.1 RISK ASSESSMENT STUDY

Environmental risks are inherent in design and operation of a complex process industry. Any major failure in the system or disaster could lead to loss of human life and/or property and damage to the environment.

Risk Assessment (RA) considers probability of occurrence of an accident and magnitude of its consequence. Hence, one way to estimate the risk for an undesired event (disaster) is to evaluate the expected frequency per unit time and the expected damage, which is magnitude of a consequence. Risk (R) can be mathematically expressed as R = f x D where, R is the risk (individual or societal), f is frequency of occurrence of an undesired event and D is expected damage due to likely occurrence of a disaster.

Risk Assessment (RA) is categorized in two phases:

The first phase deals with accidental release of hazardous chemicals and its effect on population and environment. This phase termed as Maximum Credible Accident (MCA) analysis quantifies risk in terms of extent of damage. The recommendations based on study helps in containing the hazards within the plant boundary limits thus minimizing the damages

The second phase encompasses damages which could be caused due to accidental release of hazardous chemicals with recourse to damage contour plots and suggesting risk mitigation measures which helps in outlining / upgrading the Disaster Management Plan (DMP).

The scope of work includes hazard identification, risk assessment and ranking, resulting in treatment controls and action plans.

.1.1 Level 1: Hazard Identification

Hazard identification includes:

.1.1.1 Study of Safety Issues Pertaining to the Project

- Study of process and engineering, operational information including safety concepts used in design of equipment and storages.
- Listing of hazardous inventory and identification of key hazardous substances to be used.
- Preliminary identification of hazardous sections of the plant and that of storage with recourse to fire and explosion index for these units.
- Analysis of major inventories in process and storage for identification of major hazardous locations of the plant with recourse to "Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989".
- Consultation with the personnel, who carry out or are likely to carry out the jobs.
- Delineation of the vulnerable operations.
- Maximum Credible Accident (MCA) Analysis for construction and operation and maintenance hazards.
- Past history of accidents and near misses, at an industry level.

The expected outcome of this study will be identification of hazard prone operations and estimation of maximum damages, distances based on probable accident/release scenarios.

.1.1.2 Identification of Hazard Scenarios

Identification of scenarios that can cause damage to life and property within the plant premises as well as in surrounding areas

.1.2 Level 2: Risk Assessment and Evaluation

As defined in foregoing paragraph, the risk is a function of likelihood and consequence. Likelihood is the chance that the hazard might occur. Since the risk of any hazard is dependent upon the chance that it will occur (likelihood), and the impact of an occurrence (consequence).

Risk Score = Likelihood x Consequence

In some cases personnel are only exposed to the hazard for part of the time. Hence, a more detailed analysis of the risk ranking can be carried out, by taking exposure (% time personnel are present) and probability (chance that they will be harmed) into consideration.

Thus: Risk Score = (Probability x Exposure) x Consequence

The values used for likelihood, consequence, exposure or probability need to be agreed to by the risk assessment team, and there is an element of professional judgment in exercising these choices.

.1.3 Level 3: Treatment Controls and Action Plans

.1.3.1 Treatment Controls

After examining the high priority risks, a prime consideration is given to the potential to reduce or eliminate the risk by using the hierarchy of controls. This assists in establishing methods to reduce risk. From experience, the effectiveness of each method is given as a percentage after each of the control descriptions.

The desirability of control plans (with reducing effectiveness) is as follows:

Elimination: Remove step to eliminate the hazard completely.

Substitution: Replace with less hazardous material, substance or process.

Separation: Isolate hazard from person by guarding, space or time separation.

Administration: Adjusting the time or conditions of risk exposures.

Training: Increasing awareness, improving skills and making tasks less hazardous to persons involved.

Personal protective equipment: Used as the last resort, appropriately designed and properly fitted equipment, where other controls are not practicable.

Control measures can reduce either the likelihood or consequence of the event or both. Depending on the level of reduction of the hazard, there could still be a residual risk that needs to be monitored so that a secondary prevention process can be initiated when trigger points are reached.

.1.3.2 Action Plans

The team should develop an action plan recommending actions, responsibilities and when it should be completed. The proposed action plan is required to be put forward to the decision-making authority and reviewed, if necessary, before taking a final decision to proceed.

.1.4 Level 4: Development of Disaster Management Plan

The suggested DMP is organized in a Plan, Do, Check, Review (PDCR) cycle to enable its effective implementation.

.2 CONSEQUENCE ANALYSIS

Hazardous substance, on release can cause damage on a large scale. The extent of the damage is dependent upon the nature of the release and the physical state of the material. In the present report the consequences for both flammable and toxic hazards are considered and the damages caused due to such releases are assessed with recourse to MCA analysis. Flammable substances on release may cause jet fire & less likely unconfined vapour cloud explosion causing possible damage to the surrounding area. The extent of damage depends upon the nature of the release. The release of flammable materials and subsequent ignition results in heat radiation, pressure wave or vapour cloud depending upon the flammability and its physical state. It is important to visualize the consequence of the release of such substances and the damage caused to the surrounding areas.

