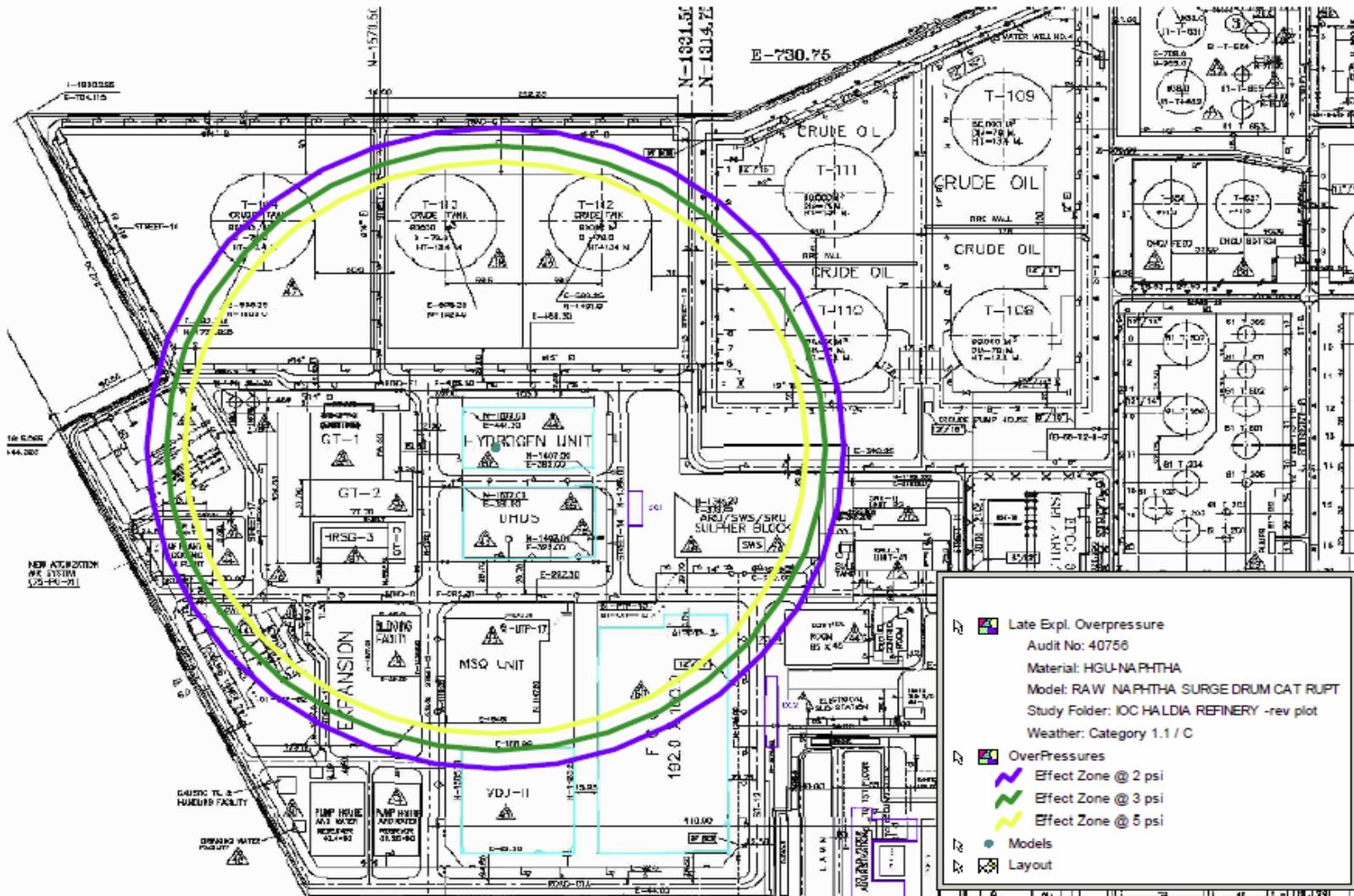
# IDENTIFICATION OF MAJOR RISK

## Overpressure distance

Wind Speed/ Pasquill stability	Overpressure dist (m)		
	2 psi	3 psi	5 psi
1.5/F	231.56	213.1	196.23
1.5/D	242.98	228.73	215.7
1.5/C	265.53	250.7	237.15



# Late Overpressure Explosion Hazard Distance, Raw Naptha Surge Drum, HGU Plant

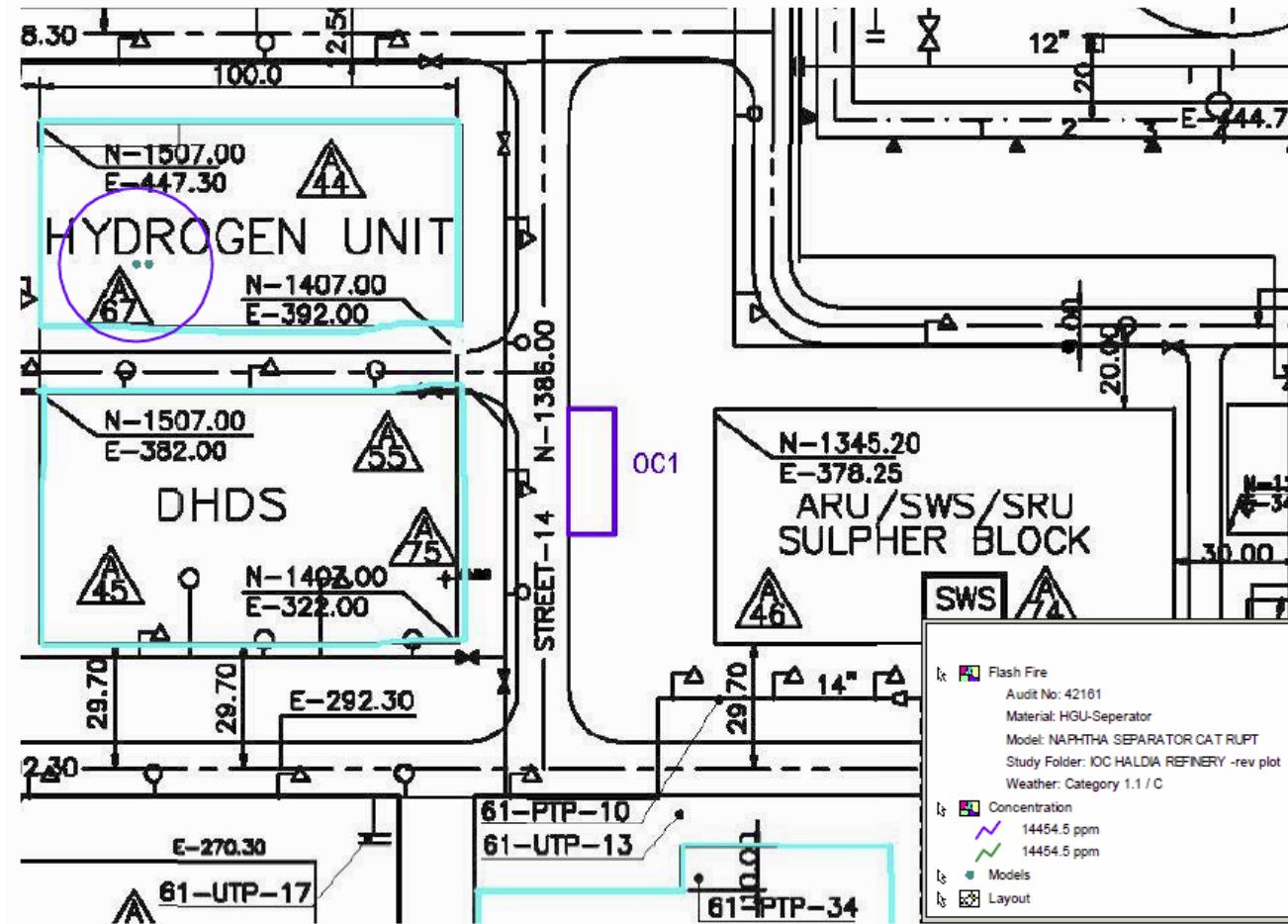


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# Flash Fire Hazard Distance, Catastrophic Rupture, Naphtha Seperator, HGU Plant



