# Risk Assessment Studies

## 7.1 Introduction

Hazard analysis involves identification and quantification of the various hazards (unsafe conditions) that exist in the plant. On the other hand, risk analysis deals with the identification and quantification of risks, the plant equipment and personnel exposed to accidents resulting from the hazards present in the plant.

Hazard and risk analysis involves very extensive studies and require a detailed design and engineering information. Assessment of risks on the neighboring population exposed as a result of hazards is analyzed. This requires a thorough knowledge of failure probability, credible accident scenario, vulnerability of population etc. Much of this information is difficult to generate. Consequently, the risk analysis is often confined to maximum credible accident studies.

Hazards are inherent to all industrial operations since they involve handling of hazardous materials (flammable, explosive, corrosive and toxic materials). The four major steps in risk assessment are hazard identification, dose response assessment, exposure assessment and risk characterization

Risks are inherent in proposed thermal power plant operations since they involve working with:

- High pressure super-heaters, re-heaters, economizer units exchanging heat with the hot flue gases
- Turbines that utilize the high pressure steam to generate power
- Fuel oil
- Hydrogen as a coolant in turbo generators drawn from hydrogen cylinders
- Switchyard including transformers, isolators

Hazard can happen because of the nature of chemicals handled and also the nature of process involved. So for risk analysis first step is to identify the hazardous chemicals which are to be studied for risk analysis. "Major Accident Hazards (MAH) installations" is defined as the isolated storage and industrial activity at a site handling (including transport through carrier or pipeline) of hazardous chemicals equal to or, in excess of the threshold quantities

Dose-response or toxicity assessment is the determination of how different levels of exposure to a hazard or pollutant affect the likelihood or severity of health effects. Responses/effects can vary widely since all chemicals and contaminants vary in their capacity to cause adverse effects. The dose-response relationship can be evaluated for either carcinogenic or no carcinogenic substances.

Exposure assessment is the determination of the magnitude of exposure, frequency of exposure, duration of exposure and routes of exposure by contaminants to human populations and ecosystems. There are three components to this step.

- Identification of contaminants being released;
- Estimation of the amount of contaminants released from all sources or the source of concern; and
- Estimation of the concentration of contaminants.

Risk characterization is the final step in which toxicology and exposure data/information is combined to obtain a qualitative or quantitative expression of risk.

### 7.2 Scope of the study

The risk analysis/assessment study covers the following:

a. Site assessment
b. Identification of potential hazard areas
c. Identification of representative failure cases
d. Visualization of the mode of chemical releases and the resulting accident scenarios
e. Assess the overall damage potential of the identified hazardous events and impact zones from the accident scenarios
f. Furnish specific recommendations on the minimization of the worst accident possibilities;
g. Preparation of DMP, on-site and off-site emergency plans and
h. Preparation of occupational and health safety plan.

### 7.3 Hazardous Identification

Identification of hazards is the primary task for planning for risk assessment in the analysis followed by quantification and cost effective control of accidents involving chemicals and processes. A classical definition of hazard states that it is the characteristic of system/process that presents potential for an accident. Hence, all the components of a system/process needs to be thoroughly examined to assess their potential for initiating or propagating an unplanned event/sequence of events, which can be termed as an accident.

The methods employed for hazard identification in this study are:

- Identification of major hazards based on Manufacture, Storage and Import of Hazardous Chemicals (MSIHC) Amendment Rules, 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)

Estimation of probability of an unexpected event and its consequences form the basis of quantification of risk in terms of damage to property, environment or personnel. Therefore, the type, quantity, location and conditions of release of a toxic or flammable substance have to be identified in order to estimate its damaging effects, the area involved and possible precautionary measures required to be taken. Based on the areas and unit operations involved in generation of power various hazards are identified which are given in **Table 7.1.**

**Table 7.1 Potential risk areas due to proposed thermal power plant**

| S.No | Blocks/Areas | Hazards Identified |
|---|---|---|
| 1 | Coal storage in open yard | Fire, Spontaneous Combustion |
| 2 | Boilers | Fire (mainly near oil burners), steam; explosions, fuel explosions |
| 3 | Coal Handling Plant including Bunker area | Fire and/or Dust Explosions |
| 4 | Power Transformers | Explosion and fire |
| 5 | Switch-yard Control Room | Fire in cable galleries and Switchgear/ Control Room. |
| 6 | Turbo-Generator Buildings | Fires in-<br>Cable galleries<br>Lube Oil Systems<br>Short Circuits in<br>Control Rooms; ii. Switchgears<br>Explosion due to leakage of Hydrogen and fire following it. Fire in Oil Drum Storage |
| 7 | Steam turbine | Hydrogen and lube oil leak leading to fire/smoke |
| 8 | Light Diesel Oil (LDO),<br>Heavy Fuel Oil (HFO) tanks | Fire |
| 9 | Hydrogen Plant<br>Hydrogen & oxygen holders in open<br>Hydrogen & oxygen cylinders in R.C.C building | Explosion and/or fire, physical dangers |
| 10 | Water Treatment of Chlorination plants<br>Pre-treatment plants HCl, NaOH | Release of Chlorine-Toxicity<br>Corrosive |

### 7.3.1 Classification of Major Hazardous Units

Based on Manufacture, Storage and Import of Hazardous Chemicals (MSIHC) Amendment Rules, 2000, hazardous substances may be classified into three main classes; namely flammable substances, unstable substances and toxic substances. The ratings for a large number of chemicals based on flammability, reactivity and toxicity have been given in NFPA codes 49 and 345 M. The major hazardous materials to be stored, transported, handled and utilized within the facility and the fuel storage details and properties are given in the **Table 7.2** and **Table 7.3.**