Similarly the accidental release of toxic substances would lead to dispersion of gas cloud in the prevailing wind direction. An insight into physical effects resulting from the release of hazardous substances can be had by means of various models. Vulnerability models can also be used to translate the physical effects occurring in terms of injuries and damage to exposed population and buildings. Table depicts the input data required for consequence analysis.

Table Error! No text of specified style in document.**-1 Date for Consequence Analysis**

Parameter	Case
Ambient Temperature	30°C
Atmospheric Stability	C&F
Relative Humidity	70 %
Wind Speed	2m/s, 3m/s & 5 m/s

Stability class F and D shows the stable and neutral conditions of the climate. Generally in the daytime, neutral condition i.e. Little Sun & High Wind causes high turbulence in the climate. And in the nighttime, stable condition i.e. with moderate cloud exists which is nothing but a calm environmental condition. As per risk point of view, out of these two conditions one is extreme calm and one is extreme worst. Dispersion point of view, both can highly affect the extent of vulnerability of probable incident. In India, the average speeds at these two conditions are assumed to be 2, 3 and 5 m/s.

.2.1 Factors Influencing the use of Physical Effect Models

In order to calculate the physical effects of the accidental release of hazardous substance, following steps must be carried out in succession

- Determining the form in which the hazardous substance occurs e.g. gas, gas condensed to liquid or as a liquid in equilibrium with vapour
- Determination of the way in which the release takes place; for example intermittent or a continuous release
- Determination of the outflow volume (as a function of time) of the gas, vapour or liquid.
- Dispersion of the released gas or vapour which has formed into the atmosphere

In case of flammable substances, the heat radiation is also calculated for the following situations:

- Torch or jet fires, if a jetted release is ignited
- In the event of an explosion of a gas cloud, the peak overpressure resulting from the explosion is calculated and the damage contours are plotted

In evaluating the dispersion of releases, Pasquill-Giffard atmospheric stability classes (A to F) and relevant ranges of wind speeds are used and as shown in below table.

Table Error! No text of specified style in document.**-2Pasquill – Giffard Atmospheric Stability**

Sr. No.	Stability Class	Weather Conditions 1
1	A	Very unstable - sunny, light wind
2	A/B	Unstable - as with A only less sunny or more windy
3	B	Unstable - as with A/B only less sunny or more windy
4	B/C	Moderately unstable – moderate sunny and moderate wind
5	C	Moderately unstable – very windy / sunny or overcast / light wind
6	C/D	Moderate unstable – moderate sun and high wind
7	D	Neutral – little sun and high wind or overcast / windy night
8	E	Moderately stable – less overcast and less windy night
9	F	Stable – night with moderate clouds and light / moderate wind
10	G	Very stable – possibly fog

The model is based on a point source. In practice, however, a point source will never exist; for example, a surface sources in the case of pools. To enable the source dimensions to be included in the calculation in the dispersion models in spite of this, an imaginary (virtual) point source is assumed, which is put back in such a way that the cloud area calculated according to the model has the source dimensions at the site of the actual source. In calculations based on a continuous source, the duration of the source is also included in the calculation. Some conditions for this calculation model are as follows:

- There must be some wind at the site
- The model applies only to open terrain; allowance is made, however, for the roughness of the terrain. The influence of trees, houses, etc. on the dispersion can be determined by means of the roughness length

.2.2 Risk Associated to Storage & Process

Fuel is the tail gas having low calorific value available from the reactor of the mother unit manufacturing carbon black and allied products.

AUXILIARY FUEL: 20 kg of LPG will be used as Auxiliary fuel. The amount is required only for 10 minutes to ignite the gas. It is used once or twice in a year or in case of emergency.

AUXILIARY FUEL STORAGE: 35-40 kg of LPG will be the only fuel stored within the plant with respect to the Captive Power Plant

.2.3 Modeling Using Aloha Version 5.4.4

Chemical Data:

Chemical Name: PROPANE (Liquefied Petroleum Gas)

Molecular Weight: 44.10 g/mol

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

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

Ambient Boiling Point: -42.0° C

Vapor Pressure at Ambient Temperature: greater than 1 atm

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

SOURCE STRENGTH:

Tank Diameter: 0.3 meters

Tank Length: 1.06 meters

Tank Volume: 75.2 liters

Chemical Mass in Tank: 36.7 kilograms

Circular Opening Diameter: 0.2 centimeters

Opening is 0.27 meters from tank bottom

.2.3.1 Scenario 1

Leaking tank, chemical is not burning as it escapes into atmosphere- Toxic Area of Vapour Cloud

Result

Release Duration: 23 minutes

Max Average Sustained Release Rate: 3.38 kilograms/min

(Averaged over a minute or more)

Total Amount Released: 35.9 kilograms

Note: The chemical escaped as a mixture of gas and aerosol (two phase flow).

