Risk Assessment

1.0 Introduction

Following Additional studies have been completed as a part of EIA studies.

- Risk Assessment
- Disaster Management Plan
- Hydro-geological studies
- Need based assessment studies and preparation of CSR Plan.
- Public Consultation

1.1 Risk Assessment

The safety aspects of the manufacturing activity were generally covered under the Factories Act of 1948. However, consequent to the Bhopal gas tragedy, the Government of India has made major amendments to the Factories Act. In the year 1987 and under the exercise of powers conferred by the Environment (protection) Act of 1986, the Central government promulgated 'The Manufacture, Storage and Import of Hazardous Chemicals Rules - 1989' and amended the rules in 1994. Under these rules, industries handling Hazardous Chemicals listed in Schedule 1, 2 and 3 of the Act have to obtain clearance from the government after submitting a safety report giving systematic hazard analysis and risk assessment of the project and made it as a general responsibility of the occupier of the said Industrial activity.

Objectives:

Hazard Identification and Risk Assessment is aimed at identifying hazardous chemicals quantifying the consequences of plant operations. The specific objectives of the study are:

- Identification and assessment of major accident hazard potential in the plant operations.
- Identification of major failure scenarios
- Consequence Analysis of the scenarios with respect to dispersion of released gases, areas affected by fire or explosion etc.
- The report includes a description of the hazards arising out of the activity together with an account of the controls that are in operation.

A hazard is a danger, peril, source of harm, or an adverse impact on people or property. Risk is an expression of chance, a function of likelihood of an adverse and the magnitude of its consequences.

Risk is associated with frequency of failure and consequence effect. Predicting such situations and evaluation of risk is essential to take appropriate preventive measures. The major concern of assessment is to identify the activities falling in matrix of high and low frequencies at which the failures occur and the degree of its impact. The high frequency, low impact activities can be managed by regular maintenance i.e., Leak Detection and Repair (LDAR) programs. Whereas, the low frequency, high impact accidents are of major concern in terms of risk assessment. As the frequency is low, often the required precautions are not taken. However, the risk assessment identifies the major concerns which require additional preventive measures, likely consequence distances considering domino effects, which will give possible causalities and ecological loss in case of accidents. These magnitudes demand the attention for preventive and Disaster Management Plans (DMPs).

Risk analysis process involves 4 questions:

- What can go wrong to cause adverse consequences?
- What is the probability of frequency of occurrence of adverse consequences?
- What is the range and distribution of the severity of adverse consequences?
- What can be done, at what cost, to manage and reduce unacceptable risks and damage?

EIA should be able to answer at least 2 question from the above i.e., the first question and give at least qualitative expression of the magnitude of impacts.
Risk assessment can be carried out in 5 sequential steps:

1. Hazard Identification- sources of adverse impacts;
2. Hazard accounting- Scoping and setting the boundaries;
3. Scenarios of exposure- how the hazard might be encountered;
4. Risk characterization- likelihood and severity of impact damage;
5. Risk management- mitigation or reduction of unacceptable risk.

1.1.1 Hazard identification

Identification of causes and types of hazards is the primary task for planning for risk assessment. Hazard can happen because of the nature of the chemicals handled and also the nature of process involved.

The methods employed for hazard identification in this study are:

- Identification of major hazards based on **Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 of GoI (as amended in 2000)** and
- Identification of hazardous units and segments of plants and units based on relative ranking technique. Example: Fire- Explosion and Toxicity Index (FE&TI)

1.1.1.1 Identification of Major Hazards (based on Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 of GoI as amended in 2000).

A systematic analysis of the fuels/chemicals and their quantities of storages have been carried out, to determine threshold quantities as notified by GoI Rules, 1989 (as amended in 2000) and the applicable rules are identified.

The proposed TPP involves storage of various hazardous bulk chemicals (Toxic and Flammable) which will be used as fuel and auxiliaries. The major hazardous Chemicals/Fuels that are stored and involved with process are Light Diesel Oil (LDO), Heavy Fuel Oil (HFO), Chlorine, and Hydrogen. The threshold quantities of storage of these substances as notified by GoI Rules, 1989 (as amended in 2000) are provided in **Table 1.1.**

Table 1.1: Details of Flammable, Explosive and Hazardous materials

S.No	Product	Codes/Label	Type of Storage	Storage Capacity
1	Coal	Flammable	Open yard	3.5 MTPA
2	Heavy Fuel Oil (HFO)/ Light Diesel Oil (LDO)	Flammable	Tanks	2000 KL (1No.) 1000 KL(1No.)
3	Hydrogen	Flammable	Cylinders	-----
4	Chlorine	Toxic	Cylinders	-----

Table 1.2: Applicability of GoI rules to Fuel/Chemical Storage for proposed TPP

S. No.	Chemical/Fuel	Listed in Schedule	Threshold Quantity for Application of Rules (MT)	
			5,7-9,13-15	10-12
1	Light Diesel Oil (LDO)	1 (part I)	5000	50000
2	Heavy Fuel Oil (HFO)	1 (part I)	5000	50000
3	Chlorine (Cl_2)	3 (part I)	10	25

1.1.2 Fire Explosion and Toxicity Index (FETI) Approach

The most widely used relative ranking hazard index is Dow's Fire Explosion Index (F&EI) and Mond's Toxicity Index (TI) together is called as Fire Explosion and Toxicity Index (FETI). It involves objective evaluation of the realistic fire, explosion, toxicity and reactivity potential of process or storage units. The quantitative methodology relies on the analysis based on historic loss data, the energy potential of the chemical under study and the extent to which loss prevention measures are already applied.

1.1.2.1 FETI objectives and Methodology

The basic objectives that characterize FETI are:

- Identification of equipment within the plant that would contribute to the initiation or escalation of an incident.
- Quantification and classification of the expected damage potential due to fire, explosion and toxicity incidents in realistic terms.
- Determination of "area of exposure" surrounding the process or storage unit.

F&EI is a product of Material Factor (MF) and Hazard Factor (F3). While MF represents the flammability and reactivity of the substances, hazard factor (F3) is itself a product of General Process Hazard (GPH) and Special Process Hazard (SPH). An accurate plot plan of the plant, a process flow sheet and Fire and Explosion Index and Hazard classification Guide published by Dow Chemical Company are required to estimate F&EI of any plant or storage units.

The toxicity index is primarily based on the index figures for health hazards established by NFPA in codes NFPA 704, NFPA 49 and NFPA 325m.

1.1.2.2 Computations and Evaluation of F&EI and Toxicity Index (TI):

The F&EI is calculated from,

F&EI= MF x F3

Where ***F3= GPH x SPH***

The degree of hazard potential is identified based on numerical value of F&EI as per the criteria given in **Table 1.3.**

Table 1.3: Degree of hazard based on F&EI

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

The TI is calculated as follows:

$$\boldsymbol{TI = \left(\frac{Th + Ts}{100}\right)(1 + GPH + SPH)}$$

Where, *Th* is the health factor.

By comparing the indices of F&EI and TI, the unit under analysis is classified into one of the following categories established for this purpose.

Table 1.4: Categories of substances based on F&EI and TI

Category	Fire and Explosion Index (F&EI)	Toxicity Index (TI)
I	< 65	< 6
II	65 ≤ F&EI < 95	6 ≤ TI < 10
III	≥ 95	≥ 10

Certain basic minimum preventive and protective measures are required for the three hazard categories.

Detailed computations of FETI for various storage tanks at proposed TPP are given in the **Table 1.5.** The flammability, reactivity, health, MF for all the materials under consideration was derived from NFPA codes. The GPH and SPH were calculated accordingly. Based on F&EI and TI, LDO and HFO were found to fall under Category I and light degree of hazard and nil toxicity, while Chlorine was under category II with light degree of hazard and severe toxicity. Hydrogen falls under category III with intermediate degree of hazard and low toxicity.

Thus further assessment are carried out to further asses the hazard likely to occur due to fire from LDO and HFO tanks while chlorine storage tank is assessed for toxic hazard by carrying out Maximum Credible Accident analysis for the same.

Table 1.5: F&EI and TI of chemical/fuels used in proposed TPP

Chemical/Fuel	NFPA Classification				GPH	SPH	F&EI	F&E category	TI	Toxicity category
	N_h	N_f	N_r	MF						
Light Diesel Oil (LDO)	1	2	0	10	1.80	2.83	50.9	Light	2.8	Light
Heavy Fuel Oil (HFO)	1	2	0	10	1.80	2.83	50.9	Light	2.8	Light
Hydrogen	0	4	0	21	1	2.63	99.3	Moderate	-	Light
Chlorine	3	0	0	1	1	2.7	2.7	Light	17.7	Severe

1.1.3 Hazard Assessment and Evaluation

A preliminary hazard analysis is carried out to identify the major hazards associated with storages in plant. This is followed by consequence analysis to quantify these hazards. Finally the vulnerable zones are plotted for which risk reducing measures are deduced and implemented.

Physical and health occupational hazards in any process plant can be broadly classified as:

- Mechanical risks
- Electrical risks
- Fire/Explosion risks

- High/Low temperature exposure risks
- Toxic /Carcinogenic chemical exposure risks
- Corrosive/Reactive/Radioactive chemical exposure risks

The first 2 types of risks are universal in nature, not specific to any particular industry. Mechanical risks which are generally encountered are injuries to head, limbs, eyes...Etc. usually as a result of negligence on part of operating/maintenance personnel in the use of tools, bypassing prescribed safety procedures neglect of personal protective wear and risks associated with high energy release from compressed gases. Electrical risks which result in shock and/or burns are most often consequence of poor maintenance, ingress of dust or moisture, handling by unauthorized personnel and use of improper or substandard hardware.

1.1.4 Preliminary Hazard Analysis (PHA)

The purpose of Preliminary Hazard Analysis (PHA) is to identify potential hazards associated with or inherent in a process design, thus eliminating costly and time consuming delays caused by design changes later.

An assessment of the conceptual design is conducted for the purpose of identifying and examining hazards related to feed stock materials, major process components, utility and support systems, environmental factors, proposed operations, facilities and safeguards.

In the proposed major hazard is fire due to storage of chemicals in the tanks. The process related hazards are very rare as the process is carried out in closed systems and does not involve exothermic reactions. Other hazardous installation is the boiler where the steam is generated and used at various stages.

The hazards associated with the propose TPP are

- Electrical Hazards
- Fire Hazards
- Cable Galleries
- Toxic release

1.1.4.1 Electrical Hazards

Electrical hazards leading to fire and explosion in switchgear and other equipment mainly due to failure of circuit breakers, insulators, fuses, busbars and poor maintenance. Accidents may also occur in transformer due to open arcing; flash over above oil level, insulator failure, failure of air cooling systems, lightening…etc. Nevertheless, all these hazards lead to localized accidents only.

1.1.4.2 Fire Hazards

There could be other areas in the plant that have potential for fire hazard and require adequate firefighting equipment for example, the raw material storage area. These are considered here since uncontrolled fire may trigger the above emergencies due to domino effect. However for the proposed plant, safety guidelines will be as per rules.

1.1.4.3 Cable galleries

For containment of fire and preventing it from spreading in the cable galleries, unit wise fire barriers are planned. The ventilation system provided will be interlocked with fire alarm system so that, in the event of a fire, the ventilation system is automatically switched off.

Also to avoid spreading of fire, all cable entries/openings in the cable galleries, tunnels, channels, floors, barriers…etc, will be sealed with nonflammable/fire resistant sealing material.