**Table 7.2 Details of Flammable, Explosive and Hazardous materials**

| S.No | Product | Codes/Label | Type of Storage | Storage Capacity |
|---|---|---|---|---|
| 1 | Coal | Flammable | Open yard | 4.05 MTPA |
| 2 | HFO | Flammable | Tanks | 1 x 2000 kilo litres |
| 3 | LDO | Flammable | Tanks | 2 x 2000 kilo litres |
| 4 | Chlorine | Toxic | Cylinders | 31500 kg<br>(35 cylinders – 900 kg each |
| 5 | Hydrogen | Flammable | Cylinders | 120 cylinders<br>(1 cylinder- 7.1 $m^3$) |

**Table 7.3 Properties of chemicals used in the plant**

| Chemical | TWA ($mg/m^3$) | BP | MP | FP | LEL | UEL |
|---|---|---|---|---|---|---|
| | | ($^0C$) | | | % | |
| LDO | 100 | 175 – 370 | - | 52 | 0.6 | 4.7 |
| HFO | 0.2 | 154 – 372 | - | 60 | 6.5 | 12.3 |
| Hydrogen | - | -252 | -259 | - | 4 | 75 |
| Chlorine | 0.5 | -34 | -101 | - | - | |
| NaOH | 2 | 1388 | 323 | - | - | |
| HCl | - | 50.5 | -25 | - | - | |
| **TLV – Time Weighted Average; BP – Boiling Point; MP – Melting Point; FP – Flash Point LEL – Lower Explosive Limit; UEL – Upper Explosive Limit** | | | | | | |

Based on the history of accidents that occurred in several industries in India over a few decades, a specific legislation has been framed covering major hazard activities by GoI in conjunction with Environment Protection Act (EPA), 1986, referred as the MSIHC Rules 1989, amended in 2000. For the purpose of identifying major hazard installations, the rules employ certain criteria based on toxic, flammable and explosive properties of chemicals. A systematic analysis of the fuels/chemicals and their quantities of storage has been carried out to determine the threshold quantities as notified by MSIHC Amendment rules, 2000 and the applicable rules are identified. Applicability of storage rules are summarized in **Table 7.4.**

**Table 7.4 Applicability of MSIHC Amendment rules to Fuel/Chemical Storage**

| S. No | Chemical/Fuel | Listed in Schedule | Threshold Quantity for Application of Rules (MT) | |
|---|---|---|---|---|
| | | | 5,7-9,13-15 | 10-12 |
| 1 | LDO | 1 (part I) | 5000 | 50000 |
| 2 | HFO | 1 (part I) | 5000 | 50000 |
| 3 | Chlorine | 3 (part I) | 10 | 25 |
| 4 | Hydrogen | 1 (part II) | 2 | 50 |

### 7.3.2 Fire Explosion and Toxicity Index (FE&TI) Approach

The most widely used relative ranking hazard index is Dow's Fire Explosion Index and Mond's Toxicity Index together called as FE&TI. 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.

### 7.3.3 FE&TI Objectives and Methodology

The basic objectives that characterize FE&TI 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 F&EI and hazard classification guide published by Dow Chemical Company are required to estimate F&EI of any plant or storage units.

The MF is obtained from the flammability and instability rankings according to NFPA 704, NFPA 49 and NFPA 325M.

### 7.3.4 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 7.5.**

**Table 7.5 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 |

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 in **Table 7.6**.

**Table 7.6 Categories of substances based on F&EI and TI**

| Category | F&EI | TI |
|---|---|---|
| I | F&EI < 65 | < 6 |
| II | 65 ≤ F&EI < 95 | 6 ≤ TI < 10 |
| III | F&EI ≥ 95 | TI ≥ 10 |

Certain basic minimum preventive and protective measures are required for the three hazard categories. Based on the MSIHC Amendment Rules 2000, the hazardous fuels used by the proposed power plant were identified. Fire and explosion are the likely hazards, which may occur due to the fuel storage. Hence, fire and explosion index has been calculated for in plant storage which are shown in **Table 7.7**.

**Table 7.7 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 | | | | | | |
| LDO | 0 | 2 | 0 | 10 | 1.8 | 2.5 | 48.1 | Light | - | Light |
| HFO | 0 | 2 | 0 | 10 | 1.8 | 2.8 | 50.4 | Light | - | Light |
| Chlorine | 4 | 0 | 0 | 1 | 1 | 2.7 | 2.7 | Light | 17.7 | Severe |

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. 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.

## 7.4 Hazardous Assessment and Evaluation

### 7.4.1 Methodology

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.

### 7.4.2 Preliminary Hazard Analysis (PHA)

PHA is based on the philosophy "Prevention is better than Cure". Safety is relative and implies freedom from danger or injury. But there is always some element of danger or risk associated with anything we do or build. This calls for identification of hazards, quantification of risk and further suggests hazard-mitigating measures, if necessary.

The purpose is to identify at the outset the potential hazards associated with design process, or inherent in a process design, thus eliminating costly and time consuming delays caused by design changes made later. This also eliminates potential hazard points at design stage itself and is more relevant when a plant is at design/construction stage. This analysis fortifies the proposed process design by incorporating additional safety factors into the design criteria.

An assessment of the conceptual design has to be 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 plant, Hydrochloric acid, Sodium Hydroxide and Chlorine will be stored in tanks and cylinders to meet its requirement.