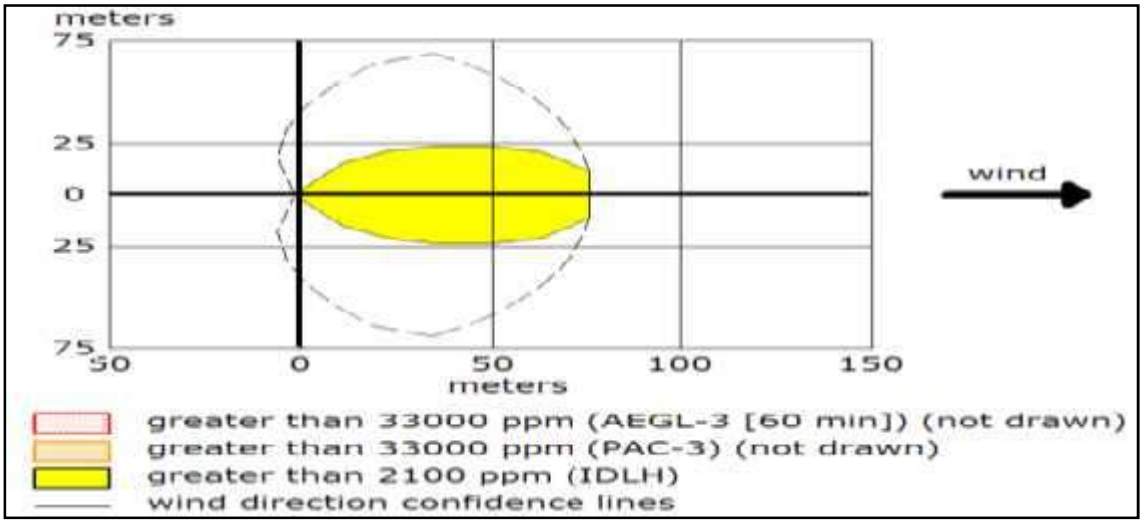

Figure Error! No text of specified style in document.**-1Toxic Area of Vapour Cloud**

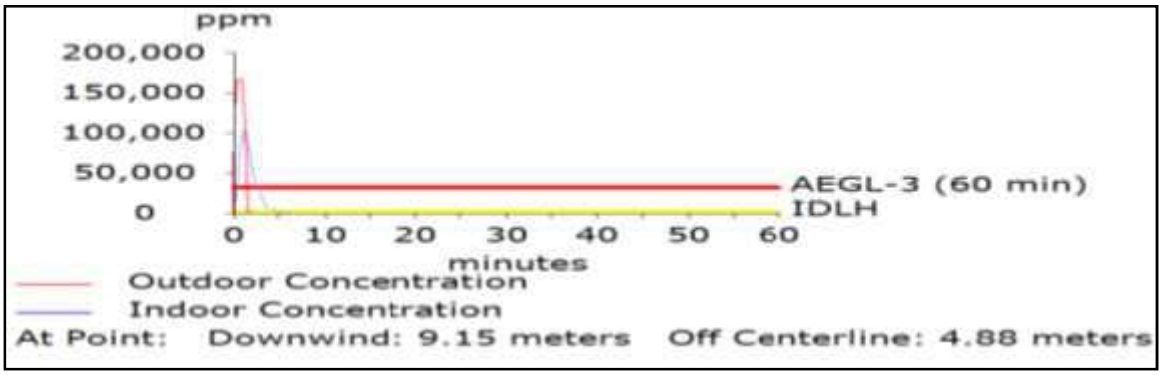

Figure Error! No text of specified style in document.**-2Showing Concentration Vs Time (at point 9.15 m down wind)**

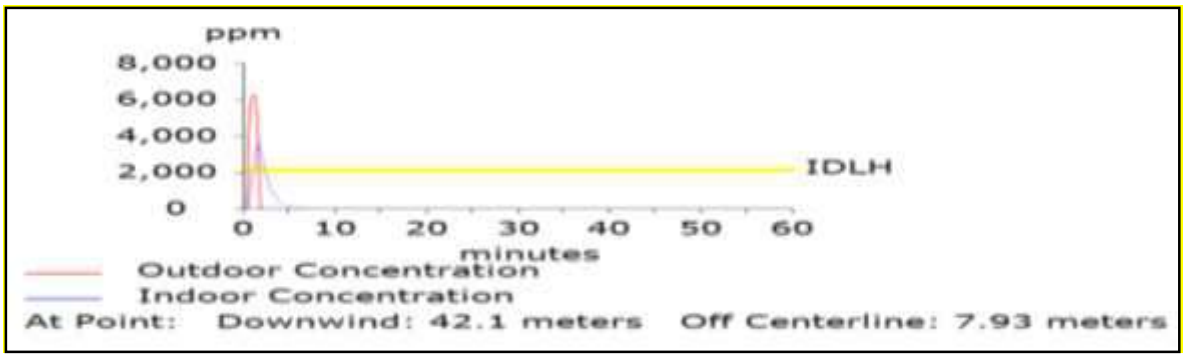

Figure Error! No text of specified style in document.**-3Showing Concentration Vs Time (at point 42 m down wind)**