1.1.4.4 Toxic Release

The major toxic chemical to be used in proposed plant is Chlorine. If not handled properly, it will lead to toxicity. Self-contained breathing apparatus will be available in the plant premises in the event of leakage. Since the quantity of toxic release will be lower, off site implications of release are not envisaged.

The **Table 1.6** gives a list of various process equipments and associated hazards identified as per PHA.

Table 1.6: Preliminary Hazard Analysis for Process/Storage Areas

Equipment	Process/Storage	Potential Hazard	Provision
Turbine	Converts pressure in steam to mechanical energy	Mechanical and Fire hazards	Layout of equipment/machinery is done in accordance to plant and electrical inspectorate.
Generator	Converts mechanical energy into electrical energy	Mechanical hazards and fire hazards in • Lube oil system • Cable galleries • Short circuits	As above
Power transformers	-	Fire and explosion	All electrical fittings and cables are provided as per the specified standards. Foam/CO_2/ DCP type fire extinguishers are to be provided

Equipment	Process/Storage	Potential Hazard	Provision
Switch yard	Switch yard	Fire	As above
Switch yard control room	-	Fire in cable galleries and switches	As above
Boilers	-	Fire, steam; Explosion	As above
DG set		Fires in cable galleries, short circuits in control rooms and switch gears	As above
HFO Storage	-	Combustion at elevated temperature	Leak detection and neutralization system will be provided
LDO Storage	-	Fire	
Hydrogen Plant	-	Explosion	
Coal Storage yard	Storage of coal	Coal dust fire and dust explosion	Water sprinklers for continuous dust suppression

1.1.5 MCA analysis

A Maximum Credible Accident (MCA) can be characterized, as an accident with maximum damage potential, which is still believed to be probable. MCA analysis does not include quantification of the probability of occurrence of accident. Moreover, since it is not possible to indicate exactly a level of probability that is still believed to be credible, the selection of MCA is somewhat arbitrary. In practice the selection of accident scenarios representative for an MCA analysis is done on the basis of engineering judgment and expertise in the field of risk analysis studies, especially accident analysis.

As an initial step in this study, a selection has been made of the storage units and activities which are believed to represent the highest level of risk to the surroundings. For this selection following factors have been taken into consideration:

- Type of compound viz. flammable or toxic
- Quantity of material present in a unit or involved in an activity
- Storage conditions such as temperature, pressure, flow, mixing and presence of incompatible mixtures.

In addition to the above factors the location of the unit or activity with respect to adjacent activities is taken into consideration to account for the potential escalation of the accident also called as Domino Effect.

Following steps are employed for visualization of MCA scenarios:

i. Chemical inventory analysis
ii. Identification of hazardous processes in individual storage units
iii. Identification of chemical release and accident scenarios
iv. Visualization of release scenarios with recourse to consequence analysis
v. Damage distance computations for the credible accident cases.

1.1.5.1 Chemical Inventory Analysis

The major inventories of fuels in storage vessels have been identified from the proposed unit. The minimum quantities have been screened as per GOI rules, 1989, amended in 2000. The chemical potential has been shortlisted and prioritized on the basis of hazard potential assessed by FETI. The detailed results have been discussed in earlier sections.

1.1.5.2 Identification of chemical release and accident scenarios

Following the accidental release of chemical, the effects thus caused depends on large number of factors like type and quantity of released material, meteorological conditions, location and presence or otherwise of an ignition source. The accident scenarios can be divided into the following categories according to mode of release, physical effects and the resulting damages:

- Liquefied gas and boiling liquid release under pressure
- Flammable gas release
- Toxic gas release
- Non boiling liquid release or pool fire
- Spontaneous Combustion of Coal Dust

Of the above scenarios toxic gas release from chlorine storage and pool fire in HFO/LDO storage vessels is assumed to occur.

1.1.5.3 Visualization of release scenarios with recourse to consequence analysis Damage Criteria

The storage and unloading at the storage facility may lead to fire and explosion hazards. The damage criteria due to accidental release of any fuel will arise from fire and explosion. Tank fire would occur if the radiation intensity is high on the peripheral surface of the tank leading to increase in internal pressure of the tank. Pool fire would occur when the flammable liquid in the tank gets ignited after leakage. The major contributors to damage in any TPP are

- Damage due to fire
- Damage due to toxic gas release
- Coal dust explosion

1.1.5.3.1 Damage due to fire

The flammable liquid in a pool will burn with large turbulent diffusion flame. This releases heat based on the heat of combustion and the burning rate of the liquid. A part of heat is radiated while the rest is convected away by rising hot air and combustion products. The radiations can heat nearby storage or process units to above their ignition temperatures and thus result in spread of fire.

The radiation can also cause severe burns or fatalities to workers or firefighters located within a certain distance. Hence, it will be important to know beforehand the damage potential of flammable liquid pool likely to be crated due to leakage or catastrophic failure of storage or process vessel. This will help decide the location of other storage/process vessels, decide the protective clothing the workers/firefighters need, the duration of time for which they can be in the zone, the fire extinguishing measures needed and the protection methods needed for nearby storage vessels.

The **Table 1.7** tabulates the damage effect on equipment and people due to thermal radiation intensity.

Table No. 1.7: Effect of thermal radiation on equipment and people

S. No.	Incident Radiation (kW/m^2)	Type of Damage Intensity	
		Damage to Equipment	Damage to people
1	37.5	Damage to process equipment	100% lethality in 1 min. 1% lethality in 10 sec.
2	25.0	Minimum energy required to ignite wood at indefinitely long exposure without flame	50% lethality in 1 min. Significant injury in 10 sec.
3	12.5	Minimum energy to ignite with a flame	1% lethality in 1 min
4	4.5	------	Causes pain if duration is longer than 20 Sec, however blistering is unlikely (Ist degree burns)
5	1.6	------	Causes no discomfort on long exposure

1.1.5.3.2 Damage due to toxic gas release

Chlorine is greenish-yellow, highly reactive halogen gas that has a pungent, suffocating odor. The vapor is heavier than air and will form a cloud in the vicinity of a spill. Like other halogens, chlorine exists in diatomic state in nature. Chlorine is extremely reactive and rapidly combines with both inorganic and organic substances. Chlorine is an eye and respiratory tract irritant and, at high doses, has direct toxic effect on lungs. The critical values of chlorine concentrations in air are given in **Table 1.8**

Table 1.8: Critical concentrations of chlorine

Criteria	Concentration (ppm)
LC_{50}	293ppm/1Hour (rats)
Immediate damage to life and health (IDLH)	10
Short Term Exposure Limit (STEL)	1
Timed Weighted Average (TWA)	0.5

1.1.5.3.3 Consequences of Over Pressure

The effects of the shock wave vary depending on the characteristics of the material, the quantity involved and the degree of confinement of the vapor cloud. The peak pressures in an explosion therefore vary between a slight over-pressure and a few hundred kilopascals (kPa). Direct injury to people occurs at pressures of 5-10 (5E-5 to E-4) kPa (with loss of life generally occurring at a greater over-pressure), whereas dwellings are demolished and windows and doors broken at pressures of as low as 3-10 kPa. The pressure of the shock wave decreases rapidly with the increase in distance from the source of the explosion. Details are given in **Table 1.9**.

Table 1.9: Over Pressure Damage

Over Pressure (Bar)	Damage
0.3	Heavy damage
0.1	Moderate damage
0.03	Significant damage

1.1.5.3.4 Coal Dust Explosion

Coal dust when dispersed in air and ignited would explode. Crusher Houses and conveyor systems are most susceptible to this hazard. To be explosive, the dust mixture should have:

- Particles dispersed in the air with minimum size
- Dust concentrations must be reasonably uniform
- Minimum explosive concentration for coal dust (33% volatile) is 50 grams/m^3

Failure of dust extraction and suppression systems may lead to abnormal conditions and increasing the concentration of coal dust to the explosive limits. Sources of ignition present are incandescent bulbs with the glasses of bulkhead fittings missing, electric equipment and cables, friction, spontaneous combustion in accumulated dust.

Dust explosions may occur without any warning with maximum explosion pressure up to 7.4 bar. Another dangerous characteristic of dust explosions is that it sets off secondary explosions after the occurrence of the initial dust explosion. Many a time, the secondary explosions are more damaging than primary ones.

The dust explosions are powerful enough to destroy structures, kill or injure people and set dangerous fires likely to damage a large portion of the Coal Handling Plant including collapse of its steel structure, which may cripple the lifeline of the power plant.

The following assumptions have been made while judging representative set of incidents:

- There are no automatic isolation valves within the system and therefore an instantaneous failure of one of the components will lead to rapid release of entire contents of the unit.
- The pipe diameter is assumed to be 2"
- Worst case environmental conditions are assumed for modeling as per past metrological data i.e., partially cloudy sky, B or C class stability, temperature of 32^0C.
- A hole in the pipeline is the most credible scenario.
- It is not continuous exposure
- No detection and mitigation measures are initiated
- There is no enough time available for warning public and initiating emergency action
- Secondary fire at public road and building is unlikely
- The effect of smoke on reduction of source radiation has not been considered; therefore hazard distances tend to be conservative
- Shielding effect of intervening trees or other structures has not been considered.

Based on the aforementioned assumptions the following incidents are considered for analysis:

- Pool fire in LDO/HFO storage vessels with thermal radiation
- Toxic gas release from catastrophic failure of chlorine storage tank
- Toxic gas release from full bore rupture of pipeline
- Toxic gas release from hole of various diameters in chlorine storage tank.

1.1.5.4 Damage distance computations for the credible accident cases

The major hazards scenarios identified for the possibility of occurrence are mainly concerned with thermal radiation for LDO/HFO tanks and Toxic gas release from Chlorine storage tank.

1.1.5.4.1 Pool Fire Of HFO/LDO Storage

One tank of HFO of capacity 500 KL and tank of LDO of capacity 200 KL is considered for the proposed project. Tank fire would occur if the radiation intensity is high on the peripheral surface of tanks leading to increase in internal tank pressure. Pool fire would occur when fuel oil collected in the dyke due to leakage gets ignited. As the tanks are provided within the dyke the fire will be confined within the dyke wall.

For all bulk storage of HFO, LDO and other flammable liquids, it is assumed that the complete liquid leaks due to tank failure or ruptures and develops into a pool and gets ignited. In the second scenario it is assumed that the dense vapors from the storage are released due to failure or increase in internal pressure of storage tanks or operator negligence and vapors could meet an ignition source and develops into a fireball and exists as a vapor cloud explosion.

For the above storage liquids, hazards distances have been arrived due to effect of pool fires. For MCA analysis full tank storage capacity has been considered for all the materials and radiation intensities at different distances are estimated as follows.