The PH’s associated with the proposed TPP are:

- Toxic release
- Fire hazards
- Electrical hazards
- Cable galleries

The major hazards associated with the plant have to be carried out followed by consequence analysis to quantify these hazards. Finally the vulnerable zones have to be plotted for which risk reducing measures will be deducted and implemented. The PHA for power plants and various process and storage areas are given in **Table 7.8 and Table 7.9** respectively**.** The following scenarios have been considered for PHA:

- Spillage of chemicals while handling
- Leakage of chlorine

**Table 7.8 Primary Hazard Analysis for Power Plants**

| PHA category | Description of plausible Hazard | Recommendations |
|---|---|---|
| Environmental Factors | Spillage of chemicals while handling (HCl, NaOH) | The spillage should be treated as per MSDS of each chemical. A copy of MSDS should be kept in chemical laboratory and stores |
| | Spillage of chemicals or baths into trench | ➢ The source of the spillage should be immediately identified and plugged.<br>➢ The spilled chemical should be washed with copious water and the washed water should be collected in floor wash tank<br>➢ The washed water in floor wash tank should be treated as per waste treatment procedure till it is exhausted. |
| | Chlorine Tank | ➢ An automatic chlorine leak absorption system should be provided for chlorination plant to neutralize chlorine leakage.<br>➢ Chlorination plant shall be provided with required chlorine containers, instrumentation Panels, chlorine leak detectors etc.<br>➢ Use ammonia spray or swab for identifying leakage. (A white cloud indicates Chlorine leakage)<br>➢ For persistent leakage connect a flexible hose pipe and put the pipe in the tank containing Caustic soda<br>➢ Isolate the area until the gas has dispersed |

**Table 7.9 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 factory and electrical inspectorate. |
| Generator | Converts mechanical | Mechanical hazards and fire hazards in | As above |

| Equipment | Process/Storage | Potential Hazard | Provision |
|---|---|---|---|
| | energy into electrical energy | ➢ Lube oil system<br>➢ Cable galleries<br>➢ Short circuits | |
| 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 |
| 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 |
| Chlorine | Used for water treatment in different phases | Accidental Toxic release | Leak detection and neutralization system will be provided |
| 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 |

### 7.4.3 Maximum Credible Accident (MCA) analysis

Hazardous substances may be released as a result of failures or catastrophes, causing possible damage to the surrounding area. This section deals with the question of how the consequences of the release of such substances and the damage to the surrounding area can be determined by means of models. Major hazards posed by flammable storage can be identified taking recourse to MCA analysis. MCA analysis encompasses certain techniques to identify the hazards and calculate the consequent effects in terms of damage distances of heat radiation, toxic releases, vapor cloud explosion etc. A host of probable or potential accidents of the major units in the complex arising due to use, storage and handling of the hazardous materials are examined to establish their credibility. Depending upon the effective hazardous attributes and their impact on the event, the maximum effect on the surrounding environment and the respective damage caused can be assessed. The reason and purpose of consequence analysis are many folds like:

- Part of risk assessment;
- Plant layout/code requirements;
- Protection of other plants;

- Protection of the public;
- Emergency planning; and
- Design criteria.

The results of consequence analysis are useful for getting information about all known and unknown effects that are of importance when some failure scenario occurs in the plant and also to get information as how to deal with the possible catastrophic events. It also gives the workers in the plant and people living in the vicinity of the area, an understanding of their personal situation.

### 7.4.3.1 Damage Criteria

The fuel storage and unloading at the storage facility may lead to fire and explosion hazards. The damage criteria due to an accidental release of any hydrocarbon arise from fire and explosion. The vapors of these fuels are not toxic and hence no effects of toxicity are expected.

**Damage due to fire**

Tank fire would occur if the radiation intensity is high on the peripheral surface of the tank leading to increase in internal tank pressure. Pool fire would occur when fuels collected in the dyke due to leakage gets ignited. A flammable liquid in a pool will burn with a large turbulent diffusion flame. This releases heat based on the heat of combustion and the burning rate of the liquid. A part of the heat is radiated while the rest is through convection by rising hot air and combustion products. The radiations can heat the contents of a nearby storage or process unit to above its ignition temperature and thus result in a spread of fire.

The radiations can also cause severe burns or fatalities of workers or fire fighters located within a certain distance. Hence, it is important to know the damage potential of a flammable liquid pool likely to be created due to leakage or catastrophic failure of a storage or process vessel and help to decide the location of other storage/process vessels, decide the type of protective clothing the workers/fire fighters, the duration of time for which they can be in the zone, the fire extinguishing measures needed and the protection methods needed for the nearby storage/process vessels. The damage effect on equipment and people due to thermal radiation intensity is given in **Table 7.10**. Similarly, the effect of incident radiation intensity and exposure time on lethality is given in **Table 7.11**.

**Table 7.10 Damage due to Incident Radiation Intensities**

| 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.<br>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.<br>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 |

| S.No | Incident Radiation ($kW/m^2$) | Type of Damage Intensity | |
|---|---|---|---|
| | | Damage to Equipment | Damage to people |
| | | | than 20 Sec, however blistering is unlikely (1st degree burns) |
| 5 | 1.6 | ------ | Causes no discomfort on long exposure |
| ***Source:*** *Techniques for Assessing Industrial Hazards by World Bank* | | | |

**Table 7.11 Radiation Exposure and Lethality**

| Radiation Intensity ($KW/m^2$) | Exposure Time (Seconds) | Lethality (%) | Degree of Burns |
|---|---|---|---|
| 1.6 | -- | 0 | No discomfort even after long exposure |
| 4.5 | 20 | 0 | 1st |
| 4.5 | 50 | 0 | 1st |
| 8.0 | 20 | 0 | 1st |
| 8.0 | 50 | < 1 | 3rd |
| 8.0 | 60 | <1 | 3rd |
| 12.0 | 20 | <1 | 2nd |
| 12.0 | 50 | 8 | 3rd |
| 12.5 | Inst. | 10 | -- |
| 25.0 | Inst. | 50 | -- |
| 37.5 | Inst. | 100 | -- |

### 7.4.4 Pool fire of LDO and HFO Storage

Two tanks of LDO having a capacity 2000 kilo liters already existing and tank of HFO with a capacity 2000 kilo liters are considered for the proposed project. As the tanks are provided within the dyke, the fire will be confined within the dyke wall. However, in the second scenario it is assumed that the dense vapors from the storage are released due to failure/ increase in internal pressure of storage tanks/ vapors could meet an ignition source and develops into a fireball and exists as a vapor cloud explosion due to operator's negligence.