.2.3.2 Scenario 2

Leaking tank, chemical is not burning as it escapes into atmosphere-flammable area of vapour cloud

Threat Modeled: Flammable Area of Vapor Cloud

Model Run: Heavy Gas

Red : 29 meters --- (12600 ppm = 60% LEL = Flame Pockets)

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

Yellow: 76 meters --- (2100 ppm = 10% LEL)

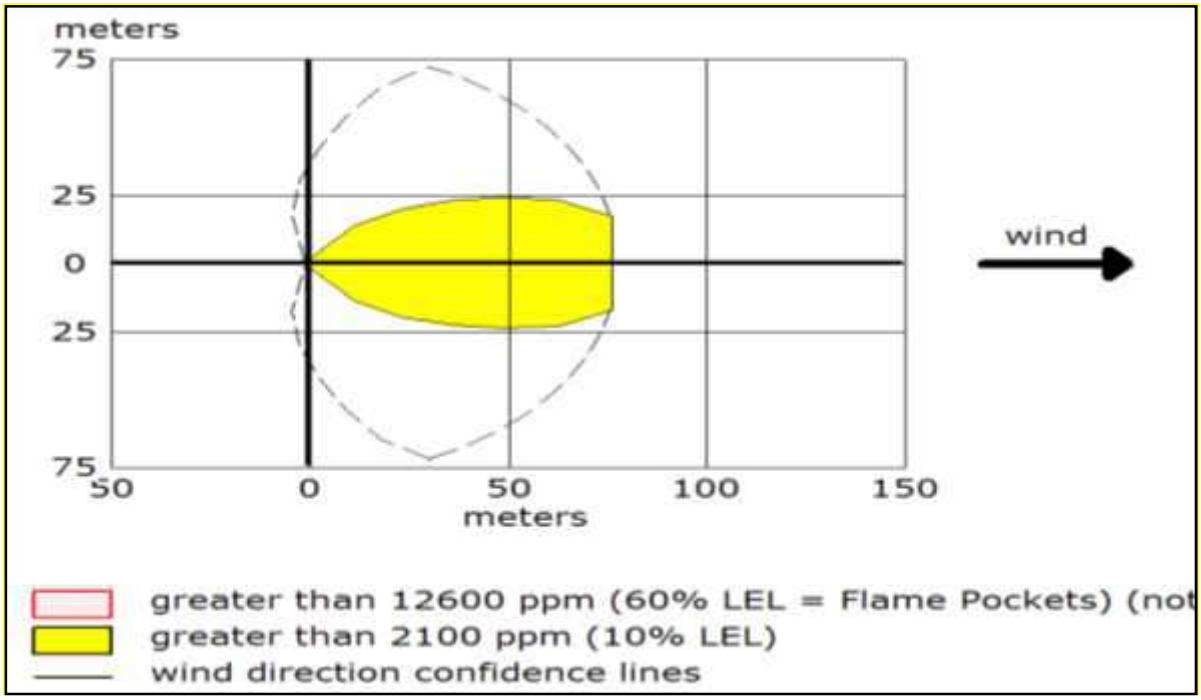

Figure Error! No text of specified style in document.**-4 showing the Lower explosion limit(LEL)Vs distance**

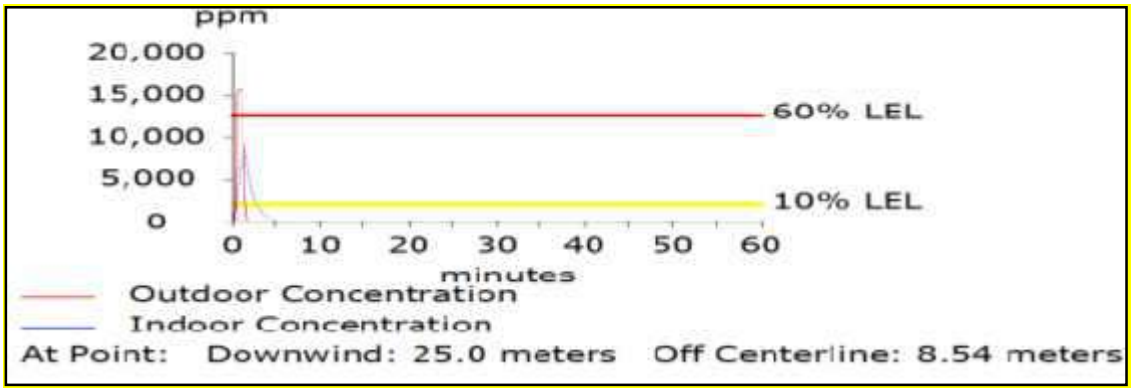

Figure Error! No text of specified style in document.**-5 Showing Lower explosion limit Vs time**