Either HFO/LDO tank is on fire:

Source Strength:

Burning Puddle / Pool Fire

Puddle Diameter: 4 meters; Puddle Volume: 6000 liters

Initial Puddle Temperature: Air temperature

Flame Length: 11 meters

Burn Duration: ALOHA limited the duration to 1 hour

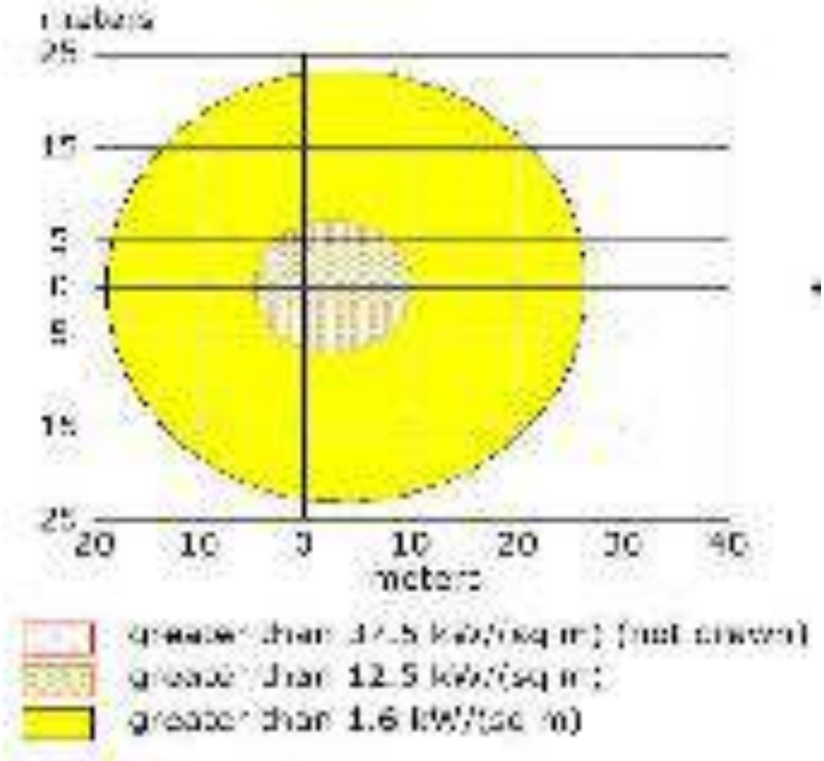
Burn Rate: 65.2 kilograms/min

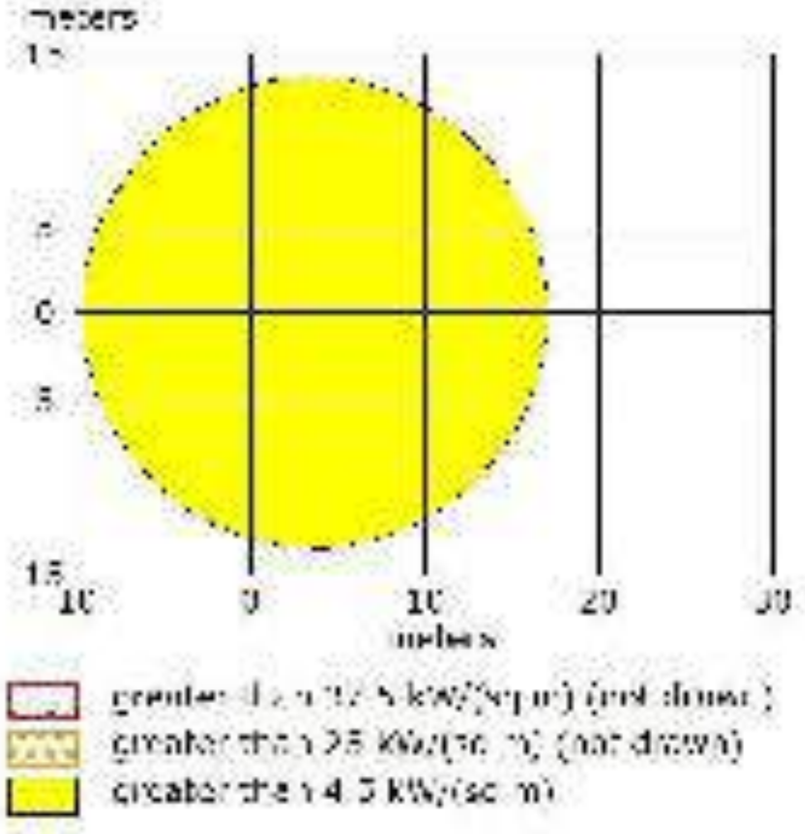
Total Amount Burned: 3,913 kilograms

Threat Zone:

Threat Modeled: Thermal radiation from pool fire
Red : less than 10 meters (10.9 yards) --- (37.5 kW/(sq m))
Orange: less than 10 meters (10.9 yards) --- (25 kW/(sq m))
Orange: 10 meters --- (12.5 kW/(sq m))
Yellow: 17 meters --- (4.5 kW/ (sq m))
Yellow: 27 meters --- (1.6 kW/ (sq m))

Figure 1.1: Threat zone when either HFO/LDO tank is on fire





1.1.5.4.2 Hydrogen gas Cylinders

Release of Hydrogen Gas from a cylinder through a partially opened valve will disperse in the atmosphere along with the prevailing wind is considered as the accident scenario for the study. The dispersed gas cloud in the air if ignited in contact with a source of ignition will cause explosion. The blast wave resulting from the explosion has the potential to cause property damage in the surroundings.

Scenario:

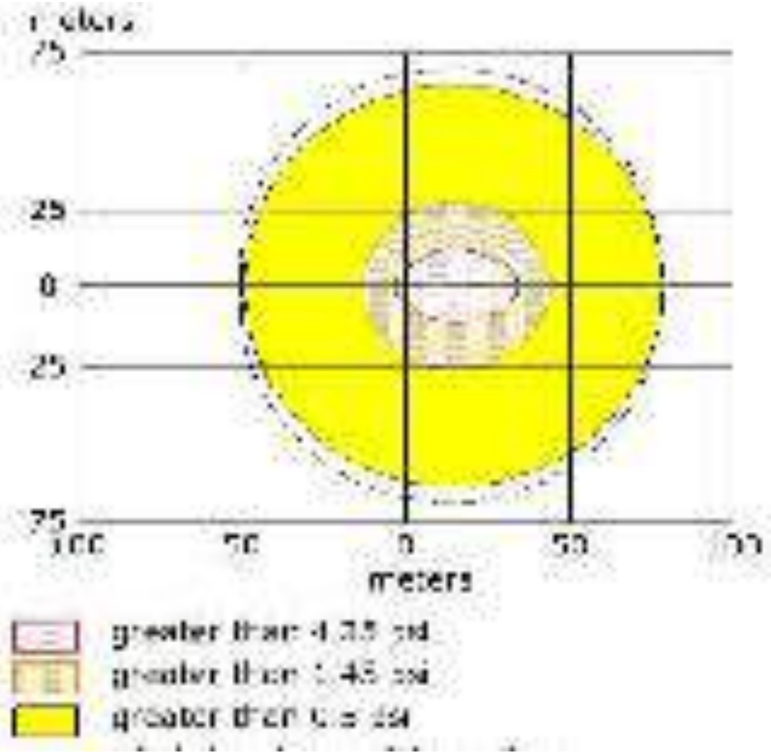
Source strength:

Direct Source: 50 grams/sec
Release Duration: 30 minutes
Release Rate: 3 kilograms/min
Total Amount Released: 90.0 kilograms

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: Gaussian
Red : 35 meters --- (4.35 psi) (0.3 BAR)
Orange: 44 meters --- (1.45 psi) (0.1 BAR)
Yellow: 79 meters --- (0.5 psi) (0.01 BAR)

Figure 1.2: Threat zone due to leak of Hydrogen gas



1.1.5.4.3 Chlorine Storage

To prevent growth of organic matter and microorganisms, which tend to foul condenser tubes etc, chlorine is the most common biocide used. Chlorine is highly toxic (IDLH – 10ppm). One tank of 1 Ton capacity is proposed to be located in the plant. Any leakage in the system will cause toxic release which will spread in down wind direction. The system is based on conventional gas chlorination using evaporator – chlorinators proposed to be housed in a building close to the cooling tower and CW pumps. Chlorine cylinders of adequate requirement would be housed in a separate semi-open shed. Worst Rupture in Chlorine Cylinder is considered for modeling.

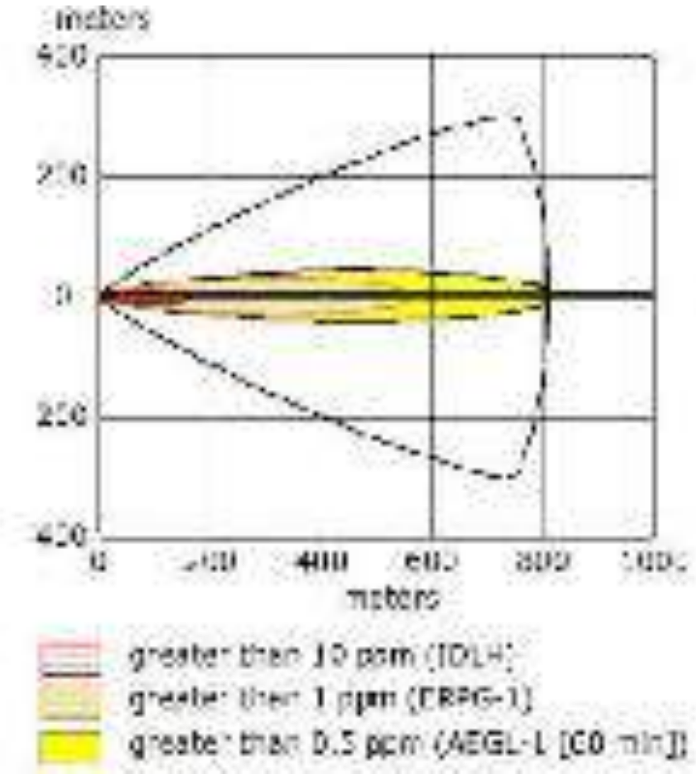
Scenario:

Direct Source: 10 grams/sec
Source Height: 5 meters
Release Duration: 5 minutes
Release Rate: 600 grams/min
Total Amount Released: 3.00 kilograms
Note: This chemical may flash boil and/or result in two phase flow.

Threat Zone:

Model Run: Heavy Gas
Red : 168 meters --- (10 ppm = IDLH)
Orange: 565 meters --- (1 ppm = STEL)
Yellow: 812 meters --- (0.5 ppm = TWA)

Figure 1.3: Threat zone due to leak of Chlorine gas



Consequence analysis

From the modeling studies on radiation intensity due to pool fire in fuel storage vessels, it can be inferred that the safe operating zone (radiation intensity < 1.6kW/m^2) for operators/firefighters is about 27m when either of fuel storage tank i.e. either of HFO or LDO tank is on fire. The distance at which equipment damage can occur is within 10m from the tank location, therefore the chances of domino effect occurring from this situation is nil, as no equipments are envisaged to be located within that distance from storage tanks. While distance at which 1% lethality can occur after an exposure for about 1min to radiation intensity of 12.5kW/m^2 is 10m from the tanks.

The modeling results of hydrogen leak, the shock wave vary depending on the characteristics of the material, the quantity involved and the degree of confinement of the vapor cloud. The peak pressure 0.3 bar cause heavy explosion at a distance of 35m. Direct injuery and moderate damage occurs at a pressure of 0.1 bar around 44m. Significant damage occurs at 79m with 0.01 bar pressure. The pressure of the shock wave decreases rapidly with the increase in distance from the source of the explosion.

From the modeling studies of Chlorine release from storage tank, during worst case situation, it was observed that the distance up to which 90% lethality (866ppm concentration) can occur after a continuous exposure for 10min is 168m, 565m for 10% lethality after 10min exposure, 812m is for IDLH to occur.

All these distances fall well within plant boundary and adequate safety measures have been planned in case an emergency situation does occur.

1.1.6 Safety Measures

Adequate number of fire detectors and toxic gas detectors will be put in place for early warning at all potential locations where accidents can occur, with the provision for alarms.