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. 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 and radiation intensities at different distances are estimated. For computing the damage distance from the tank failure area, Areal Locations of Hazardous Atmospheres (ALOHA) software is used and the results are given in **Table 7.12.** Threat zones are shown in **Figure 7.1**.

**Table 7.12 Properties of Fuels considered for Modeling and Thermal Radial Distances**

| Parameters | LDO | HFO |
|---|---|---|
| **Input details** | | |
| Tank size | L-30m, Dia-10m | L-30m, Dia-10m |
| Wind speed (m/s) | 1.5 | 1.5 |
| Opening diameter (cm) | 10 | 10 |

| Parameters | LDO | HFO |
|---|---|---|
| **Computational data generated** | | |
| Max flame length (m) | 19 | 20 |
| Max burn rate (kg/min) | 352 | 343 |
| Total amount burned (kg) | 20,873 | 20,390 |
| **Thermal radiation damage distances** | | |
| Red (25kW/m$^2$) | 11 | 10 |
| Orange (12.5kW/m$^2$) | 17 | 17 |
| Yellow (4.5kW/m$^2$) | 32 | 31 |

A perusal of the above table clearly indicates that for 25 kW/m$^2$ thermal radiation, the radius of the pool is computed to be 11 and 10 m respectively for LDO and HFO tanks. Similarly, the threshold limit for first degree burns of 4.5 kW/m$^2$, the damage distances are 32 and 31 m for LDO and HFO storage tanks respectively.

### 7.4.5 Chlorine and Hydrogen Storage

Chlorine is highly toxic (Immediate damage to life and health (IDLH-10 ppm). The critical concentrations of chlorine are given in **Table 7.13**. 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 cooling water pumps. Chlorine cylinders of adequate requirement would be housed in a separate semi-open shed. 900 kg single cylinder is considered for modeling and threat zone shown in **Figure 7.2**.

**Table 7.13 Critical Concentration of Chlorine**

| Criteria | Concentration (ppm) | Distance in m |
|---|---|---|
| $LC_{50}$ | 146.5 ppm/ 4h (rats) | - |
| Immediate damage to life and health (IDLH) | 10 | 129 |
| Short Term Exposure Limit (STEL) | 1 | 442 |
| Timed Weighted Average (TWA) | 0.5 | 638 |

**Source Strength:**

Leak from hole in horizontal cylindrical tank
Non-flammable chemical is escaping from tank
Tank Diameter: 5 meters Tank Length: 14.3 meters
Tank Volume: 281250 liters
Chemical Mass in Tank: 900 kilograms
Circular Opening Diameter: 0.5 centimeters
Max Average Sustained Release Rate: 201 grams/min (averaged over a minute or more)
Total Amount Released: 11.9 kilograms

**Threat Zone**:

Red : 129 meters --- (10 ppm = IDLH)
Orange: 442 meters --- (1 ppm)
Yellow: 638 meters --- (0.5 ppm)

### 7.4.5.1 Hydrogen

Storage of hydrogen pose hazards related to fireball formation and explosion. Release of hydrogen gas from a cylinder through leakage dispersing in the atmosphere along with the prevailing wind is considered as an accident scenario for the study. The gas cloud in the air if ignited when 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.

**Source Strength:**

Leak from hole in horizontal cylindrical tank
Flammable chemical escaping from tank (not burning)
Tank Diameter: 1.4 meters; Tank Length: 5 meters
Chemical Mass in Tank: 136 kilograms; Internal Press: 240 atmospheres
Circular Opening Diameter: 0.5 centimeters
Max Average Sustained Release Rate: 9.46 kilograms/min
Total Amount Released: 133 kilograms

**Threat zone:**

Threat Modeled: blast force from vapor cloud explosion
Type of Ignition: ignited by spark or flame

Model Run: Gaussian
Red : 56 meters --- (8.0 psi = destruction of buildings)
Orange : 71 meters --- (3.5 psi = serious injury likely)
Yellow : 125 meters --- (1.0 psi = shatters glass)