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# IDENTIFICATION OF MAJOR RISK

## Raw Naphtha Pump Seal Failure Flash Fire & Post Fire Hazard Distances

CONSEQUENCES : Flash Fire & UVCE

Level : 1

Wind Speed/ Pasquill stability	Flash Fire Dist. (m)	Thermal Radiation due to pool fire		
		4 kw/m <sup>2</sup>	12.5 kw/m <sup>2</sup>	37.5 kw/m <sup>2</sup>
1.5/F	29.45	41.54	32.63	27.30
1.5/D	28.78	41.50	32.62	27.29
1.1/C	28.89	42.78	33.68	28.56



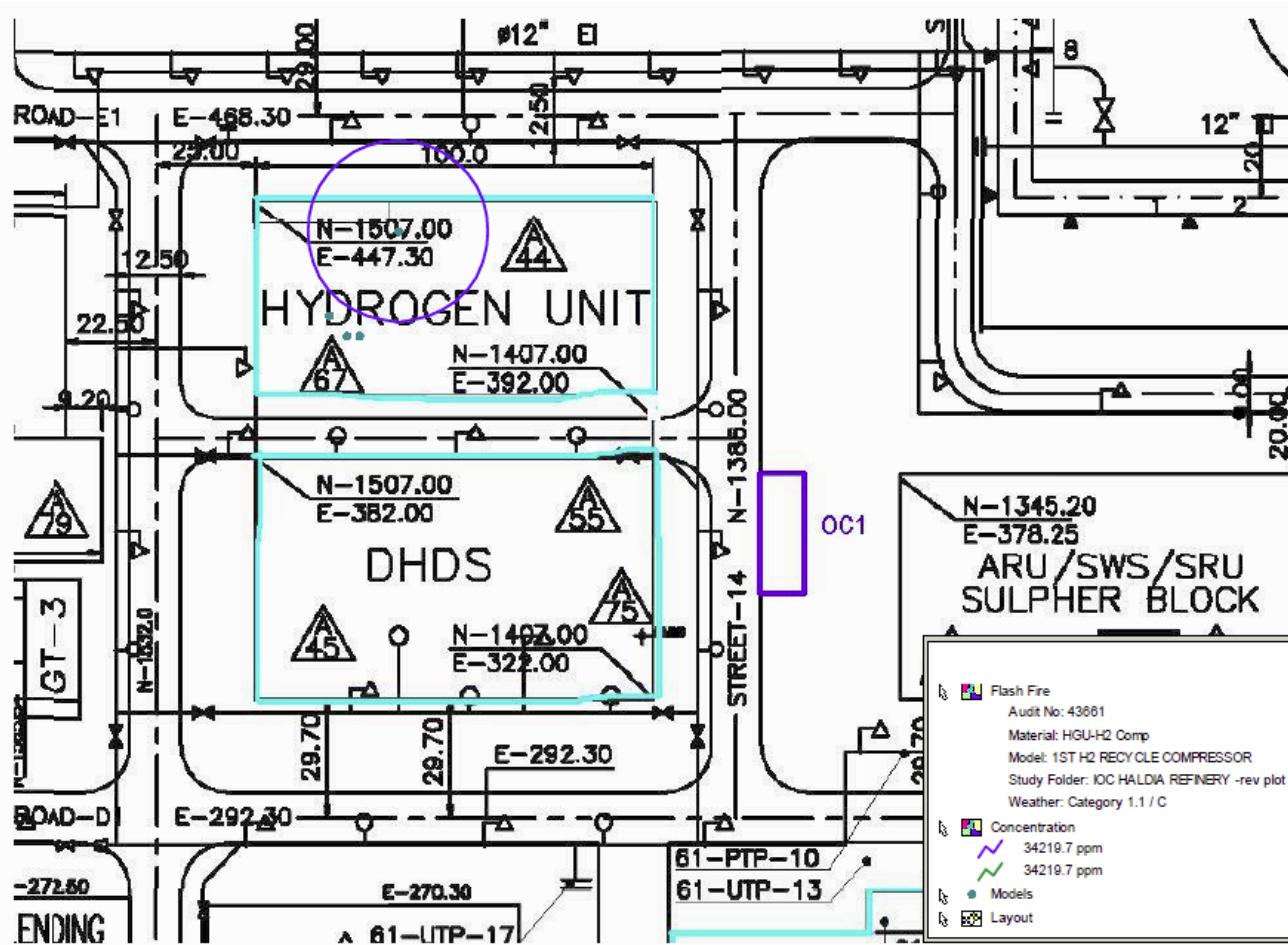
# IDENTIFICATION OF MAJOR RISK

## UCVE Overpressure distance

Wind Speed/ Pasquill stability	Overpressure dist (m)		
	2 psi	3 psi	5 psi
1.5/F	28.99	26.95	25.89
1.5/D	28.59	26.65	24.87
1.5/C	28.66	26.66	24.88



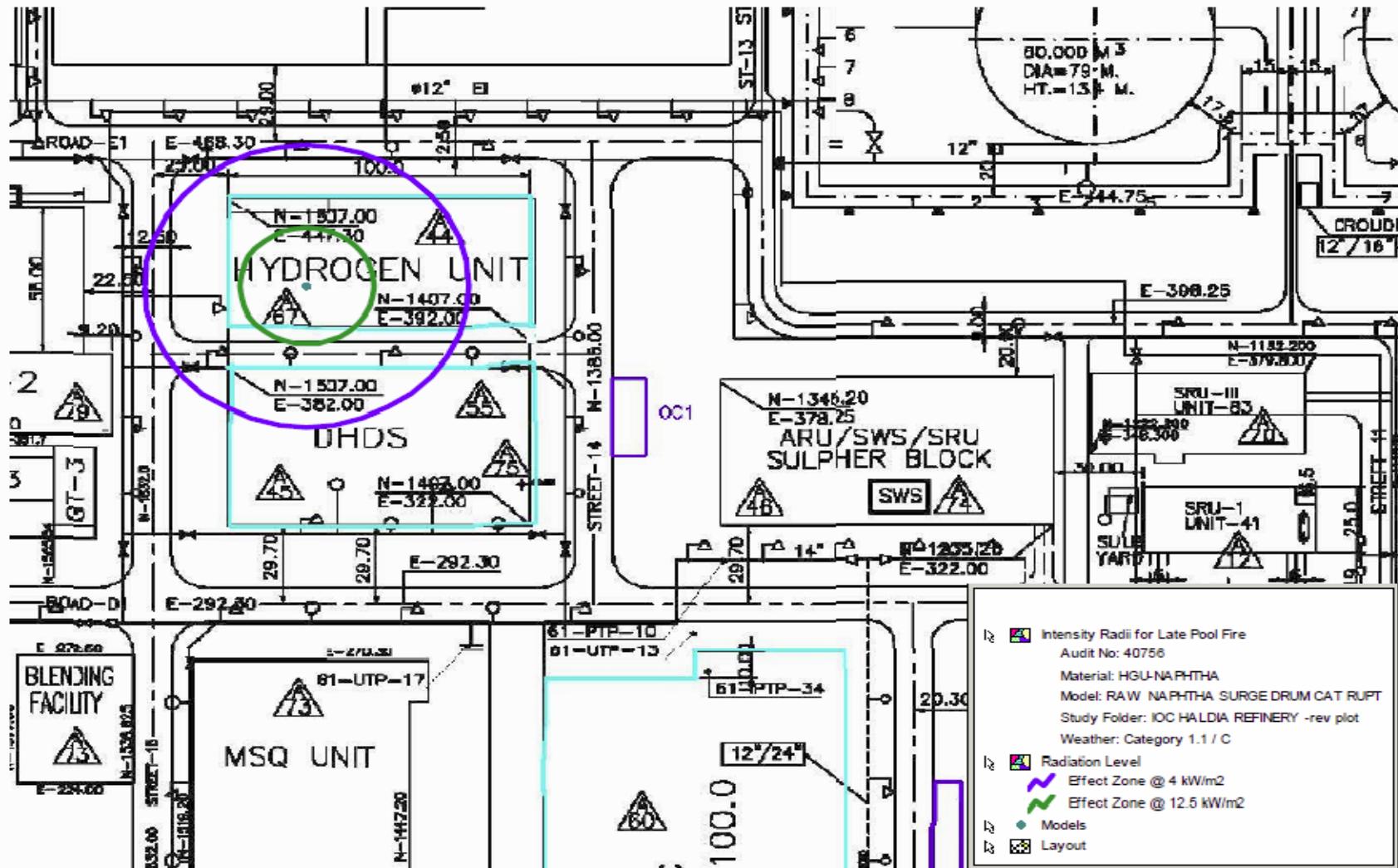
# Flash Fire Hazard Distance, 1ST STAGE HYDROGEN RECYCLE COMPRESSOR Seal Failure, HGU Plant