For protection against fire, all yard equipment and plant equipment will be protected by a combination of hydrant system; automatic sprinkler spray system (emulsifier system); fixed foam system for oil handling areas; automatic high velocity and medium velocity sprinkler spray system; auto-modular inert gas based system for control rooms apart from portable and mobile fire extinguishers located at strategic areas of plant buildings and adequate Passive Fire Protection measures. The systems will be designed as per the recommendations of NFPA or approved equals in accordance with the Tariff Advisory Committee of the Insurance Association of India stipulations.

For scenarios involving toxic gas release adequate numbers of face masks and isolation chambers with oxygen supply will be provided at strategic locations within the plant premises.

Emergency Management plan will be out in place along with the provision for carrying out regular safety exercises and work permit system.

1.2 Disaster management plan

1.2.1 Preamble

The objective of any industry should be engage in safe operation / Production: All efforts, right from the design stage, therefore should emphasize safety and elimination of accidents in the industry. However due to human errors or system malfunctions, accidents could happen. The suffering and damage as a result of an accident is determined by the potential of loss, surrounding the event. But by taking effective action at the time of occurrence of the incident, severity and full potential loss can be largely contained/ avoided. Effective action will be possible for handling major emergencies, only if preplanned procedures are practiced by utilizing the combined resources of the factory and out-side emergency services.

The obligation of occupier of the plant, handing hazardous chemicals is to prepare an emergency plan as stipulated in Rule-13 of the manufacture, storage and import of hazardous chemicals rules, 1989 (amended in 1984).

Apart from the provision of the hazardous chemicals rules, section 41B(4) of the factories act, 1948 (as amended) also require every occupier to draw up an On-site Emergency Plan with detailed disaster control measures for the industry and to educate the workers employed in the factory premises. The general public living in the vicinity is also to be informed and educated about safety measures and actions required to be taken in the event of an accident.

Accordingly "**Disaster Management Plan**" is prepared and will be circulated to all concerned widely.

This plan deals with probable hazards, their consequences, protections, preventive measures and action Plan to deal with the emergencies. It also clearly assessed its strengths and weakness, supports available within and from neighboring industries/ organization etc. This Plan also identifies the authority / responsibilities and actions of the people to act at the time of emergency. All emergency numbers (fire station, police station, nearby hospitals, ambulance services, doctors, plant heads, inspector of factories, pollution control board, etc) will be displayed at strategic locations and at security gate.

1.2.2 On –Site Emergency Plan

1.2.2.1 Objective

Emergencies may occur due to many reasons. It may occur due to natural causes like earth quake, cyclone, flood etc. It may occur due to terrorist activity or it may be due to malfunction of standard working systems or practices.

In the industry handling hazardous materials, large-scale emergencies will be essentially those of a major release of flammable or toxic material and of events, which have significant environmental impact.

This On-site Emergency plan is made considering the nature and scale of the events and based upon all relevant information including, most importantly, practical operating experience.

The Emergency plan is aimed at enduring safety of people, protection of environment, protection of installation, restoration of production and salvage operations in the same order of priorities. For effective implementation of the Emergency plan, it will be widely circulated and personnel are trained through mock drills.

The Emergency plan should reflect the probable consequential severities of the undesired event due to deteriorating conditions or through 'Knock on 'effects. Further the Emergency Plan should be able to demonstrate that the correctness of assessment of the consequences, use of supporting evidences currently available and reliable information and incident data and if necessary the reports of outside consultancies.

To tackle the consequences of a major emergency inside the factory (Power Plant) a major emergency plan has been formulated and this document is called "DISASTER MANAGEMENT PLAN".

The objective of the major emergency plan is to make use of the combined resources of the plant and the outside services to achieve the following.

1. Effect the rescue and Medical treatment of casualties.
2. Safeguard other people.
3. Minimize damage to property and the environment.
4. Initially contain and ultimately bring the incident under control.
5. Identify any dead.
6. Provide authoritative information to the news media.
7. Provide for the needs of relatives.
8. Secure the safe rehabilitation of affected area.
9. Preserve relevant records and equipment for the subsequent enquiry into the cause and circumstances of the Emergency.

1.2.2.2 Identification of Major Hazard Potentials

1.2.2.2.1 Major Plant Sections

Considering the process and the material to be used at Thermal Power Station, the following can be considered as major plant sections.

(a) Coal Handling plant.
(b) Main plant (Boiler, Turbo Generator, Lube Oil Tanks)
(c) Water treatment plant.
(d) Hydrogen filling area.
(e) Switchyard including sub-stations and transformers.
(f) Fuel oil handling plant.
(g) Cable Galleries.
(h) Stores where hazardous, flammable and explosive materials are stored.

1.2.3 Major Hazard Potential Assessment

The major disasters or emergencies usually take birth from one or any combination of the following:

(a) Slow isolated fires.
(b) Fast spreading fires.
(c) Explosions.
(d) Bursting of pipes Lines/vessels.
(e) Uncontrolled release of toxic/corrosive/flammable liquids.
(f) Uncontrolled release of toxic/flammable gases/ducts depending upon the nature, scale, speed and impact on environment.
(g) Breach of dam/ash dyke.

1.2.4 Release of Gases / Dust – Areas

(a) Chlorine in Water treatment Plant.
(b) Hydrogen in Turbo Generator area of Main Plant.
(c) Pulverized coal dust from mills associated piping and flue gases.
(d) Coal dust in transfer points of CHP, Crushers, Wagon tippers and Mill areas.
(e) Flue gases from the ducts.

1.2.5 Release of Chemicals Areas

(a) Chemical tanks and Chlorine in Water treatment plant.
(b) Acid & Alkali storage tanks in Water Treatment Plant.
(c) Fuel oil tanks in Fuel oil handling section.
(d) Control Fluid in turbine system.

1.2.6 Major Causes of On-Site Emergency

1.2.6.1 Chlorine Leakage

Liquid Chlorine filled containers are brought by the suppliers through their own transport. The toner containers are placed on its seat, specially fabricated for this purpose.

The toner containers are connected to the manifold system and then to the evaporation line for use. The possible emergencies in this process are mentioned below.

1.2.6.2 Explosion of Cylinders Due To Terrorist / Sabotage Activities

In case of any terrorist activity and blasting of manifold system or Chlorine toners with the use of explosives, heavy quantum of Chlorine may leak, which in no case can be sealed. In that case, only action is evacuation of victims and others.

However, such probabilities are reduced to almost zero, by providing fool proof security measures and restricting entry into chlorine handling / storage area.

1.2.6.3 Explosion Due To Fire

Such an explosion may occur due to fire also. But again to prevent such event, no flammable material is allowed to be kept in the vicinity of Chlorine. Even uncontrolled growth of grass is not allowed there.

1.2.6.4 Release of Chlorine Due To Leakage

Due to corrosion or mishandling leakage of chlorine from chlorination system has happened in different parts of the country. Most of the leakage occured from the toner valves and joints. On few occasions, leakage at the shell has also come to the light.
To control such leakage, emergency sealing kits have been provided close to the chlorine container stores.

The staff been fully trained to seal any leakage with the help of such emergency kit in shortest possible time and neutralize the leaking Chlorine. A specially designed chlorine neutralization pit is available at Chlorination plant. This can be used if there if there is any uncontrollable chlorine leakage from any toner. Breathing equipment are also provided, to use in such operation.

1.2.6.5 Explosion

Explosion in the plant is possible in Hydrogen filling area, oil storage tanks, or where Hydrogen Cylinders are stored. To prevent such possibility Hydrogen is purged with inert gas like Nitrogen or Carbon Di-Oxide and always purity above 98% is maintained.

1. In oil storage tanks appropriate fire fighting system is provided.
2. Explosion of Boiler Furnace due to internal pressurization.

1.2.6.6 Coal Dust Explosion

Coal dust can explode when they are suspended in air. A coal dust explosion may occur if the coal dust is present in the concentration between Upper Explosive Limit & Lower Explosive Limits i.e., 30-2000 grams/m^3 of air and also a source of ignition like sparks caused by friction or static electricity. However measures are adopted to prevent the chances of explosion in the design state itself. To prevent the accumulation of dust, dust suppression and dust extraction systems are propose at strategic locations.

1.2.6.7 Boiler Explosion

Whenever Boiler gets pressurized due to non-evacuation of steam, there are chances of Boiler explosion. However, various interlocks and protections will be provided for Boiler during design stage to avoid Boiler explosion.

1.2.6.8 Turbine Generator Explosion

Hydrogen gas explosion is a possible hazard in generator. However, the Generator is designed to withstand explosion. Seal oil system is also provided for the Generator to prevent the leakage of H_2 gas. And also the H_2 purity is continuously monitored and maintained always above 98%. All the H_2 cylinders are checked for high purity.

1.2.6.9 Fire in Cable Galleries

The main hazard in cable galleries is fires. To contain fires, heat sensors and smoke detectors are provided in the cable galleries to detect the fires at the inception stage itself. Automatic sprinkler systems will be provided at important places to extinguish the fires. Also fires resistance barriers will be provided at the cable entries/ intersections, intermittent places on cable trays, cable raisers and cable entry points.

1.2.6.10Transformer Hazards

Possible hazards in transformers are:

1. Failure of terminal bushings and flashover.
2. Sudden gas pressure formation due to transformer internal failure and subsequent failure of explosion vents and pressure release devices may cause explosion of transformer and fires.
3. Accumulated leakage oil from different parts of transformers can catch fire due to spurious sparking.
4. To take care above possible hazards, adequate protection systems are proposed as per engineering and in case of failure emulsifier system is provided to quench fires.

1.2.6.11Sub-Station Hazards

Where indoor switchgears are provided, fires and explosions may occur due to:

- Short Circuit either at bus bars, breaker high voltage parts or cable termination chambers may occur due to reptile's ingress or falling of internal accessories on to live parts.

- Failure of supporting insulators of bus bars, breakers, termination and subsequent earthling of supply may cause flash over.

- Failure of measurement equipments like CTs & PTs may cause flashover in the concerned chambers.

To take care of the above problems, the following precautions are taken.

- Plugging of cable gland plates and breaker inspection plates against reptile entry.
- Periodical inspection. / testing of switchgear equipment.
- Providing proper nomenclature of switchgear equipment with regards to voltage level, feeder description and panel numbering to avoid wrong identification.

1.2.6.12Water Treatment Plant Hazards

There are chances of spill-over from storage tank. There are chances of chemical burns due to contact with acids/alkalies. However, dyke walls are provided to contain any over flow / leakage of acids from tanks. Also all these spill-overs are collected in neutralization pits and disposed off.

1.2.6.13Fuel Oil Handling System Hazards

The main hazard in fuel oil section in fires and storage tanks explosion. However, to contain the chances of fires/explosions due to spillover dyke walls are provided all around the fuel oil storage tanks. Apart from this, foam pores and MV water spray systems are provided on all Fuel Oil tanks. The level gauges and temperature monitors are also provided on the fuel oil tanks.

1.2.6.14Storage /Godown-Hazards

The main hazards in stores / godowns are fire and explosion due to stored gas cylinders. However to prevent the chances of fires and explosions, gas cylinders and flammable materials are stored safely with utmost care and precautions. Fire hydrant/Portable fire extinguishers systems will be provided in nearby storage area.