.2.3.3 Scenario 3

Leaking tank- blast force from vapour cloud explosion

Threat Modeled: Overpressure (blast force) from vapor cloud explosion

Type of Ignition: ignited by spark or flame

Model Run: Heavy Gas

Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)

Orange: 19 meters --- (3.5 psi = serious injury likely)

Yellow: 41 meters --- (1.0 psi = shatters glass)

Type of Ignition: ignited by spark or flame within 2 Minutes from the leak-After 2 Minutes no part of the cloud is above Lower Explosion Level

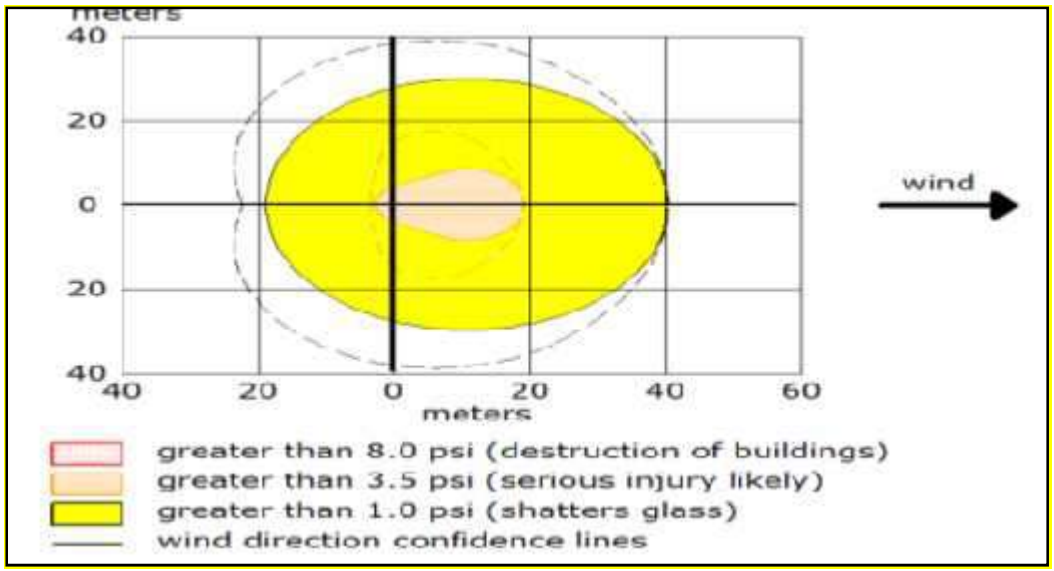

Figure Error! No text of specified style in document.**-6 showing the Blast area of Vapour cloud**

.2.3.4 Scenario 4- BLEVE

BLEVE stands for Boiling Liquid Expanding Vapour Explosion. BLEVE is a follow-up effect, which occurs if a pipeline/gas cylinder is heated by a torch of a pool fire. Due to the heating, the vapour pressure will rise and the material of the pipeline/cylinder wall will weaken. At a given moment the weakened pipeline/cylinder wall will no longer be able to withstand the increased vapour pressure and it will burst open. As a result of the expansion and flash-off a pressure wave occurs. In the case of flammable liquid/gas are:

A fireball: There are models with which the radius of the fireball and the thermal load can be calculated