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# Flash Fire Hazard Distance, Seal Failure, Raw Naphtha Pump Pump, HGU Plant



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# IDENTIFICATION OF MAJOR RISK

## Propane Vessel Catastrophic Rupture Flash Fire & Post Fire Distances

**CONSEQUENCES :** Flash fire, fireball ,UVCE

**Level** : 3

Wind Speed/ Pasquill stability	Flash Fire Dist. (m)	Thermal Radiation dist due to pool fire (m)		
		4 kw/m <sup>2</sup>	12.5 kw/m <sup>2</sup>	37.5 kw/m <sup>2</sup>
		-----	-----	-----
1.5/F	68.45	655.33	355.99	142.64
1.5/D	60.37	652.8	354.58	368.12
1.1/C	56.25	142.64	141.55	150.61



# IDENTIFICATION OF MAJOR RISK

## UCVE Overpressure

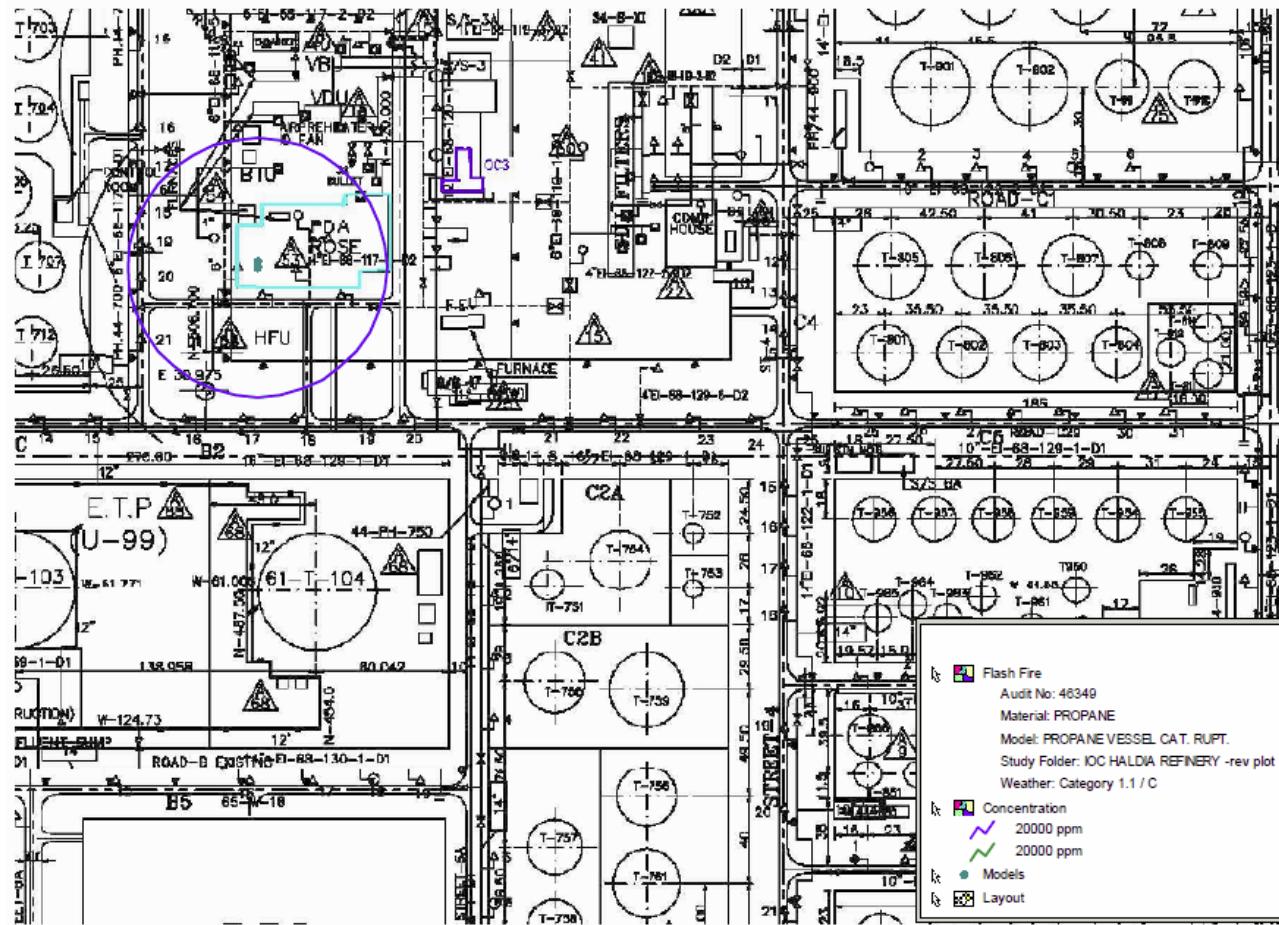
Wind Speed/ Pasquill stability	Overpressure dist (m)		
	2 psi	3 psi	5 psi
1.5/F	309.77	253.24	201.57
1.5/D	296.16	240.44	189.53
1.5/C	304.88	247.19	194.48