1.2.7 Facilities Proposed to Control Hazards

1.2.7.1 Fire Fighting

For protection against fire, all yard equipment and plant equipment will be protected by a combination of hydrant system, automatic sprinkler spray system (emulsifier system), fixed foam system for oil handling areas, automatic high velocity and medium velocity sprinkler spray system, auto-modular inert gas based system for control rooms apart from portable and mobile fire extinguishers located at strategic areas of plant buildings and adequate Passive Fire Protection measures. The systems will be designed as per the recommendations of NFPA or approved equivalents in accordance with the Tariff Advisory Committee/Loss prevention Association of India stipulations.

- In view of vulnerability to fire and its importance in the running of the power station, effective measures will be taken to tackle fire in the susceptible areas such as cable galleries, fuel oil handling areas, coal handling plant areas including transfer points, crusher houses and tunnels, etc.

- For containment of fire and preventing it from spreading in cable galleries, unit wise fire barriers with self-closing fire doors will be provided. In addition, all cable entries / openings in the cable galleries, tunnels and floors will be sealed with non-inflammable / fire resistant sealing materials to prevent fire propagation for at least three (3) hour. Fire protection cable coating compound over cables at switchgear entry points, power station building entry points and trays shall be provided to prevent damage from fire for at least thirty (30) minutes.

Adequate separating distances will be maintained between different process blocks and hazardous equipment. To prevent fire from spreading through ventilation & air conditioning ducts, dampers with auto closing arrangements will be provided at appropriate locations. FRLS power and control cables will be used.

Fire water pumps are installed in the filtered water pump house. In the filtered water storage tank water will be stored as dedicated dead storage for meeting firewater requirement in exigencies.

In addition to the above facilities, adequate number of manual call points, as well as portable and mobile (wheel mounted) fire extinguishers of soda acid type, foam type, chemical type, and carbon-dioxide type will be provided at suitable locations throughout the plant area to meet NFPA code as well as Tariff Advisory Committee/ Loss prevention Association of India stipulations. These extinguishers may be used during the early stages of fire to prevent from spreading.

1.2.7.1.1 Fire Wing

A full fledged fire station operated by Fire Officer & sufficient staff. The fire control room is manned in 3 shifts round the clock. The minimum strength in each shift available shall be as follows.

1 no - Leading Fire Man
1 no – Driver
3 nos - Fire Man

The fire station will be equipped with the following facilities to handle the fire promptly and actively.

1.2.7.1.2 Hydrant Landing Valves / Yard Hydrant

Fire hydrant mains will be laid covering all major risk areas. The layouts of hydrant mains are kept at all the shift officers. The details of the fire hydrants and sprinkler systems proposed and fire detection systems are given in **Table 1.10 & 1.11**

Table 1.10: Fire hydrant & sprinkler systems

S. No.	System capacity (Lts/sec)	Equipment	Head (mts)	Discharge Lts/Sec
1.	Hydrant	Diesel Engine Driven Pump	92	75
2.	Hydrant	AC Motor driven Pump	92.5	75.8
3.	Hydrant	AC Motor driven Pump	92.5	75.8
4.	Spray/ Sprinkler	AC Motor driven Pump	92.6	113
5.	Spray/ Sprinkler	Diesel driven Pump	92.8	113
6.	Pressurization	AC Motor driven Jockey pump	99	8.3
7.	Pressurization	AC Motor driven Jockey Pump	99	8.3
8.	Pressurization	Air compressor	29.67 m^3/hr	-
9.	Pressurization	HPT TANK	220 m^3/hr	-

Table: 1.11: Fixed Fire Detection and Protection System

S. No.	Type & Nomenclature of fire protection / fire detection system	Data on qty/capacity	Data on premises installed
1.	a) Water sprinkler system and Emulsifier	8 Kgs working pressure	On all Transformers
	b) Water spray system	8 Kgs working pressure	On all conveyor system
2.	Medium Velocity Water spray system	8 Kgs working pressure	On all oil tanks
3.	Smoke Detectors	-	At all control rooms, switch gear rooms, cable galleries etc.,

a) Fixed Foam System

HFO & LDO Tanks would be provided with fixed foam system. The foam station would be situated near Heavy Fuel Oil Tanks where foam concentrate has to be kept in tanks. The mixer of water and foam concentrate goes to the HFO, LDO tanks, thrown on to the top surface of the oil tanks and converts into foam to extinguish the fire.

b) Medium Velocity System

In addition to the foam system, the LDO tank would be provided with Medium Velocity Spray system to cool down the oil vapors which develop due to heating of the oil in case of fire incident.

c) Sprinkler System

All coal conveyors would be provided with the sprinkler system against fire hazard. Quartz old bulb and Fusible plug heat detectors would be provided at the tips of each pipe covered. Under the network of pipe meant for sprinkling system, the bulbs break at 79^0C of heat and through the tips the water automatically spray out on the Conveyor, Transformers and LDO tank areas to arrest the fire.

d) Emulsifier System

The Emulsifier system is proposed on transformer areas GT, UATs, Station Transformers. In the emulsifier system Quartz old bulb fuses at 79 ^{0}C and release air from the line due to pressure drop of air deluge valve opens and water sprinkles through separate nozzles provided on the transformers.

e) Portable Fire Extinguishers:

In addition to above fire fighting equipments, portable and mobile fire extinguishers would be installed at all locations of the plant including Main Plant, control rooms, Switch Gear rooms, Laboratories, Off site Administration building etc. Details are in **Table 1.12**

Table 1.12: Details of Portable Fire Extinguishers

S.No	Type of Extinguishers	Capacity	No. of Extinguishers.	
1	CO_2 Type	22.5 Kgs 9.0 Kgs 6.5 Kgs 3.0 Kgs.	2 10 20 28	Total 60
2	Foam Type	9 lts mech foam	10	Total 10
3	DCP type	75 kgs. 25 kgs. 10 kgs. 5 kg.	5 5 10 20	Total 40

1.2.7.2 First Aid Centre

A First Aid center and dispensary will be provided inside the plant premises and manned round the clock. Ambulance facility would be available round the clock within the plant premises and tie up will be made with nearest hospitals. The minimum medical staff will be as follows.

No. of Doctor	1
No. of Nursing Staff	4
Ambulances (with oxygen administration facility)	1
Lab Technicians	2
Pharmacist	2

1.2.7.3 Communication Facilities

Public address system would be provided in the plant, Telephone and Internal Communication facilities would be available at all required desk or with officials in control room. P & T (STD) telephones, Fax & Carrier Communication facilities would be provided in Chief Engineer/ O&M office and in unit control board to contact nearby industries to ask for assistance. The facility is also used to contact district authorities for information and help. The plant would be connected to corporate office through VSAT (Very Small Aperture Terminals).

1.2.7.4 Emergency Power Supply

Emergency lights would be provided at all vulnerable areas for lighting arrangements as well as to operate minimum equipment for operating the plant safely. Both the units would be provided with DG Sets as well as DC battery Systems which comes on automatically in case of power failure. More than one supply through different transmission systems would also be provided to ensure electric supply without fail.

1.2.7.5 Emergency Safety Equipment

The following emergency safety equipments would be made available in Unit Control Board, Fire Station, Water Treatment Plant, Fuel Oil Pump House, Shift in charge engineer’s office and Safety Office.

- Self contained breathing apparatus.
- Gas masks.
- Chlorine leak arresting kits.
- Emergency suits.
- Gum boots.
- Hand gloves.
- Aprons etc.

1.2.8 Emergency Control Centre (ECC)

The Emergency Control Centre is proposed which would be fully equipped with all communication facilities to contact. Emergency control centre will be centrally located and will see that it is nearer to Unit Control Board, Switch Yard Control Room & Chemical wing to give instructions to the Officers.

The Emergency Control room will be manned by the Chief Incident Controller, the Officials nominated as key personnel and Sr. Officers of outside services called in for assistance. No other personnel shall have access to the Control Centre.

ECC will also contain the following data:

a) Safety data pertaining to all hazardous materials likely to cause emergency.
b) Procedure of major and special fire fighting, rescue operations, first aid etc.,
c) Procedures for tackling Chlorine gas and other chemical leakages.
d) Emergency call out list of persons drafted for emergency control, key personnel, Fire, Safety, First aid, Medical, Personnel, Welfare & Industrial Relations, Security, Police and District Administration Authorities.

1.2.8.1 Evacuation & Assembly Points

In an emergency, it would certainly be necessary to evacuate personnel from affected areas and as per precautionary measure to further evacuate non-essential workers, in the first instance from areas likely to be affected where the emergency escalate. The evacuation will be effected on getting necessary instructions from Superintending Engineer / O&M/. On evacuation, employees shall assemble at assembly points.

The following areas are identified as assembly points and employees shall assemble at the assembly points depending on the area of emergency.

1. Switch yard control room (MCR)
2. Main plant security gate.
3. Service building.

1.2.8.2 Emergency Alarms

The Emergency siren will be sounded by the Security Personnel with the instructions of Divisional Engineer/Shift Engineer from the Security control room and it is proposed to install the sirens at the following places.

1) Fire Station Control Room
2) Housing Colony Security Gate

The above locations are manned round the clock. The emergency alarm shall consist of represent long short blast for continuous period of 2 minutes. The purpose is to advise all persons on the major emergency occurred in the plant. The alarm is sounded such that the nature of emergency can be distinguished as a Chlorine release or a major fire.

1.2.8.2.1 Emergency Siren

1.	In case of Fire	-	5 Seconds ON 2 Seconds OFF 3 Times.
2.	Emergency Siren for Heavy Chlorine leak		20 Seconds ON 10 Seconds OFF 5 Times
3.	All clear Signal	-	continuous siren for 3 minutes

1.2.8.3 Action Plan

For effective control and management of an Emergency, an action plan and organization chart is prepared along with responsibilities.

The Action Plan Consists of

1. First Information from the site.
2. Responsibility of Superintending Engineer / O&M concerned.
3. Responsibility of Divisional Engineer / O&M.
4. Responsibility of declaration of Emergency.
5. Responsibility of Emergency communication officer.
6. Responsibility of Key personnel.
7. Responsibility and action to be taken by essential staff and various teams.
8. Responsibility for all clear signal.