Percentage of Cylinder Mass in Fireball: 100%

Fireball Diameter: 19 meters

Burn Duration: 2 seconds

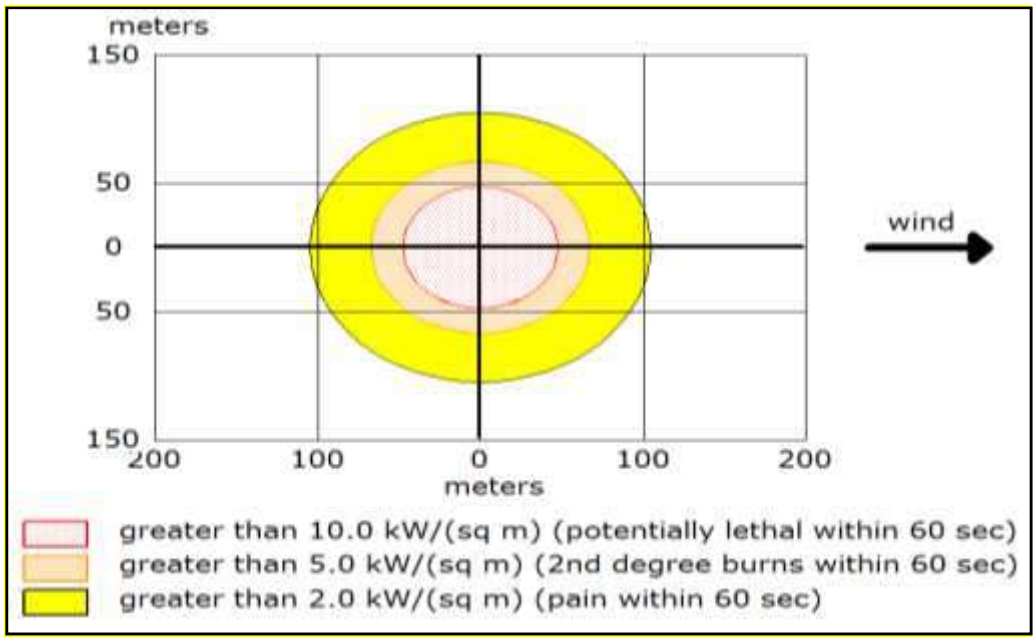

Figure Error! No text of specified style in document.**-7showing the thermal Radiation from Fire ball**

.2.4 Conclusion of Storage Risk

Small quantity of inventory (35-40 Kg LPG) is proposed to be stored within the premises & hence the window of critical impact last from 1 to 2 minutes only. Dedicated yard with fire fighting equipments& protective barriers will be provided to mitigate the impacts.

.3 PROCESS SAFETY MEASURES IN PRACTICES

- Systems exist to ensure that all process areas and containment vessels have the necessary design safeguards, such as fire detection and prevention systems, spill containment barriers, ignition source prevention, etc.
- Programs exist to ensure the proper segregation and separate storage and handling of incompatible materials at all times
- Containment vessels, reactors and other process equipment are equipped with proper safety devices, such as pressure relief valves, flame arrestors, static discharge systems, etc.
- Instrumentation, detectors and other process safety sensing equipment are properly placed, maintained, calibrated and distributed so as to perform as intended in monitoring operations

.4 ON SITE EMERGENCY PREPAREDNESS & RESPONSE PLAN

.4.1 Purpose

Himadri Chemicals & Industries Limited will bring safety on to of mind of all business process. An action plan in the form of On-site Emergency plan considering the extreme emergency situation is formulated. This plan has been developed to deal with any emergency/disaster situation systematically with the help of available resources in a preplanned way.

.4.2 Scope & Objectives of Plan

1. To minimize and prevent loss of life.
2. To minimize and prevent damage to environment.
3. To protect workers inside and people living outside.
4. To control the hazardous situation with in shortest possible of time.
5. to effect and rescue and treatment of casualties.

.4.3 Pre-Emergency Activities

1. To identify the potential disaster area.
2. To asses reliability and adequacy of built in safety measures.
3. To arrange routine monitoring of plant environment and to ensure effective communication and coordination within and outside the organization.

.4.4 Emergency Time Activities

- To localize the emergency and to control it with minimum damage to men and materials and to rescue the victims.
- To minimize and prevent damage to environment.
- To attend to the emergency situation with in shortest possible of time.

.4.5 Post Emergency Activities

- To rehabilitate the affected persons.
- To restore systems back to normal.
- To analyze the situation and take step to avoid any recurrences.

.4.6 Definitions

Definitions of terms as per I.L.O guidelines:

Key Personnel: The action necessary in an emergency will depend upon the surrounding circumstances. Nevertheless, it is imperative that the required actions are initiated and directed by nominated people, each having specified responsibilities as part of a coordinated plan. They are the Key Personnel, Main Key Personnel are...

1) Works Main Controller. (WMC)

2) Works Main Incident Controller. (WMIC)

Works Main Controller (WMC): In the major emergency situation, decision will have to betaken by collaboration with senior managers & officers which may affect the whole or a substantial part of the works and even places outside. It is essential that a senior manager is made works main controller and given the authority to make decisions on behalf of the works.

Works Main Incident Controller (WMIC): The works emergency procedure should provide for the attendance of a nominated person at the scene, which duties include the directions of the efforts of the works emergency team to control the situation.

Other key personnel: The other key personnel will include senior personnel from all sections e.g. Process, Maintenance, Laboratory, Medical, Transport, Personnel, Safety etc.

.4.7 Responsibilities

Works main controllers

will rush to site, coordinate and advise Works Main Incident Controller (WMIC) and then

come back to emergency control room.

will mobilize emergency teams after declaration of major emergency.

will call in all key personnel to report to emergency control room.

will ensure that outside emergency services have been called.

will contact police and other state government authorities with the help of key personnel.

will take policy decisions.

will ensure that casualties are receiving adequate attention.

Responsibilities of Works Main Incident Controller:

will rush to the site and coordinate with Works Main Controller

pending the arrival of the Works Main Controller, will assume the duties of the post.

will immediately proceed to the scene of emergency.

Will coordinate and advice all Incident Controller.

will ensure non-essential staff evacuates the affected area.