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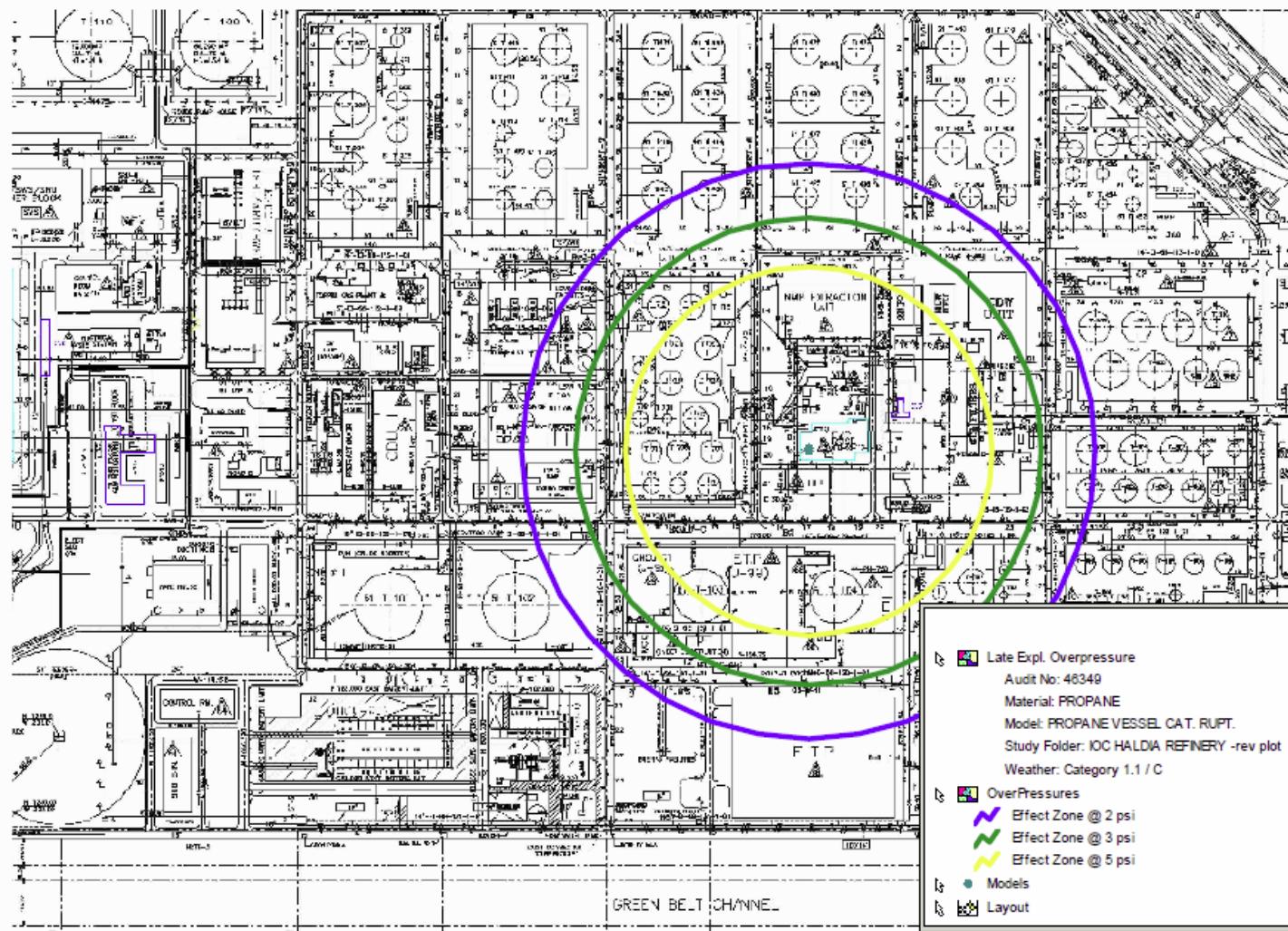
# Flash Fire Hazard Distance, Catastrophic Rupture, Propane Vessel, PDA Plant



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# Late Explosion Overpressure Hazard Distance, Catastrophic Rupture, Propane Vessel, PDA Plant



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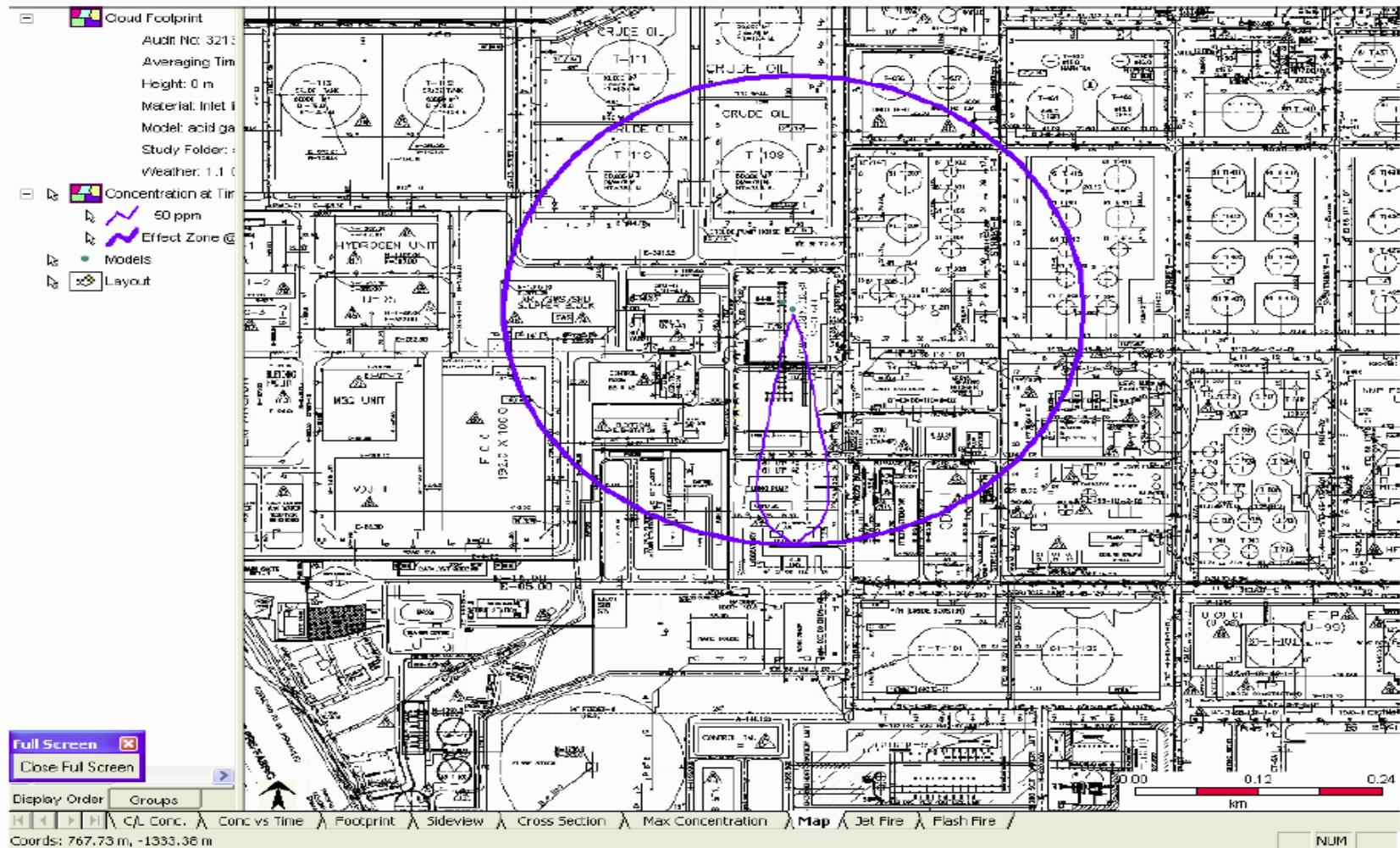
# IDENTIFICATION OF MAJOR RISK

- Toxic gas dispersion affect distances for 50 ppm,  
Instrument tapping Failure, Acid gas Inlet line from  
ARU to acid gas KOD, SRU-III
- CONSEQUENCES : Gas Dispersion                  Level : 1

Wind speed & Pasquill Stability	Toxic Gas Lethality Distances ( m)		
	500 ppm	200 ppm	50 ppm
1.5/F	118	173	515
1.5/D	110	164	256
1.1/C	122	184	258



# DISPERSION PLUME WITHIN PLANT



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# SRU UNIT, H<sub>2</sub>S & SO<sub>2</sub> Leakage from Main Combustion Chamber

## LEVEL 3

Dispersed Cloud (Only H <sub>2</sub> S )				Toxic dose (mg /m <sup>3</sup> .min)	Percent Lethality
B-3m/s		E-1m/s			
Length (m)	Width (m)	Length (m)	Width (m)		
19	4	91	7	1.51E+8	99
35	7	198	18	1.47E+7	50
49	11	303	26	4.07E+6	10
64	14	433	36	1.43E+6	1