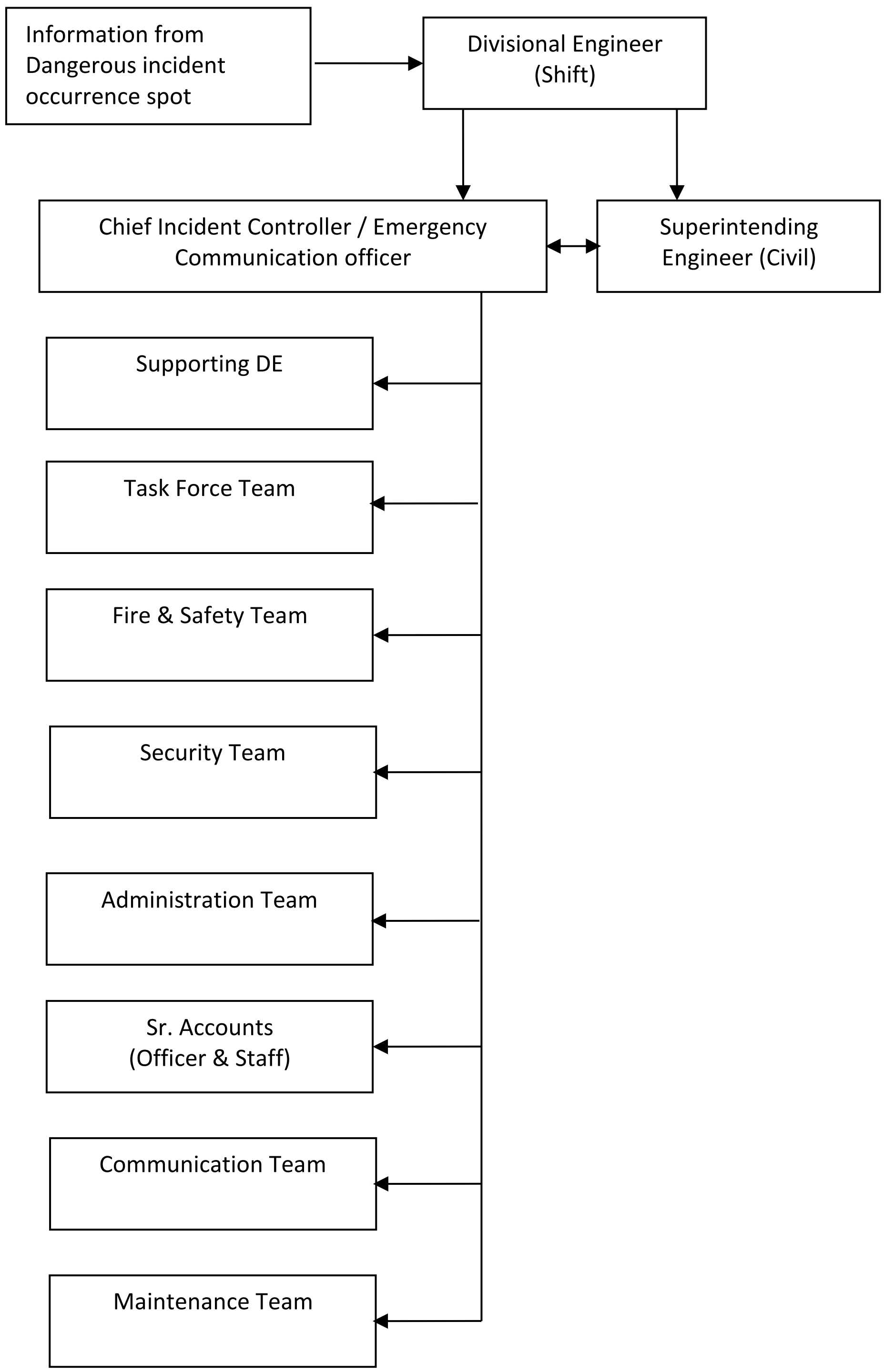


Figure: 1.4: Emergency Management Organization Chart

1.2.8.3.1 First Information from the Site

The first person who observes / identifies the hazardous incident shall inform by announcing through public addressing system and by telephoning to the Shift Divisional Engineer in Unit Control Board about the hazard. The observer shall also telephones to Fire station in case of Fire hazard. The Divisional Engineer / Shift will inform to concerned Superintending Engineer (According to the area of hazard) and also to the Chief Engineer / O&M and Asst. Divisional

Engineer / Peshi to Chief Engineer / O&M and communicate it to all key personnel about the incident.

1.2.8.3.2 Responsibilities of Superintending Engineer

The Superintending Engineer on knowing about hazardous incident, immediately will rush to the incident site and take overall charge and inform the same to Chief Engineer / O&M. On arrival, he will assess the extent of emergency and decide if major emergency exists and inform the Emergency Communication Office accordingly. His responsibilities will be:

1. To direct all operations within the affected area taking into consideration priorities for safety of personnel, minimum damage to the plant, property, environment and minimum loss of materials.
2. To provide advice and information to the Fire & Security Officers and the local Fire Services.
3. To ensure that all non-essential workers/staff on the areas affected are evacuated to the appropriate assembly points and the areas are searched for casualties.
4. To set up communication points and establish contact with Emergency Control Centre in the event of failure of electric supply and thereby Public Address System (PAS) and internal telephones failure.
5. To report on all significant developments to the Chief Engineer / O&M.
6. To have regard to the need to preserve the evidence so as to facilitate any enquiry into the cause and circumstances, which caused or escalated the emergency.

1.2.8.3.3 Responsibilities of The Chief Incident Controller (Chief Engineer / O & M)

The Chief Engineer / O&M, who is also the Chief Incident Controller, will assume overall responsibilities for the Factory and its personnel in case of any emergency. His responsibilities are:

1) To assess the magnitude of the emergency situation and decide if staff needs to be evacuated from their assembly points to identified safer places.
2) To undertake continuous review of possible developments and assess in consultation with key personnel as to whether shutdown of the plant or any section of the plant and evacuation of personnel are required.
3) To Co-Ordinate with senior officials of Police, Fire brigade, Medical, Factories Inspectorate and provide advice on possible effects on areas outside the factory premises.
4) To look after rehabilitation of affected persons and discontinuation of emergency.
5) To issue authorized statements to news media, and ensure that evidence is preserved
6) For enquiries to be conducted by the Statutory Authorities.

1.2.8.3.4 Responsibilities for Declaration of Major Emergency

The Superintending Engineer on hearing the hazardous incident shall go to the scene of the incident make an informal assessment of the situation and decide whether a major emergency exists or is likely develop. On his decision he will inform the Chief Engineer / O&M and activate the major emergency procedure Superintending Engineer /O&M who has knowledge and experience to recognize the fact of major emergency potential for it, in consultation with Chief Engineer /O&M, declare a Major Emergency.

Once the Emergency alarm is raised the Emergency Procedures will be activated.

Making the Emergency Known inside the Plant

The major emergency will be made known to everyone inside the plant by resounding the alarm. Separate alarms are sounded to warn different types of major emergencies such as Fire and Explosion or Toxic gas escape same alarm can be used with different number of times as given and Public Address System will also be available throughout the Plant.

A) Sample Emergency Message:

On getting the message that emergency has been declared, Chief Engineer / O&M/ Superintending Engineer / O&M will rush to the affected / likely to be affected areas and announce through fixed / mobile P.A. system the following message.

"Heavy Chlorine Leak Has Taken Place in Power Project and as a result of which Chlorine content in the atmosphere may become high"

B) "Step To Control The Situation Is In Progress".

In the mean time you are advised to:

1) Not to get panic.
2) Keep the doors and windows tightly closed.
3) Don't try to come out from closed doors if you find irritating smell.
4) If found necessary we may evacuate you to the nearest evacuation centre be prepared it.

Announcement would be made by the concerned official in Local Language and English. Similarly announcement termination of the emergency also would be made.

1.2.8.3.5 Responsibilities of Emergency Communication Officer

On hearing the emergency alarm he will proceed to emergency control centre. He will:-

a) Report to Chief Engineer / O&M and Superintending Engineer /O&M and maintain contact with them.

b) On the information received from the Superintending Engineer/ O&M of the situation recommending evacuation, if necessary, evacuate the staff from assembly points.
c) Identify suitable staffs to act as runners or a messenger, who is listed in the Essential Staff, between him and the Superintending Engineer /O&M if the telephone and other system of communication fail due to any reason.
d) Maintain inventory of items in the Emergency Control Centre.
e) Contact local meteorological office to receive early notification of changes in weather condition in case of gas leak and prolonged action.
f) Maintain a log of incidents.
g) Keep in constant touch with happenings at the emergency site and with Superintending Engineer /O&M.
h) Liaise with neighborhood fire brigades, hospitals, civil and Police authorities on advice from Chief Engineer /O&M.

1.2.8.3.6 Key Personnel

a) All divisional heads.
b) Superintending Engineer /O&M.
c) Chief Medical Officer.
d) Head of Safety
e) Security Officer.
f) Fire Officer.
g) Essential Staff.

A list of key personnel and their phone numbers shall be informed to all concerned suitably. If necessary, they will decide the actions needed to shut down plant, evacuate personnel, carryout emergency engineering works, arrange for supplies of equipment, personnel etc., carryout atmosphere test, provide catering facilities, liaison with local bodies, state government authorities, inform relatives of the victims, media etc.,

1.2.8.3.7 Responsibilities of Key Personnel

A) Departmental Heads
The departmental heads will provide assistance as required by Chief Incident Controller. They will decide which member of their departments is required at the incident site.

B) Superintending Engineer / O&M
He will:

a) Report to Chief Engineer/O&M.
b) Ensure that all non-essential workers in the affected areas are evacuated to assembly points in consultation with the Chief Engineer/O&M.

c) Receive reports from nominated persons from assembly points and pass on the information.
d) Keep liaison with other co-coordinators to meet the requirements of services such as materials, security management, transportation, medical, canteen facilities etc., as required during emergency.
e) Be in constant touch with Chief Engineer /O&M and feed him correct information of the situation.
f) Give information to press, public and authorities concerned on instruction from Chief Engineer /O&M.
g) Ensure that causalities received adequate attention at medical centre and arrange required additional help and inform relatives of the injured.
h) Arrange to inform public on Radio and TV about evacuation etc.,
i) Arrange TV coverage on handling emergency.

C) Chief Medical Officer

Chief Medical Officer will render medical treatment to the injured and if necessary will shift the injured to nearby Hospitals. He will mobilize extra medical help from outside if necessary. He will keep a list of qualified first aid workers.

D) Head of Safety

On hearing the emergency alarm, he will proceed to the site. He will:-

a) Make sure that all safety equipments are made available to the emergency teams.
b) Participate in rescue operations.
c) Co-ordinate to transfer the injured persons to medical centre and arrange for first aid.
d) Keep in contact with the Chief Engineer /O&M and the Superintending Engineer/O&M and advise them on the condition of injured persons.

E) Security Officer

On hearing the Emergency alarm, he will proceed to main entrance / main gate.
He will:

- Arrange to control the traffic at the gate and the incident area.
- Direct the security staff to the incident site to take part in the emergency Operations under his guidance and supervision.
- Evacuate the people in the plant or in the nearby areas as advised by Superintending Engineer / O&M after arranging the transport through Transport-In-charge.
- Allow only those people who are associated with handling emergency.
- Maintain law and order in the areas; if necessary seek the help of Police.
- Maintain communication with Chief Engineer/O&M & Superintending Engineer/O&M.

F) Fire Officer

On hearing the emergency, he will reach the fire station and arrange to sound the alarm as per the type of emergency in consultation with Superintending Engineer/O&M. He will:

a) Guide the fire fighting crew i.e., firemen and trained plant personnel and shift the fire fighting facilities to the emergency site. Adequate facilities will be made available.
b) Take guidance of the Superintending Engineer/O&M for fighting as well assessing the requirement of lighting and providing temporary by pass of the work.
c) Maintain communication with Superintending Engineer/O&M & Chief Engineer/O&M.

G) Essential Staff

1 Attendants.
2 First Aiders.
3 Personnel for emergency engineering work such as for providing extra lighting or replacement of lighting, providing temporary by pass of the work.
4 Personnel for transporting equipment to the incident site from other parts of the works.
5 Personnel for moving tankers or vessels from area of risk
6 Personnel for acting as runners in case of communication difficulties
7 Personnel for manning plant entrance, in liaison with the police to Direct emergency vehicles entering the plant, to control traffic leaving the plant and to turn away or make alternate arrangement for visitors and other traffic arriving at the gate.

It is the responsibility of the Superintending Engineer O&M to identify the above essential staff and form a Task Force which report at defined plant control centers so that they can be readily contacted. It is the responsibility of the Superintending Engineer/O&M to remove all non-essential staff to assembly points.