**Figure 7.1 Threat zone for LDO and HFO**

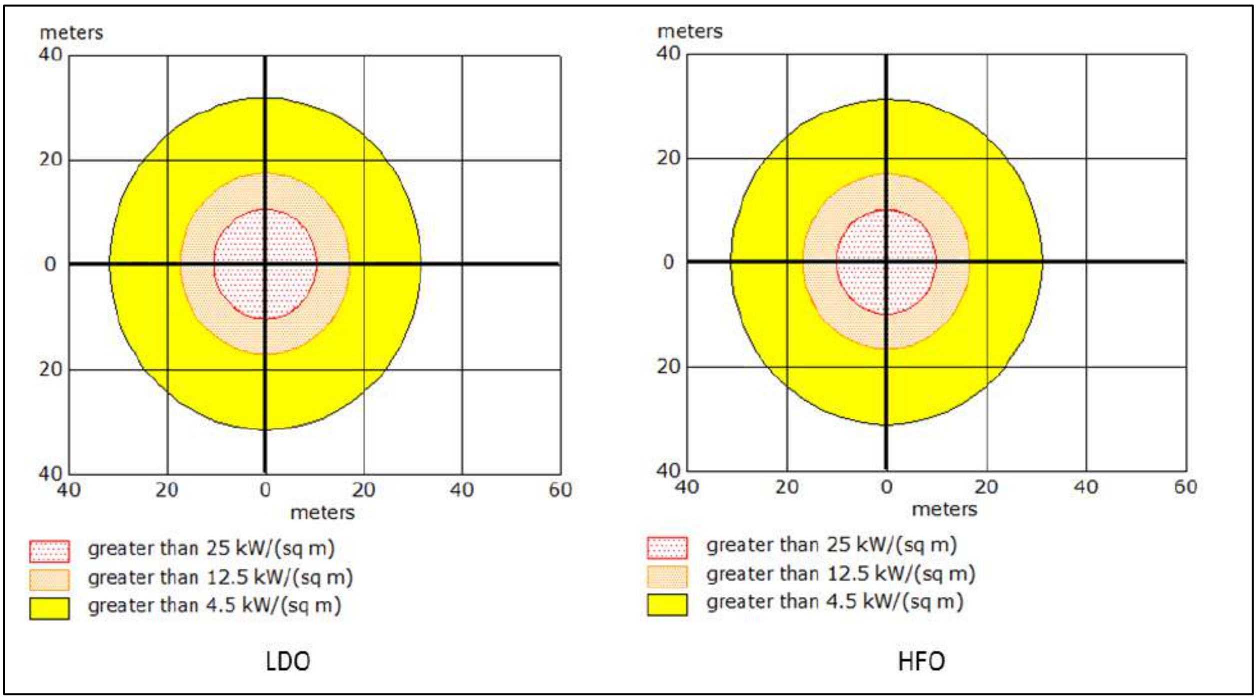



**Figure 7.2 Threat zone for Chlorine**

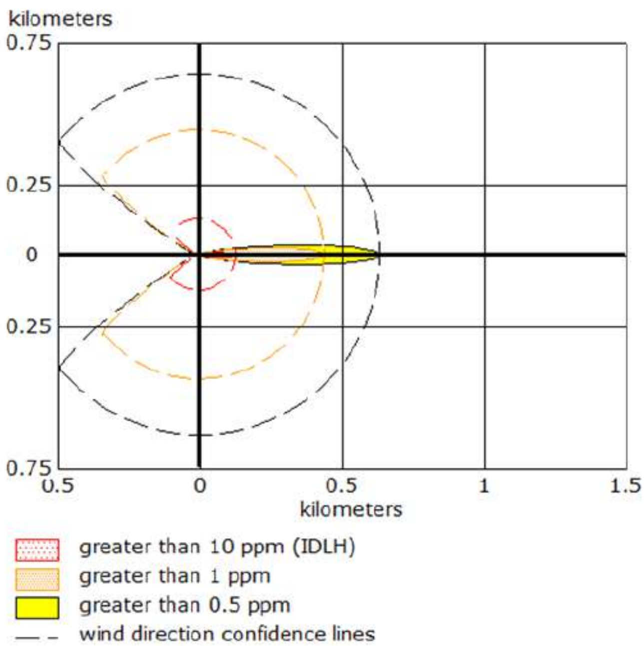
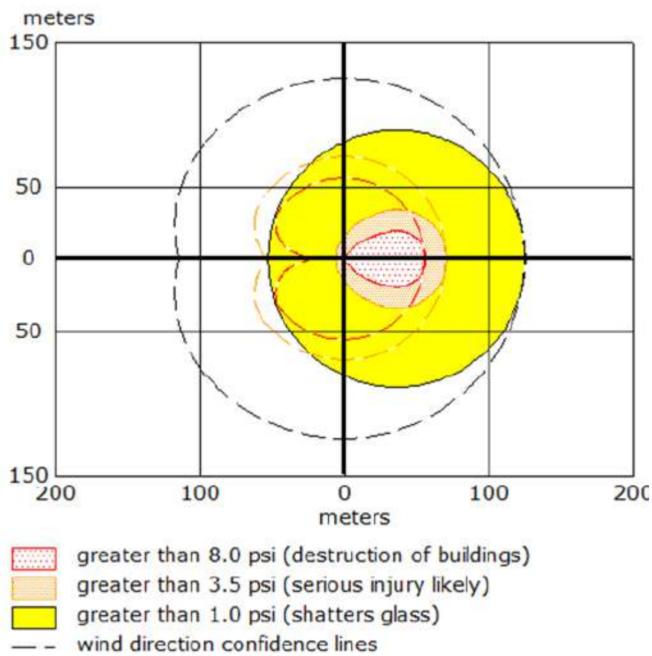



**Figure 7.3 Threat zone for Hydrogen**



### 7.4.6 Coal Handling Plant - Dust Explosion

Coal dust when dispersed in air and ignited would explode. Crusher house and conveyor systems are the 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; and
- Minimum explosive concentration for coal dust (33% volatiles) is 50 gm/$m^3$

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

Dust explosions may occur without any warnings with maximum explosion pressure up to 7.4 bars. Another dangerous characteristic of dust explosions is that it sets off secondary explosions after the occurrence of initial dust explosion. Many a times the secondary explosions are more damaging than the 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 CHP including collapse of its steel structure which may cripple the lifeline of the power plant.

In order to mitigate these effects, the following preventive measures will be taken:

- Stockpile areas will be provided with automatic garden type sprinklers for dust suppression as well as to reduce spontaneous ignition of the coal stockpiles.
- Necessary water distribution network for drinking and service water with pumps, piping, tanks, valves etc will be provided for distributing water at all transfer points, crusher house, control rooms etc.
- A centralized control room with microprocessor based control system (PLC) has been envisaged for operation of the coal handling plant.
- Except for locally controlled equipment like traveling tripper, dust extraction/ dust suppression /ventilation equipment, sump pumps, water distribution system etc, all other inline equipment will be controlled from the central control room but will have provision for local control as well.
- All necessary interlocks, control panels, MCC’s, mimic diagrams etc will be provided for safe and reliable operation of the coal handling plant.