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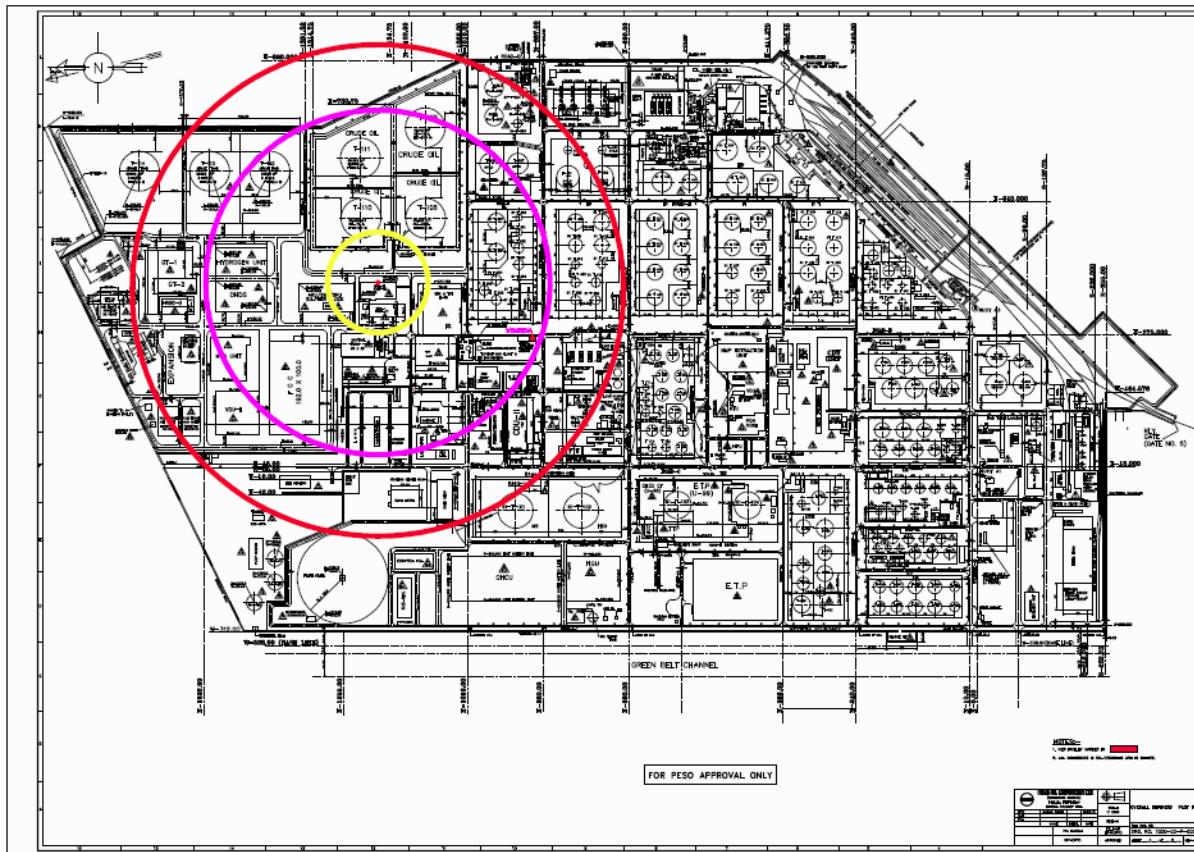
Dispersed Cloud (For SO <sub>2</sub> )				Toxic dose (mg /m <sup>3</sup> .min)	Percent Lethality
B-3m/s		E-1m/s			
Length (m)	Width (m)	Length (m)	Width (m)		
21	4	100	9	1.51E+11	99
38	8	221	20	1.47E+10	50



# SRU UNIT, Leakage from Main Combustion Chamber

## LEVEL 3

SRU Unit, Leakage From Main Combustion Chamber

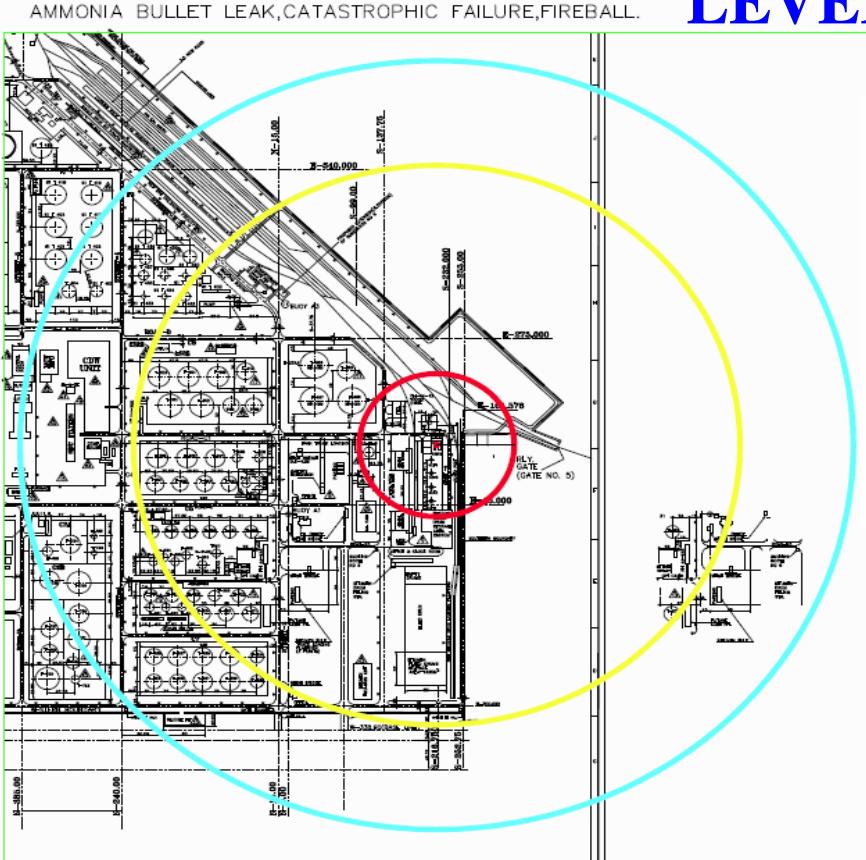


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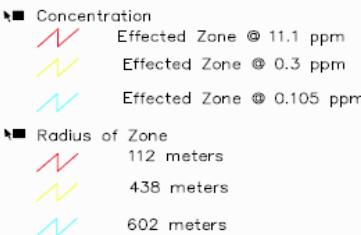


# Ammonia Bullet Leak, Catastrophic Failure, Fireball

**LEVEL 3**



Dispersed Cloud				Toxic dose (mg /m <sup>3</sup> .min)	Percent Lethality
B-3m/s		E-1m/s			
Length (m)	Width (m)	Length (m)	Width (m)		
61	20	112	45	1.11E+10	99
121	49	289	196	1.08E+9	50
176	71	438	312	3E+8	10
235	94	602	427	1.05E+8	1



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# IDENTIFICATION OF MAJOR RISK

## DHDS & OHCU H<sub>2</sub> BULLET CATASTROPHIC FAILURE

CONSEQUENCES : FIRE BALL ; LEVEL : 3

Heat Radiation  $\Rightarrow$  Released 400kg  $\Rightarrow$  Fire Ball duration 4.05 sec  
 $\Rightarrow$  Fire Ball dia 45.42 m