1.2.8.3.8 Responsibilities of Teams

A. Task Force

- To identify source of hazard and try to neutralize / contain it.
- To isolate remaining plant and keep that in safe condition.
- To organize safe shut down of plant, if necessary.
- To organize all support services like operation of fire pumps, sprinkler systems etc.

B. Maintenance Team

- Attend to all emergency maintenance jobs on top priority.

- To take steps to contain or reduce the level of hazard created due to disaster.

- To organize additional facilities as desired.

C. Fire Fighting Team

In case fire erupts and emergency is due to fire the Fire Fighting team is responsible for.

- To rush to fire spot and extinguish the fire.
- To seek help from outside fire fighting agencies through knowledge of plant officials.
- To evacuate persons affected due to whatever reasons.

D. Communication Team

- To maintain the Communication network in working condition.
- To attend urgent repairs in the communication system, if required.
- To arrange messengers for conveying urgent messages when needed so.
- To help plant authorities to communicate with external or internal authorities /officials.

E. Security Team

- To man all gates.
- To bar entry of unauthorized persons.
- To permit, with minimum delay, the entry of authorized personnel and outside agencies, vehicles etc., who have come to help
- To allow the ambulance / evacuation vehicles etc., to go through the gates with security escort.

F. Administration Team

- To rescue the casualties on priority basis.
- To transport casualties to first aid post, safe places, or medical centers.
- To account the personnel.
- To pass information to the kith and kin of fatal or seriously injured persons.

G. Safety Team

- To arrange required safety equipment.
- To measure gas concentrations, in case of gas leakage at various places.
- To guide authorities on all safety related issues.
- To record accident details.
- To collect and preserve evidences in connection with accident inquiry.
- To report the accident to statutory authorities and Chief Engineer/O&M

H. Medical Team

- To arrange first aid materials / stretchers immediately and reach the site of incident.
- To arrange for immediate medical attention.
- To arrange for sending the casualties to various hospitals and nursing homes etc.,
- To ask specific medical assistance from outside including specialists in consultation with Chief Engineer / O&M and Superintending Engineer /O&M.

1.2.8.3.9 Support Teams

In addition to the teams already mentioned, there will be two additional teams known as support teams.

A. Support team to Chief Engineer / O&M

This team assists Chief Engineer / O&M during the emergency to execute his functioning in consultation with him. The members of the team and their responsibilities are given below.

a) **Head of Personnel** (Divisional Engineer /Admn.)
   - Contacting statutory authorities.
   - Arranging for relievers and catering facilities.
   - Giving information to News Media.
   - Arranging shelters for affected persons.
   - Contacting medical centers and nursing homes.
   - Providing all over support, as necessary.

b) **Head of Materials** (Divisional Engineer/Stores)
   - Arranging for urgently required materials through cash purchase or whatever means.

c) **Head of Finance** (Sr. Accounts Officer)
   - Arranging funds for various relief measures as well as emergency purchase of materials and sending his representative for emergency purchases.

B. Supporting Team to Superintending Engineer / O&M.

The support team to Superintending Engineer/O&M will consists of

- Asst. Divisional Engineer/Technical.
- Divisional Engineer/General.
- Divisional Engineer /Electrical, Maintenance.

The team may call any more persons depending upon the need.

The team will assist the Superintending Engineer/O&M in manning communication and passing instruction the team.

One Asst. Engineer / Technical shall always be available with Superintending Engineer/O&M for recording all information coming in and instructions going out.

1.2.8.3.10 Responsibility for All Clear Signal

After cessation of emergency, Superintending Engineer/O&M will communicate to Chief Engineer/ O&M about it. After verification of Status, Chief Engineer /O&M will communicate to announce the "All clear" by instructions to sound the "All Clear Signal".

1.2.9 Off-Site Emergency Plan

The task of preparing the Off-Site Emergency Plan lies with the district collector; however the off-site plan will be prepared with the help of the local district authorities. The proposed plan will be based on the following guidelines. Off-site emergency plan follows the on-site emergency plan. When the consequences of an emergency situation go beyond the plant boundaries, it becomes an off- site emergency. Off-site emergency is essentially the responsibility of the public administration. However, the factory management will provide the public administration with the technical information relating to the nature, quantum and probable consequences on the neighboring population.

The off-site plan in detail will be based on those events which are most likely to occur, but other less likely events which have severe consequence will also be considered. Incidents which have very severe consequences yet have a small probability of occurrence will also be considered during the preparation of the plan. However, the key feature of a good off- site emergency plan is flexibility in its application to emergencies other than those specifically included in the formation of the plan.

The roles of the various parties who will be involved in the implementation of an off- site plan are described below. Depending on local arrangements, the responsibility for the off- site plan will be either rest with the works management or, with the local authority. Either way, the plan will identify an emergency co-ordinating officer, who would take the overall command of the off-site activities. As with the on-site plan, an emergency control center will be setup within which the emergency co-ordinating office can operate. An early decision will be required in many cases on the advice to be given to people living "within range" of the accident - in particular whether they should be evacuated or told to go indoors. In the latter case, the decision can regularly be reviewed in the event of an escalation of the incident. Consideration of evacuation may include the following factors.

- In the case of a major fire but without explosion risk (e.g an oil storage tank), only houses close to the fire are likely to need evacuation, although a severe smoke hazard may require this to be reviewed periodically;
- If a fire is escalating and in turn threatening a store of hazardous material, it might be necessary to evacuate people nearby, but only if there is time; if insufficient time exists, people should be advised to stay indoors and shield themselves from the fire.

1.2.9.1 Aspects Proposed to be considered in the Off-Site Emergency Plan

The main aspects, which will be included in the emergency plan, are:

Organization

Details of command structure, warning systems, implementation procedures, emergency control centers.

Names and appointments of incident controller, site main controller, their deputies and other key personnel.

Communications

Identification of personnel involved, communication center, call signs, network, lists of telephone numbers.

Specialized Knowledge

Details of specialist bodies, firms and people upon whom it may be necessary to call i.e. those with specialized chemical knowledge, laboratories.

Voluntary Organizations

Details of organizers, telephone numbers, resources etc

Chemical Information

Details of the hazardous substances stored or procedure on each site and a summary of the risk associated with them.

Meteorological Information

Arrangements for obtaining details of whether conditions prevailing at the time and weather forecasts.

Humanitarian Arrangements

Transport, evacuation centers, emergency feeding treatment of injured, first aid, ambulances, temporary mortuaries.

Public Information

Arrangements for dealing with the media press office; informing relatives, etc.

Assessment

Arrangements for: (a) collecting information on the causes of the emergency; (b) reviewing the efficiency and effectiveness of all aspects of the emergency plan.

1.2.9.2 Role of the Emergency Co-ordinating Officer

The various emergency services will be co-ordinated by an Emergency Coordinating Officer (ECO), who will be designated by the District Collector. The ECO will liase closely with the site main controller. Again depending on local arrangements, for very severe incidents with major or prolonged off-site consequences, the external control will be passed to a senior local authority administrator or even an administrator appointed by the central or state government.

1.2.9.3 Role of the Local Authority

The duty to prepare the off-site plan lies with the local authorities. The Emergency Planning Officer (EPO) appointed will carry out his duty in preparing for a whole range of different emergencies within the local authority area. The EPO will liase with the works, to obtain the information to provide the basis for the plan. This liaison will ensure that the plan is continually kept up-to-date.

It will be the responsibility of the EPO to ensure that all those organizations which will be involved off site in handling the emergency, know of their role and are able to accept it by having for example, sufficient staff and appropriate equipment to cover their particular responsibilities. Rehearsals for off-site plans will be organized by the EPO.

1.2.9.4 Role of Police

Formal duties of the police during an emergency include protecting life and property and controlling traffic movements. Their functions will include controlling bystanders evacuating the public, identifying the dead and dealing with casualties, and informing relatives of death or injury.

1.2.9.5 Role of Fire Authorities

The control of a fire will be normally the responsibility of the senior fire brigade officer who would take over the handling of the fire from the site incident controller on arrival at the site. The senior fire brigade officer will also have a similar responsibility for other events, such as explosions. Fire authorities in the region will be apprised about the location of all stores of flammable materials, water and foam supply points, and fire-fighting equipment. They will be involved in on-site emergency rehearsals both as participants and on occasions, as observes of exercises involving only site personnel.

1.2.9.6 Role of Health Authorities

Health authorities, including doctors, surgeons, hospitals, ambulances, and so on, will have a vital part to play following a major accident, and they will form an integral part of the emergency plan. For major fires, injuries will be the result of the effects of thermal radiation to a varying degree, and the knowledge and experience to handle this in all but extreme cases may be generally available in most hospitals. Major off-site incidents are likely to require medical equipment and facilities additional to those available locally, and a medical "mutual aid "scheme should exist to enable the assistance of neighboring authorities to be obtained in the event of an emergency.

1.2.9.7 Role of Government Safety Authority

This will be the factory inspectorate available in the region. Inspectors are likely to want to satisfy themselves that the organization responsible for producing the off-site plan has made adequate arrangements for handling emergencies of all types including major emergencies. They may wish to see well documented producers and evidence of exercise undertaken to test the plan. In the event of an accident, local arrangements regarding the role of the factory inspector will apply. These may vary from keeping a watching brief to a close involvement in advising on operations.

1.2.10 Disaster Management & Emergency Preparedness for Natural disasters

1.2.10.1 Introduction

The Natural disasters include cyclones, floods, earthquakes, volcanic eruptions, famines, drought, landslides etc. Amongst all the ones mentioned floods and earthquakes are the most common in India. India is no exception as it has been traditionally vulnerable to natural disasters on account of its unique geo-climatic conditions.

Natural disasters can neither be predicted nor prevented. The problem before us is how to cope with them, minimizing their impact. Increase in urban population coupled with the construction of man-made structures often poorly built and maintained subject cities to greater levels of risk to life and property in the event of earthquakes and other natural hazards. One of the main objectives is to reduce the risk of loss of human life and property and to reduce costs to the society. We have to recognize that in such cases of natural disasters, we deal with phenomena of enormous magnitude that cannot be controlled by any direct means of human intervention. But what we try to do is to reduce the impact on human beings and property.

Tamil Nadu has witnessed havoc caused by cyclones and storm surge in the coastal regions, earthquakes, monsoon floods, landslides, and recently the Tsunami. Increase in urban population coupled with the construction of man-made structures often poorly built and maintained subject cities to greater levels of risk to life and property in the event of earthquakes and other natural hazards.

Tamil Nadu covers an area of 130, 0582 kms and has a coastline of about 1,076 kms which is about 15% of the coastline of India. More than 40% of the fisher population lives within 1km of coast and 50% of them live within 2 km of the coast. The geographical setting of Tamil Nadu makes the state vulnerable to natural disasters such as cyclones, floods and earthquake-induced tsunami. About 8% of the state is affected by five to six cyclones every year, of which two to three are severe. Cyclonic activities on the east coast are more severe than on the west coast, and occur mainly between April-May and October-November.

1.2.10.2 Floods & Cyclones

Floods are high stream flow that overflows the natural banks of the rivers and most of the times become calamitous. The main causes of floods are excessive rains in river catchments, poor natural drainage, Change of river course, Landslide restricting river flow, cyclone and very intense rainfall.

From the flood hazard map of India (shown as **Figure 1.5**), it is seen that no area in Tamil Nadu falls in the risk zone.

But within a local body area, particularly with reference to an area's proximity to a major drainage system like rivers, canals, and also water bodies like lakes, and further with reference to contour levels/low-lying areas, flood prone area mapping has to be done.