#### 7.4.6.1 Control Measures for Coal Yards

The total quantity of coal shall be stored in separate stockpiles, with proper drains around to collect washouts during monsoon season. Water sprinkling system shall be installed on stocks of coal in required scales to prevent spontaneous combustion and consequent fire hazards. The stock geometry shall be adopted to maintain minimum exposure of stock pile areas towards predominant wind direction.

### 7.4.7 Identification of Major Hazard Potentials

### a) 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.

### 7.4.8 Major Causes of On-Site Emergency:

**a) Chlorine Leakage**

Chlorine filled cylinders are brought by the suppliers through their own transport. The cylinders are placed on its seat, specially fabricated for this purpose. The cylinders are connected to the manifold system and then to the evaporation line for use. The possible emergencies in this process are mentioned below:

**Explosion of Cylinders Due to Terrorist / Sabotage Activities**

In case of any terrorist activity and blasting of manifold system of chlorine cylinders 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.

**Explosion Due To Fire**

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

**Release of Chlorine Due To Leakage**

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

The staff will be 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 is any uncontrollable chlorine leakage from any toner. Breathing equipment will be provided, to use in such operation.

**b) Explosion**

Explosion 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 dioxide and always purity is maintained above 98%.

**c) 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 (UEL) and Lower Explosive Limits (LEL) 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 stage itself. To prevent the accumulation of dust and dust suppression, dust extraction systems are proposed at strategic locations.

**d) Boiler Explosion**

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

**e) 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 leakage of $H_2$ gas. And also the $H_2$ purity is continuously monitored and maintained always above 98%. All the $H_2$ cylinders will be checked for high purity.

**f) Fire in Cable Galleries**

The main hazard in cable galleries is fire. 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, fire resistance barriers will be provided at the cable entries/intersections, intermittent places on cable trays, cable raisers and cable entry points.

**g) Transformer Hazards**

Possible hazards in transformers are:

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

**h) Sub-Station Hazards**

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

- Short circuit either at bus bars/ breakage of high voltage parts/ cable termination chambers/ due to reptile's ingress/ falling of internal accessories on to live parts etc.
- Failure of supporting insulators of bus bars, breakers, termination and subsequent earthling of supply may cause flash over.
- Failure of measurement equipments like current transformers (CTs) 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.

**i) Water Treatment Plant Hazards**

There are chances of spill-over from chemical storage tanks. There are chances of chemical burns due to contact with acids/alkalis. 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 of.

**j) Fuel Oil Handling System Hazards**

The main hazard in fuel oil section is fire and storage tanks explosion. However, to contain the chances of fire/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.

**k) Storage /Godown-Hazards**

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

## 7.5 Facilities Proposed to Control fire Hazards

### 7.5.1 Fire Fighting

For protection against fire, all yard and plant equipments 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 TAC/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 hours. 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 minutes.

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

### 7.5.2 Fire Detection & Protection System

A comprehensive fire detection and protection system is envisaged for the complete power station. This system shall generally be as per the recommendations of TAC (INDIA)/ IS: 3034 & NFPA- 850.

**The following protection systems are envisaged:**

1) Hydrant system for complete power plant covering main plant buildings, boiler area, turbine and its auxiliaries, coal handling plant, all pump houses and miscellaneous buildings of the plant. The system shall be complete with piping, valves, instrumentation, hoses, nozzles, hose boxes/stations etc.

2) Automatic high velocity water spray system for all transformers located in transformer yard and transformers having oil capacity above 2000 liters located within the boundary limits of plant, main and unit turbine oil tanks and purifier, oil canal, generator seal oil system, lube oil system for turbine driven boiler feed pumps, boiler burner fronts, etc. This system shall consist of QB detectors, deluge valves projectors, valves, piping and instrumentation (P&I).

   - Automatic medium velocity water spray system for cable vaults and cable galleries of main plant, coal conveyors, coal galleries, switchyard control room, transfer points, stacker reclaimer, etc. and ESP control room consisting of smoke detectors, linear heat sensing cable detectors, deluge valves, isolation valves, piping, instrumentation, etc.

   - This system shall consist of QB detectors, linear heat sensing cables, deluge valves, nozzles, piping, instrumentation, etc.

   - Automatic medium velocity water spray system for un-insulated fuel oil tanks storing fuel oil having flash point $65^0$C and below consisting of QB detectors, deluge valves, nozzles, piping, instrumentation, etc.

- Fire detection cum sprinkler system for crusher house along with alarm valves, sprinkler nozzles, piping, instrumentations etc.

- Automatic Foam injection system for fuel oil/storage tanks consisting of foam concentrate tanks, foam pumps, in-line inductors, valves, piping & instrumentation, etc.

- For protection of central control room, control equipment room, programmer room and UPS, inert gas extinguishing system as per NFPA2001 (edition 2004 or latest) would be opted.

- Fire detection and alarm system - A computerized analogue, addressable type fire detection and alarm system shall be provided to cover the complete power plant. Following types of fire detection shall be employed.

    - Multi-sensor type smoke detection system
    - Photo electric type smoke detection system
    - Combination of both multi sensor and photo electric smoke detection systems
    - Linear heat sensing cable detector
    - Quartzite bulb heat detection system
    - Infra-red type heat detectors (for selected coal conveyors)

- Portable and mobile extinguishers, such as pressurized water, $CO_2$, foam, dry chemical powder type, will be located at strategic locations throughout the plant.