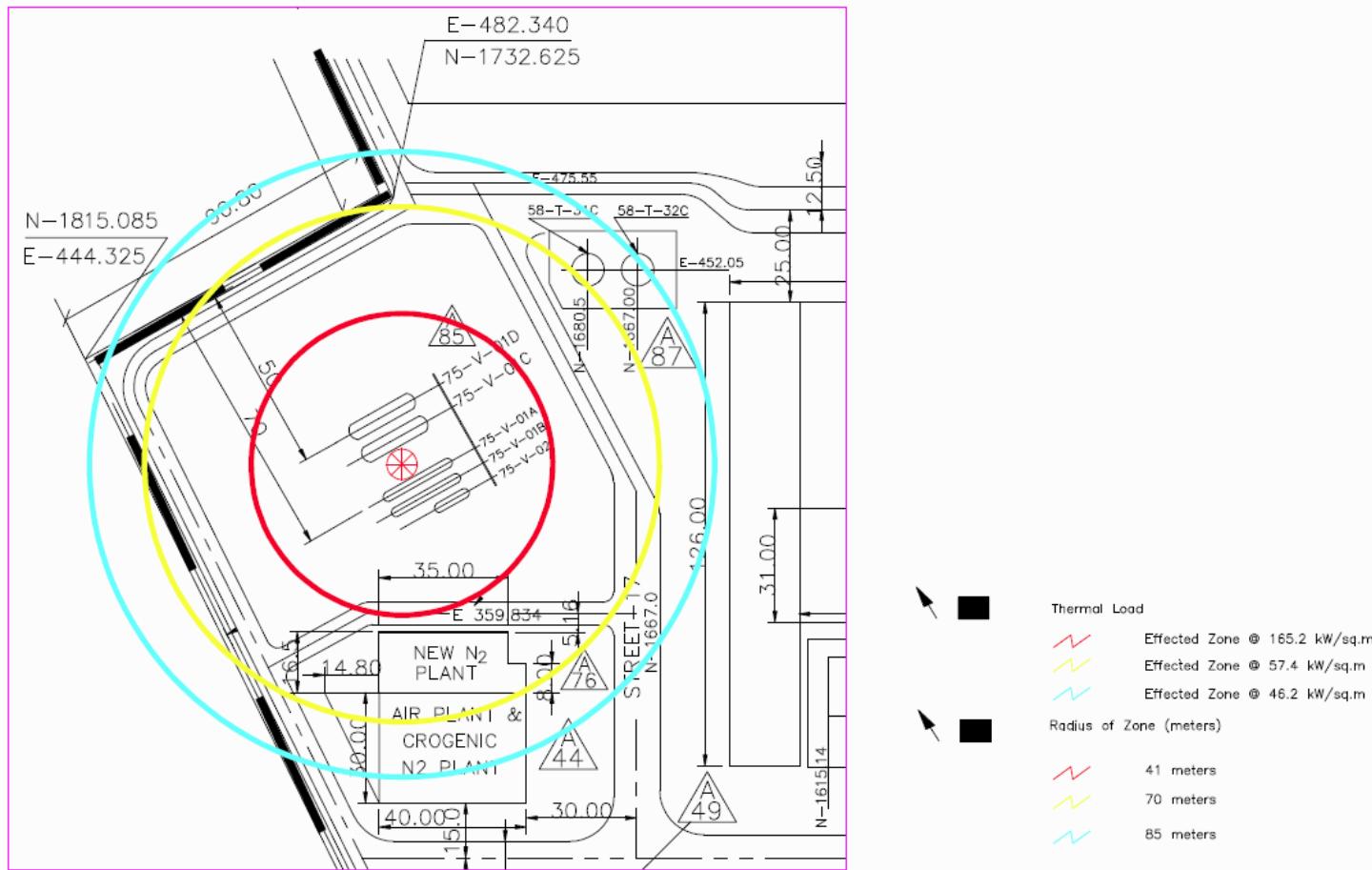
Percent Lethality (m)	Thermal load (KW/m <sup>2</sup> )	Dist. From the Centre of Fire Ball
--------------------------	-----------------------------------	---------------------------------------

99	165.2	41
50	83.2	60
10	57.4	70
1	46.2	85



# DHDS Hydrogen Bullet Catastrophic Failure, Fireball

DHDS HYDROGEN BULLET CATASTROPHIC FAILURE, FIREBALL.

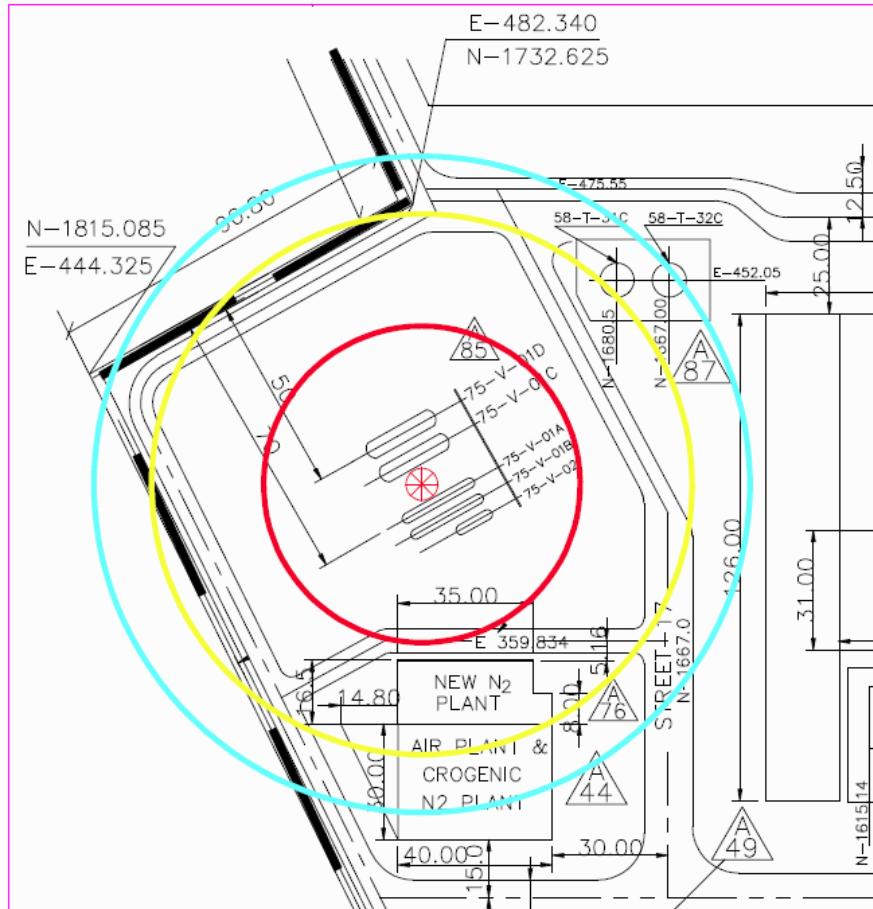


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# DHDS Hydrogen Bullet Catastrophic Failure, Fireball

DHDS HYDROGEN BULLET CATASTROPHIC FAILURE, FIREBALL.



Thermal Load

- Effected Zone @ 165.2 kW/sq.m
- Effected Zone @ 57.4 kW/sq.m
- Effected Zone @ 46.2 kW/sq.m

Radius of Zone (meters)