Figure 1.5: Flood Hazard Map of India

Tamil Nadu is also subjected to annual flooding, including flash floods, cloudburst floods, monsoon floods of single and multiple events, cyclonic floods, and those due to dam bursts or failure. Every year, on average thousands of people are affected, a few hundred lives are lost, thousands are rendered homeless and several hectares of crops are damaged. The cause of flood is mainly the peculiarities of rainfall in North east monsoon period in the state. Out of the total annual rainfall in the state, 90% is concentrated over short monsoon season of three months. As a result, heavy discharges from the rivers during this period causing widespread floods in the delta regions. Floods occur mainly in the coastal districts basin that carries 100% of the state total river flows.

Cyclones

Cyclone refers to a whirl in the atmosphere with very strong winds circulating around it in anti-clockwise direction in the Northern Hemisphere and clockwise in the Southern

Hemisphere. Cyclones are intense low pressure areas with pressure increasing outwards. Cyclones can be hazardous as Cyclones are normally associated with strong winds. A storm surge is an abnormal rise of sea level near the coast caused by a severe tropical cyclone; as a result, sea water inundates low lying areas of coastal regions drowning human beings and lives-stock, eroding beaches and embankments, destroying vegetation and reducing soil fertility. Apart from strong winds, cyclones can result in heavy rains causing floods. However, the most destructive factor associated with the cyclones is the storm surge.

For cyclone forecast and advance warning, the Government has strengthened the Meteorological Department, by providing Cyclone Surveillance Radars at Calcutta, Paradeep, Visakhapatnam, Machilipatnam, Madras and Karaikal in the east coast and at Cochin, Goa, Bombay and Bhuj in the west coast. Bay of Bengal is one of the five cyclone prone areas of the world. The coastal regions surrounding this bay are frequently affected by flooding from the sea as well as from the rivers due to tropical cyclones and related storm surges and heavy rainfall. In Tamil Nadu during the years 1990 to 1995, and 2006 the damages caused to property were worth 5800 million rupees and the loss of human lives were more than 500.

Tamil Nadu lies in the southern part of Indian peninsula and has a long east coast. The east coast is more vulnerable to cyclones and floods. Tamil Nadu has a very long coastline of about 1076 km with 591 coastal villages, which is exposed to tropical cyclone arising in the Bay of Bengal and has seasonal character to Tamil Nadu. The coast line starts from Pulicat along the east coast and extends up to Erayamanthurai in Kanniyakumari District and consists of Estuaries of ecological importance, Major and Minor ports, Fishing harbours, Monuments of international heritage, Tourist locations, Pilgrimage centers, etc.

Disaster management should aim at reducing the impact of the three main characteristics and effects of a cyclone, which are- High speed winds, Storm Surge and Floods caused by Heavy and wide-spread rainfall. The focus therefore has to be on the following: -

a. Understanding the mechanism of formation, development, structure and movement of cyclones,
b. The capability of detecting cyclones while out at sea,
c. The capability to predict their movement and behaviour,
d. Capacity to warn vulnerable people in time,
e. Measures for cyclone preparedness both in advance and during a cyclone,
f. Relief and rehabilitation after the cyclone.
g. An integrated hazard mitigation policy dove-tailed into the development plan.

The first four are essentially based on meteorology and the rest are in the field of planning, organising, and implementation. For the sake of clarity a separate chapter on tropical cyclones is included to cover the aspects from (a) to (d) above. It will be found that most measures (e) and (f) above have been included in the state contingency plan for cyclones. The aspects covering (g) are now formulated by Disaster Management Unit (DMU) under the Revenue Department.

1.2.10.3 Earth Quake-Prone Areas:

Earthquakes are powerful manifestations of sudden releases of strain energy accumulated within the crust and propagated as seismic waves. The need to understand and study the phenomenon of earthquake is for a simple reason, that it is the most disastrous natural calamity for mankind. The first Seismological observatory in India was established in the year 1898 in the city of Calcutta. Over the years the department has been exponentially expanded by the Meteorological Department of India.

Figure 1.6: Seismic Zone Map of India

Tamil Nadu is not as seismically active as states in the northern and western parts of the country, small to moderate earthquakes have occurred in the state of Tamil Nadu. The frequency of earthquakes is low i.e. the gap between moderate sized events is fairly long (**Figure 1.6**). The seismic hazard map of India was updated in 2000 by the Bureau of Indian Standards (BIS). According to the new map more areas of Tamil Nadu are susceptible to damage from earthquakes than previously thought (**Figure 1.7**).

The city of Chennai, formerly in Zone II now lies in Zone III. Districts in the western part of the state, that lie along the border with Kerala also lie in Zone III, along with districts along the border of Andhra Pradesh and a section of the border with Karnataka. The maximum intensity expected in these areas would be around MSK VII. The rest of the state lies in Zone II.

Figure 1.7: Seismic Zone Map of Tamil nadu

Since the earthquake database in India is still incomplete, especially with regards to earthquakes prior to the historical period (before 1800 A.D.), these zones offer a rough guide of the earthquake hazard in any particular region and need to be regularly updated.
According to GSHAP (Global Seismic Hazard Assessment Program) data, the state of Tamil Nadu falls mostly in a region of low seismic hazard with the exception of western border areas

that lie in a low to moderate hazard zone. Puducherry lies in a low hazard region. As per the 2002 Bureau of Indian Standards (BIS) map, Tamil Nadu and Puducherry fall in Zones II and III. Historically, parts of this region have experienced seismic activity in the M5.0 range. Tamil Nadu is also prone to very severe damaging earthquakes. Its people feel much more vulnerable to earthquake-induced tsunamis since the 2004 Indian Ocean tsunami, which affected the coast of Tamil Nadu destroying much of the marine biology and severely damaging the ecosystem.

Largest Instrumented Earthquake occurred in Tamil Nadu and Puducherry on 26th September 2001(11.984 N, 80.225 E, D=010.0 kms, OT=14:56:55 UTC). A moderate earthquake occurred in the Bay of Bengal, off the coast of the union territory of Puducherry, on 25 September 2001 at 20:26 PM local time resulting in three deaths and minor damage to property in Puducherry and coastal Tamil Nadu. It had a magnitude of Mw=5.5.

Earthquake disaster mitigation program consists of three components which are Preparedness, Rescue and Rehabilitation as described below. Earthquake mitigation program and preventive action program in India are outlined.

a. Preparedness:

The preparedness phase involves the following aspects:

I. Hazard zoning.
II. Earthquake prediction and warning.
III. Implementation of earthquake engineering codes.
IV. Strengthening of existing structures.
V. Education & training.
VI. Seismic instrumentation-new & upgradation.
VII. Insurance.
VIII. Emergency preparedness

Preparation of contingency plan and creation of administrative structure for effective and coordinated action during the emergency. This would include arrangements of digging & clearing equipment (bulldozers, cranes, chain saw, drills & crowbars etc.) for rescue of people trapped in collapsed houses, materials for shelters, emergency bridges, fire wood, medical facilities including mobile hospitals & medicines, immunisation, water tankers & water purifiers.

IX. Training for handling damaged buildings.

b. Rescue:

Rescue at the time of emergency involves the following operations:

I. Maintenance of law and order; prevention of trespassing, looting, Keeping roads clear from sight seeing persons so that free movement of rescue vehicles is assured, etc.
II. Evacuation of people.
III. Recovery of dead bodies and their disposal.

IV. Medical care for the injured.
V. Supply of food and water and restoration of water supply lines.
VI. Temporary shelters like tents, metal sheds.
VII. Restoring lines of communications & information.
VIII. Restoring transport routes
IX. Quick assessment of damage and demarcation of damaged areas according to grade
of damage.
X. Cordoning off of severely damaged structures that are liable to collapse during after shocks.
XI. Temporary shoring of certain precariously standing buildings to avoid collapse and
damage to other adjoining buildings.

c. Rehabilitation

After the emergency, rehabilitation involves the following aspects:

I. Repair, restoration, strengthening or demolition of damaged buildings.
II. Selection of sites for new settlements, if necessary.
III. Adoption of strategies for new constructions like construction through contractors or
by self-help; construction of core houses only or supply of construction material only.
IV. Execution of the construction program.
V. Preview/review of seismic codes & construction norms.
VI. Training of personnel, engineers, builders and artisans.
VII. Rehabilitation of destitute persons, orphans, widows, the aged and the handicapped.

1.2.11 Responsibility for All Clear Signal

After cessation of emergency, Superintending Engineer/ O&M will communicate to Chief Engineer/ O&M about it. After verification of Status, Chief Engineer/ O&M will communicate to announce the "All clear" by instructions to sound the "All Clear Signal".

1.2.12 Evaluation & Functioning of Disaster Plan

1.2.12.1 Full Mock Drill Monitoring Committee

The mock drills will be conducted at regular intervals; the full mock drill monitoring committee consists of the following committee members.

CE/O&M	-	Chairman of the committee
SE/O&M	-	Vice Chairman
SE/CHP	-	(Alternate to Chairman in his absence)
Fire Officer	-	Organizer
DE/E&P	-	Member

Medical Officer	-	Member
Welfare Officer	-	Member
Security Officer	-	Member
DE/TMD/	-	Member
Safety Officer	-	Member

The committee may invite any other official/expert, if considered necessary.

The committee shall supervise the following activities:

- Functioning of emergency Control centre, specifically availability of all facilities as mentioned in the plan and its functional healthiness.

- To evaluate communication of the Disaster Management Plan to all segments of employee's to familiarize them about their responsibilities in case of any disaster including evaluation of behavior of employees and others.

- To ensure that all facilities as required under the plan from within the plant or from nearby industries/aid centers under mutual assistance scheme or otherwise are available.

- To ensure that the necessities under material assistance scheme is properly documented and the concerned employees are fully aware of this.
- To ensure that employees are fully aware of the steps to fight any emergency like sealing of chlorine leakage, fire fighting or other such causes.
- All employees are trained about their responsibilities /duties. They are all aware of evacuation routes, direction of evacuation and the equipment to be used during evacuation or the method of evacuation.
- All employees are fully trained to rescue their colleagues who are affected due to cause of disaster. In case they are unable to rescue their colleagues, they should know to whom they are to inform about such persons.
- All employees will be fully trained in first aid, use of desired equipment including breathing apparatus, first aid box etc., and will be available at the desired location.
- All Warning alarms will be functional. Public address system will be in healthy condition.
- All telephone lines / communication systems will be provided in control rooms and there will no removal of the facilities (as prescribed) for the control rooms.
- It is very clear amongst the concerned officers who shall call for assistance under Mutual Aid Scheme or the facilities (as prescribed) from the control room.
- It is very clear amongst the concerned officers who shall call for assistance under Mutual Aid scheme or the facilities from within.
- It is clear at the plant who shall declare emergency.

- It is clear at the Plant, who shall inform the District Authorities, State Authorities and Corporate Centre.

1.2.12.2 Steps of Mock Drills

The Mock Drills should be carried out step by step as stated below.

First Step	:	Test the effectiveness of communication system.
Second Step	:	Test the speed of mobilization of the plant emergency teams.
Third Step	:	Test the effectiveness of search, rescue and treatment of Casualties.
Fourth Step	:	Test Emergency isolation and shut down and remedial measures taken on the system.
Fifth Step	:	Conduct a full rehearsal of the actions to be taken during an emergency.

The Disaster Management Plan should be periodically revised based on experience gained from the Mock Drill.