- CW blow down shall be used for supply of firefighting water. An alternate connection from clarified water makeup line shall also be provided as a backup source for firefighting water. It is proposed to provide two numbers of steel tanks for storage of fire water system. Fire water pumps shall be located in the pump house and horizontal centrifugal pumps shall be installed in the pump house for hydrant and spray system and the same shall be driven by electric motor and diesel engines as per the regulations of TAC. The water for foam system shall be tapped from the hydrant system network.

- For the above fire water pumping station, automatic pressurization system consisting of jockey pumps shall be provided.

- Complete instrumentation and control system for the entire fire detection and protection system shall be provided for safe operation of the complete system.

#### 7.5.2.1 Fire Station

A full-fledged fire station will be operated by fire officer and 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.

- Leading Fire Man 1 No
- Driver 1 No
- Fire Man 3 No’s

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

### 7.5.2.2 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 offices. The details of the fire hydrants and sprinkler systems proposed and fire detection systems are given in the below **Table 7.14** and **7.15**.

**Table 7.14 Fire hydrant & sprinkler systems**

| S. No | Systems | Equipment | Head (m) | 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 7.15 Fixed Fire Detection and Protection System**

| S.No | Type and Nomenclature of Fire Protection / Fire Detection System | Data on Qty./Capacity | Data on Premises Installed |
|---|---|---|---|
| 1. | a) Water sprinkler system and Emulsifier | 8 Kg working pressure | On all Transformers |
| | b) Water spray system | 8 Kg working pressure | On all conveyor system |
| 2. | Medium velocity water spray system | 8 Kg working pressure | On all oil tanks |
| 3. | Smoke Detectors | - | At all control rooms, switch gear rooms, cable galleries etc., |

#### a) Fixed Foam System

HFO and LDO tanks will be provided with fixed foam system. The mixer of water and foam concentrate go to the HFO and LDO tanks, thrown on to the top surface of the oil tanks and converts into foam to extinguish the fire.

#### b) Medium Velocity Spray 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 are developed 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 the fire hazard. Quartz old bulb and fusible plug heat detectors would be provided at the tip of each pipe covered. Under the network of pipe meant for sprinkling system, the bulbs break at 79 $^{o}$C of heat and the water is automatically sprayed out on the conveyor through the tips, transformers and LDO tank areas to arrest the fire.

**d) Emulsifier System**

The emulsifier system is proposed on transformer, GT, UATs, station transformers. In the emulsifier system, quartz old bulb fuses at 79 $^{o}$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 the above firefighting 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. The details are tabulated below in **Table 7.16.**

**Table 7.16 Details of Portable Fire Extinguishers**

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

**7.5.2.3 First Aid Centre**

A first aid centre 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 |

**7.5.2.4 Communication Facilities**

Public address system would be provided in the plant. Telephone and internal communication facilities would be available at all required desks or with officials in control room. Telephones, fax and carrier communication facilities would be provided in unit control board to contact the 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).

#### 7.5.2.5 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 are automatically switched on in case of power failure. More than one supply through different transmission systems would also be provided to ensure electric supply without fail.

**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.

## 7.6 Emergency Control Centre (ECC)

The ECC is proposed which will be fully equipped with all communication facilities. ECC will be centrally located and will see that it is nearer to unit control board, switch yard control room and chemical wing to give instructions to the officers.

The ECC will be manned by the Chief Incident Controller. The officials nominated as key personnel and senior officers outside the services will be called in for assistance. No other personnel shall have access to the control centre.

**ECC will also contain the following data:**

- Safety data pertaining to all hazardous materials likely to cause emergency.
- Procedure for major and special firefighting, rescue operations, first aid etc.,
- Procedures for tackling chlorine gas and other chemical leakages.
- Emergency call out list of persons drafted for emergency control, key personnel, fire, safety, first aid, medical, personnel, welfare and industrial relations, security, police and district administration authorities.

## 7.7 Evacuation and Assembly Points

In an emergency, it would certainly be necessary to evacuate personnel from affected areas and as per precautionary measures to further evacuate non-essential workers, in the first instance from areas likely to be affected where the emergency escalates. 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.

- Switch yard control room (MCR)
- Main plant security gate.
- Service building.

**a) Emergency Alarms**

The emergency siren will be given by the security personnel with instructions from the security control room and it is proposed to install the sirens at following places.

- Fire station control room
- Housing colony security gate

The above locations are manned round the clock. The emergency alarm shall consists of 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 declared such that the nature of emergency can be distinguished as a chlorine release or a major fire.

**b) Emergency Siren**

The siren codes for various types of emergency are given below.

| **Declaration of Emergency** | **Siren Code** |
|---|---|
| Small Fire | No siren |
| Major Fire | Siren ON for 10 seconds & OFF for 5 seconds. This is to be repeated for a total period of 2 minutes |
| Toxic Release | Siren ON for 20 seconds & OFF for 5 seconds. This is to be repeated for a total period of 3 minutes |
| All Clear (for fire) | Straight run siren for two minutes |
| Test | Straight run siren for two minutes |