- 41 meters
- 70 meters
- 85 meters

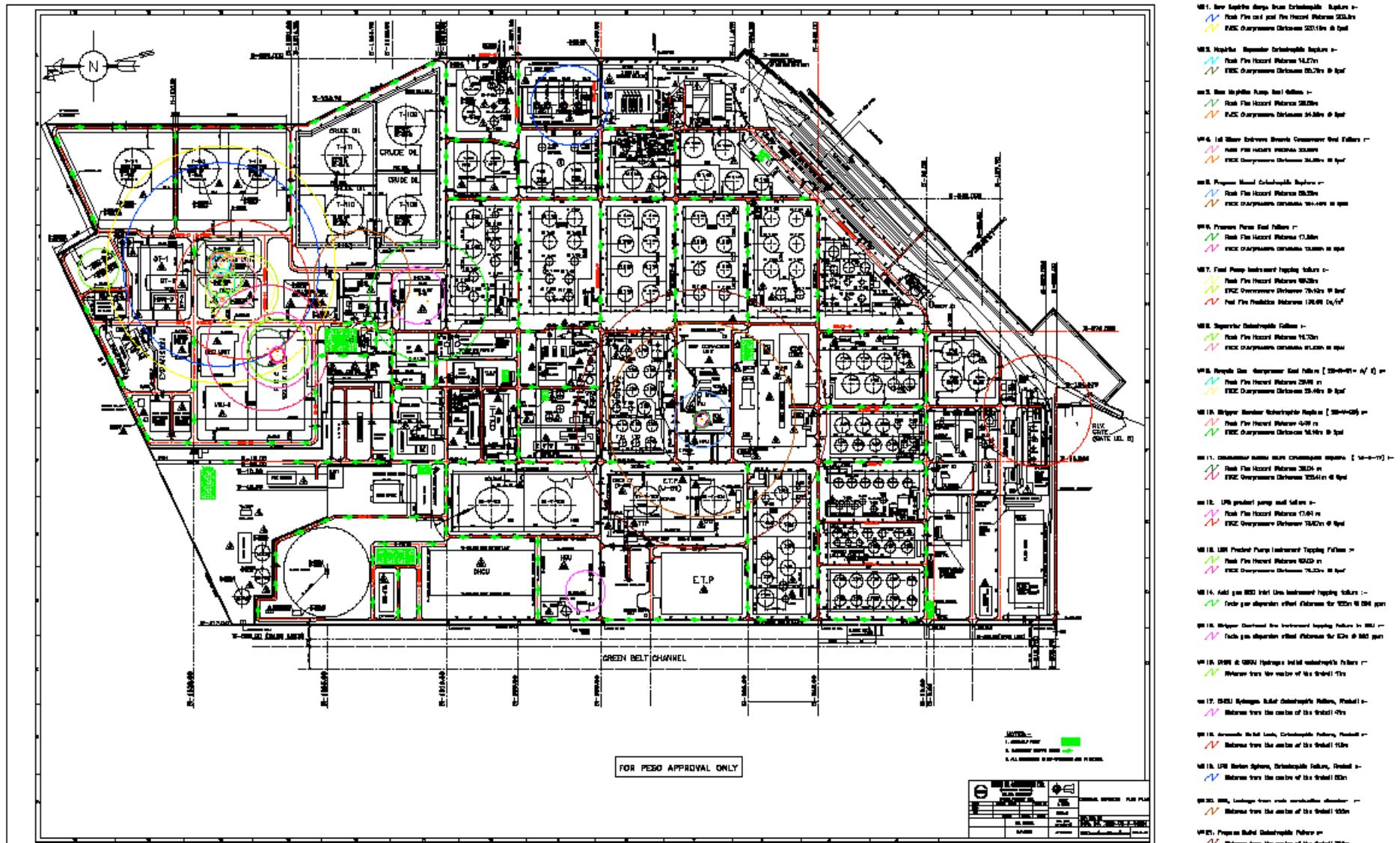


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# Escape Route

REFINERY FLOOR PLAN WITH ASSEMBLED FORMS OF ESCAPE ROUTE \*



# EMERGENCY MITIGATION

- **Resource Mobilization**
- **Manpower -** **Factory**
  - Neighbouring Units
  - Civil Authorities
- **Fire Fighting Appliances**
  - Fire Tender, Foam Tender, HVLR, Spray, Nozzle.



# EMERGENCY MITIGATION

## Safety Equipment

- **Hydraulic Lift**
- **Rescue Tender**
- **BA Set.**
- **Rescue Stretcher**
- **Chemical Suits**

## **Communication**

- **Walkie Talkie**
- **Manual Call Points**
- **PA System & Siren**



# EMERGENCY MITIGATION

## Transport

- **Jeep, Car, Trucks**
- **Ambulance**
- **Buses**
- **Tractors.**
- **Misc.**
  - **Ropes, Empty Drums, Buckets, Sand bags, Dewatering pump, still / video camera.**
- **Assembly Points**



# EMERGENCY MITIGATION

## Incident Preventing Measures

- **HSE Policy**
- **Safety Management System**
- **Safety Awareness Programmes**
- **Management Safety Committee**
- **Loss Control Tour**
- **Safety Ambassador**
- **Safety Audit**
- **Work Permit System**
- **Security logic**
- **Water Sprinklers**



# EMERGENCY MITIGATION

## Emergency Preparedness Measures

- **Mock Drill**
  - **Fire Drill**
  - **On site disaster drill**
- **Emergency Scenarios Identified through Risk Analysis**
- **Checking/Calibration of gas detectors**
- **Off-site disaster drill**
- **Debriefing session**
- **Mutual Aid**
- **Training**
  - **Contract Worker**
  - **Security personnel (CISF)**
  - **Fire Training Ground**



# EMERGENCY MITIGATION

## Response Procedure & Measures

- Layout & Flow Diagrams
- Location of Assembly Point
- Rules and Responsibilities
  - Factory personnel
  - Police
  - Fire & Rescue Service
  - Medical Services/Ambulance
  - Emergency Coordinator
  - Advice for public



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# EMERGENCY ORGANISATION & RESPONSIBILITIES

## Objective of an Emergency Control Organization

- **Control problems quickly**
- **Limit impact on off-site**
- **Allocate manpower to handle emergencies**

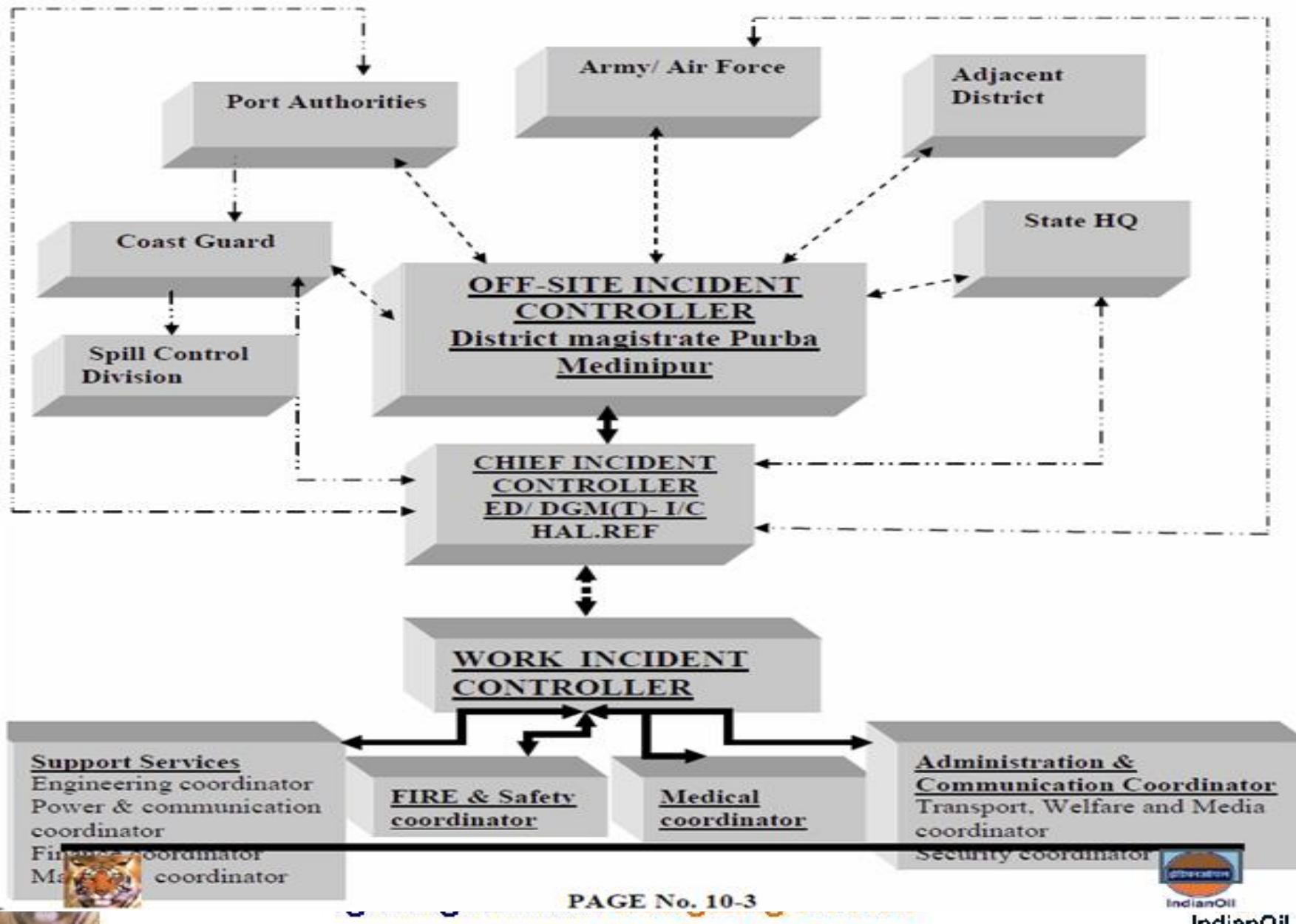
## Chief Coordinator

- **Declaration of disaster based on field impact**
- **Communication with Director/Chairman/Govt. officials**
- **Press Meet**
- **Ensure mutual aid assistance**
- **Conduct close out meeting after control of disaster**