Incident Controller I

Concerned plant Shift-In-Charge being the Incident Controller I

will rush to the spot of emergency.

pending the arrival of the Works Main Controller and Works Main Incident Controller, will assume the duties of the post.

will keep liaison with WMC & WMIC.

will direct essential operation staff for maintaining control on operation parameters.

will inform Safety & Fire services and will guide them on their arrival.

Incident Controller II & III

Concerned Shift-In-Charge of maintenance departments being the Incident Controllers II & III Will maintain constant touch with other Incident Controller and will report to WMIC on his arrival.

Incident Controller IV

Shift In-Charge (SHE) being the Incident Controller IV

will respond to emergency call immediately.

will ask water treatment plant operation to maintain sufficient level of water in the reservoir and also to have a watch on the auto operation on the fire pumps.

will rush to site and report to WMIC.

will direct the fire crew to efficiently fight the emergency.

will keep in touch with Manager Safety who will contact external Fire and Safety services for assistance under mutual aid scheme consulting with WMC, if necessary

Responsibilities of Key personnel

Manager Maintenance is being one of the Key Personnel.

will keep liaison with Works Main Incident Controller.

will keep tract on availability of tools/tackles and welding set etc. and inform to work shop for stand by requirements.

Head-Plant HR & ADMN being one of the Key Personnel:

will rush to Emergency Control Room.

Will asses Law and order situation and engage Security Personnel to maintain it getting advice from WMC.

will assist WMC in such other co-ordination jobs.

will arrange to mobilize Security Personnel to assist rescue and Fire Fighting Team.

will arrange for transport.

will arrange to contact relatives to the affected person.

Manager Electrical is being one of the Key Personnel:

will keep liaison with WMC & WMIC.

will arrange for electric supply to vital machinery and emergency lights with the help of Incident controller II

will collect feedback from Incident controllers in the front and assist WMC in co-ordination job.

will maintain contact with Power Plant

Manager-Safety being one of the Key Personnel:

will rush to the scene of emergency and will take stock of the situation.

will establish contact with WIMC and will maintain close co-ordination in handling the emergency situation.

will direct Safety and Fire to efficiently fight the emergency and rescue operations.

will guide essential staff in proper operation of safety appliances.

will assist WMC to contact outside emergency services like fire brigade, Civil defence and upon their arrival will guide them to front.

will maintain liaison with Inspector of factories.

will keep WMC informed regarding developments in the emergency front.

.4.8 Monitoring and Measurement

a) Fire Fighting Drill as per Rule 62, W. B. Factories Rules, 1958, Fire Fighting Drills shall be held at least once in every month.

b) Formulation of the On-Site Emergency Plan:

Method of reporting authority

Any employee when discovering an emergency will immediately inform it to Shift-In Charge.

He in term will inform to WIMC and other Shift-in-charge over Mobile / Telephone / Intercom /Walkie-talkie and act as per action plan. WIMC will immediately assume charge for controlling the situation.

c) Method of Declaring Emergency:

Works Main Controller (WMC) wills immediately asses the type of emergency. If it is a major emergency, he will arrange to notify the same by blowing the siren and will also inform the following local authorities as per action plan.

- Sub-divisional Officer (S.D.O)
- Police Station
- W.B. Fire service

d) Emergency Shutdown: Works Main Incident Controller (WMC) will determine the shut down priorities at the initial stage of emergency.

e) During holidays or on non office hours key personnel will be called in by WMC during major emergency

f) Evacuation: As a precautionary measure it is necessary to evacuate personnel from effected area particularly those of non essential category. WMC and WMIC take decisions in respect of assembly point.

g) Accounting of Personnel:

WIMC with the help of Key Personnel will record the names of casualties who have been shifted to Hospital or given First-Aid. Responsibilities have been fixed up to the following personnel to inform the relatives of the casualties Head Plant & ADMN.

h) Rehabilitation:

WMC, WIMC, Senior Officers outside of plant and outside emergency services will take decision to declare that emergency has ended by sounding Siren. Relevant records, equipments etc. will be preserved for subsequent enquiry by management and other authorities.

.4.9 Emergency Response Procedure

.4.9.1 Major Emergency (Due to Fire)

- To alert the personnel working nearly
- To call factory Fire & Safety personnel
- Stop fuel supply.

Major Emergency due to Fire in Bulk Storage:

1. Ask Security personnel to blow Emergency Siren.
2. Inform Works Main Incident Controller he will direct to stop all connected operations of the plant and engage all essential staff to control the situation.
3. Works Main Incident Controller will also inform the following local authorities as per Action Plan
   a. W.B. Fire Service.
   b. Police Station (If required).
   c. Sub-Divisional officer (If required).
4. Fire Brigade will try to cover up affected area / tank with Foam by leading Foam Branches.

Simultaneously they will try to protect other tanks which are not affected with fire.