# ORGANOGRAM

**Chain of Communication:** Starts from bottom from level -1



# EMERGENCY ORGANISATION & RESPONSIBILITIES

## Incident Controller

- Establish emergency control room
- Mobilize all Coordinators
- Ear mark danger zone
- Nodal person for communication with all
- Organize mutual aid
- Approve release of information to Press



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# EMERGENCY ORGANISATION & RESPONSIBILITIES

**Crash shutdown Coordinator**

**Fire fighting Coordinator**

**Rescue, repair & salvage Coordinator**

**Communication Coordinator**

**Medical Coordinator**

**Engineering Coordinator**



# EMERGENCY ORGANISATION & RESPONSIBILITIES

**Security Coordinator**

**Material Coordinator**

**Transport, PR, welfare Coordinator**

**Water Supply Coordinator**

**Decontamination Coordinator**

**Finance & Insurance Coordinator**



# EMERGENCY ORGANISATION & RESPONSIBILITIES

## SIREN CODE

- Small fire - No siren
- Major fire - Wailing for 2 minutes
- Disaster - Same as major fire but repeated 3 times at 1 minute gap
- All clear - Straight run for 2 minutes



# EMERGENCY ORGANISATION & RESPONSIBILITIES

## Emergency Control Centre

- Telephone
- Wireless set
- Telephone Directory
- List of Coordinators
- Public Address System

## Conference Centre

- Black board / Display Board
- Overhead Projector
- Photocopying machine
- Fax



# EMERGENCY ORGANISATION & RESPONSIBILITIES

## Medical Facilities

- First Aid Centre
  - Oxygen cylinder/face mask/structure/wheel chair/trolley on wheel/Glucometer/sterilizer
  - Emergency medicine
  - Decontamination/Bath tub
  - Ambulance
  - Industrial Hygiene Lab
- Township Hospital
- Occupational Health Centre
- List of locally available Doctors
- List of facilities having indoor treatment
- Hospital nursing home at Kolkata

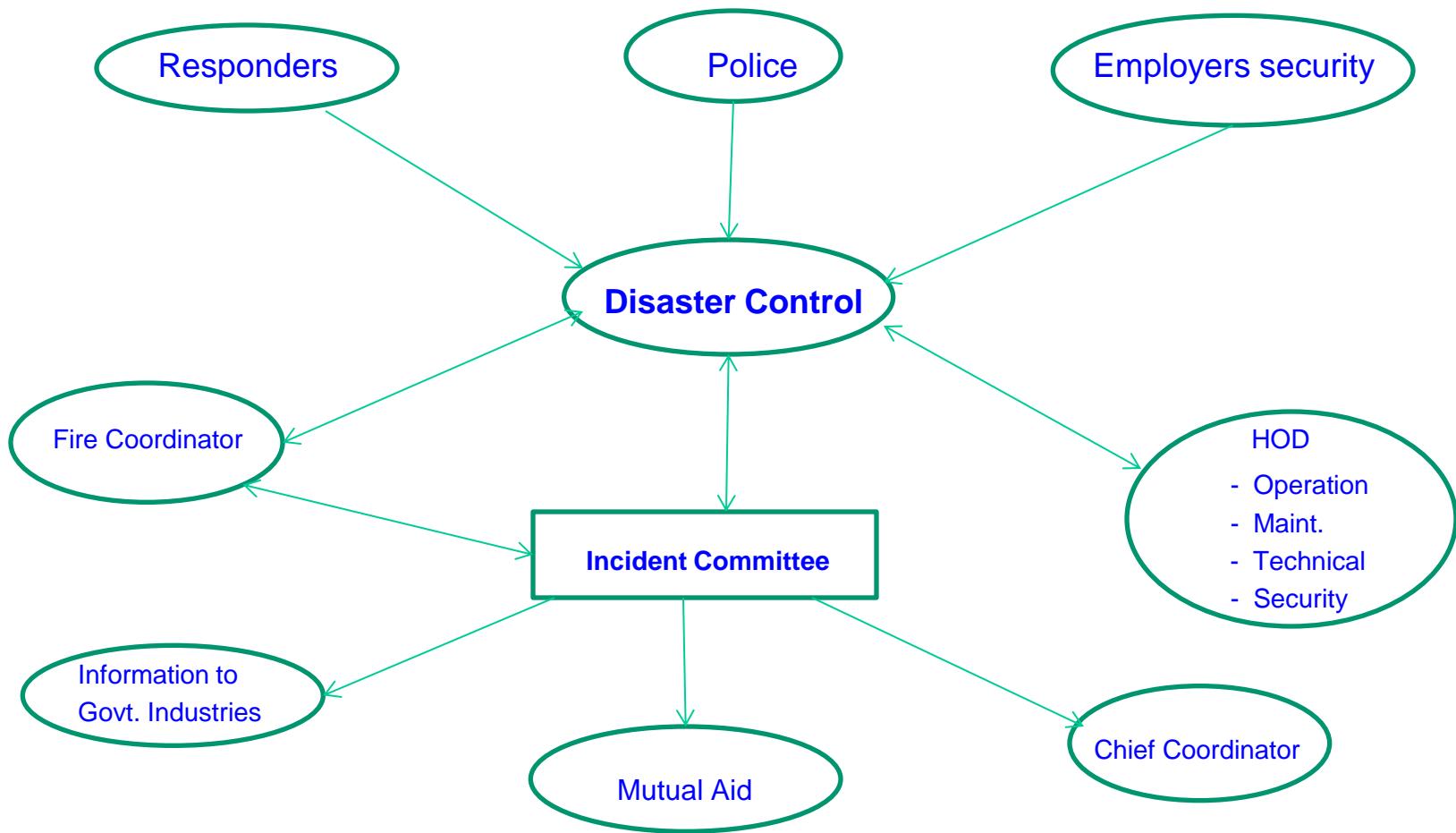


## Evaluation & Sheltering

- Gate Control
- Movement through escape route
- Mustering of people to assembly point



# EMERGENCY ORGANISATION & RESPONSIBILITIES



# EVACUATION

**Fire** - More time to escape

- Small affected area

- Injuries due to thermal radiation

**Explosion** - Little time to warn explosion

- Larger affected area

- Injuries due to shock wave, derris, thermal radiation.

**Toxic Gas** - Drifting cloud

- Layer affected area

- Warning depends on air direction/vel.



# EVACUATION OUTSIDE BATTERY AREA

## Control by District Administration

- **Relief camp**
- **Temporary shelter**
- **Entire population may have to move at short notice.**
- **Requisition of buses/trucks – multiple trips.**
- **Fixed pick up points in different areas**
- **Entire area should be divided into convenient sector**
- **Each sector evacuation supervised by competent persons**



# **EVACUATION OUTSIDE BATTERY AREA**

- **Finalize routes of evacuation**
- **Police assistance may be taken**
- **Make repeated announcement**
  - **Mobile vans**
  - **PA System**
- **Destination should be known to drivers of trucks/buses**
- **Sheltering of people shifted**
  - **Food**
  - **Drinking water**
- **Meticulous planning for multiple trip**
- **Torches for evacuation during power failure**



# EDUCATION

- General public regarding potential hazard
- Distribution of pamphlets/booklets
- Notice boards/help line
- Help from NGO's
- Periodic meeting with village head

## INCIDENT REPORTING :

Level 1 – Maintain record

Level 2 & 3 – Report to Board in specified format

- Report within 48 hours of happening



# EDUCATION

## Criteria for Major Incident :

- Fire for more than 15 minutes
- Explosion/blow out
- Fatal accident
- Loss above Rs 05 lacs.
- Plant shutdown/outage
- Level 3 incident

**Investigation a must for Major, Minor, Near misses**



# THANK YOU



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