.4.9.2 Chemical / Oil Spill or releases

There is a Spill possibility from five sources at the Carbon Black Plant & CPP

1. The heavy aromatic hydro tar / oil used in the process.
2. The end product of Carbon Black.
3. Molasses used as a binder in the pelletizing process.
4. Hydrochloric acid used in cooling tower water treatment.
5. Sodium hydroxide (Caustic soda) used in water treatment plant.
6. Release of Auxiliary fuel LPG from Power plant

Response Procedure:

1. Immediately notify Shift in Charge / Emergency Coordinator / SHE department.
2. Contact Control Room for necessary action, in the event of oil spill, every effort will be made to prevent the spill from reaching sewers, drains and Settling Pond.

.4.9.3 Natural Disaster

1. To contact with SHE dept. / Shift in Charge / Dept. HOD
2. Determine the level of Chemical contamination as per the inform action of Shift In Charge.

3. Employees will not be permitted to leave shelter until authorized to do so by the Shift In

Charge after assuring damage, surveys and Environmental Reports

4. Employees will be released to return to their work station as their departments are declared Secure

.4.9.4 Severe Personal Injury

1. Apply immediate First – Aid.

2. Contact with the Shift In-Charge who will evaluate the situation and contact emergency aid (Ambulance) if necessary

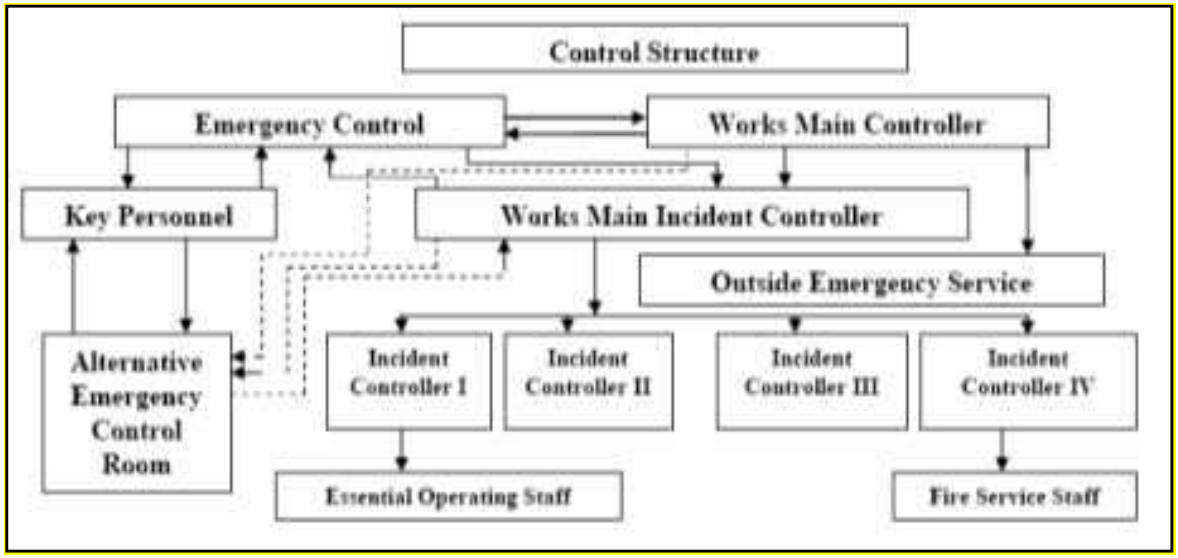

Figure Error! No text of specified style in document.**-8 Flow Chart showing the Control Structure**

.5 FACILITIES AVAILABE AT SITE

Table Error! No text of specified style in document.**-3 Personal Protective Equipment (PPE)**

Sl. No.	Item	Total Qty	Location of Posting
1.	Full face mask with dust filter.	6 Nos.	Carbon Black Division
2.	Full face mask with CO_2& CO vapour filter canister.	6 Nos.	Carbon Black Division
3.	Apron (PVC Suit)	10 Nos.	Safety Dept.
4.	Safety Goggles	20 Nos.	Evenly distributed in plant.

5.	Gloves	100 pairs Issued to all employees	Evenly distributed in plant.
6.	Helmet		Evenly distributed in plant.

Table Error! No text of specified style in document.**-4Fire Fighting Equipments**

Sl. No.	Item	Total Qty.	Location of posting
1.	Fire Hydrant	26 Nos.	Distributed throughout the plant.
2.	Mobile Foam Unit	1 Nos.	Tank Farm Area
3.	Fixed Water Monitor	8 Nos.	Distributed throughout the plant.
4.	Fire Extinguisher		Distributed throughout the plant.

Table Error! No text of specified style in document.**-5First -Aid Items**

Sl. No.	First -Aid Item	Total Qty.	Location of posting
1.	First Aid boxes	10 Nos.	Available in each plant
2.	Ambulance	1 No.	Always available in each shift for emergencies.
3.	Transport Car	6 Nos.	Always available in each shift for emergencies

The Emergency response plan for Captive Power Plant is enclosed in **Annexure-14**