## 7.8 On-site emergency plan

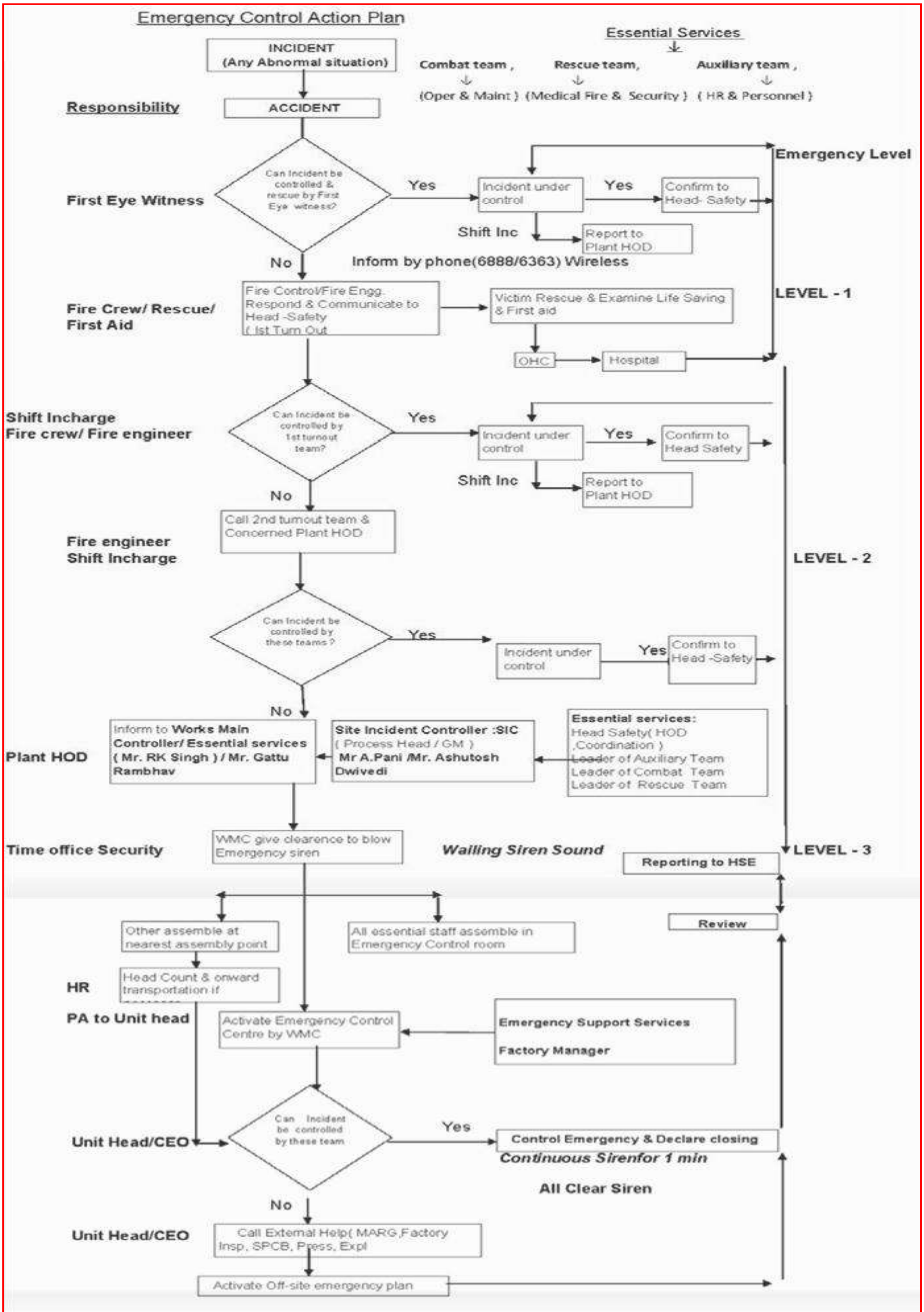
SCCL has a dedicated team of professionals who are involved in the emergency operations. For effective control and management of an emergency, an action plan and organizational chart is prepared along with responsibilities. The action plan for on-site emergency in case of fire hazard is given in **Table 7.17** and the flow chart of on-site emergency control action plan is given in **Figure 7.4**.

**Table 7.17 Action plan for on-site emergency for fire hazard**

| Step No. | Initiator | Action to Take |
|---|---|---|
| 1. | **The person noticing the emergency** | • Inform the Fire control room and the concerned Shift-in-charge who in turn will inform Combat Team Leader immediately regarding the fire hazard. |
| 2. | **Combat Team Leader (CTL)** | • Inform Site Incident Controller (SIC) through common dialing system and rush to spot for combating the situation. Take charge of the situation, arrange for evacuation of people not directly concerned. |

| | | |
|---|---|---|
| | | • To organize for trained personnel equipped with firefighting appliances and call for fire tender at the place of fire.<br><br>• To start combating, shutdown equipments and taken steps to extinguish fire with fire fighting facilities.<br><br>• To find out the root cause of fire and to take necessary action for prevention of fire. |
| 3. | **Site Incident Controller (SIC)** | • Inform Works Main Controller (WMC) and will rush to Site. In case of failure electronic communication system, the standby available provision for runner with bike, will be there to pass on the command as advised.<br><br>• Discuss with Combat Team Leader (CTL), assesses the situation and call the Rescue Team Leader (RTL) & Auxiliary Team Leader (ATL).<br><br>• Inform to the Rescue Team leader, and Auxiliary Team leader to send the Rescue Team to site.<br><br>• Arrange to evacuate the unwanted persons and call for additional help.<br><br>• Time to time pass on the information to the Works Main Controller (WMC) about the situation at site. |
| 4. | **Works Main Controller (WMC)** | • Rush to Emergency Site and observe the ongoing activities.<br><br>• Take stock of the situation in consultation with the SIC.<br><br>• Move to Emergency Control Room.<br><br>• Take decision on declaration of emergency and ask for emergency wailing siren.<br><br>• Advise Auxiliary Team Leader to inform the statutory authorities and seek help of mutual aid if required.<br><br>• Decide on declaration of normalcy of emergency after combating the situation.<br><br>• Ensure thatthe emergency operations are recorded chronologically. |

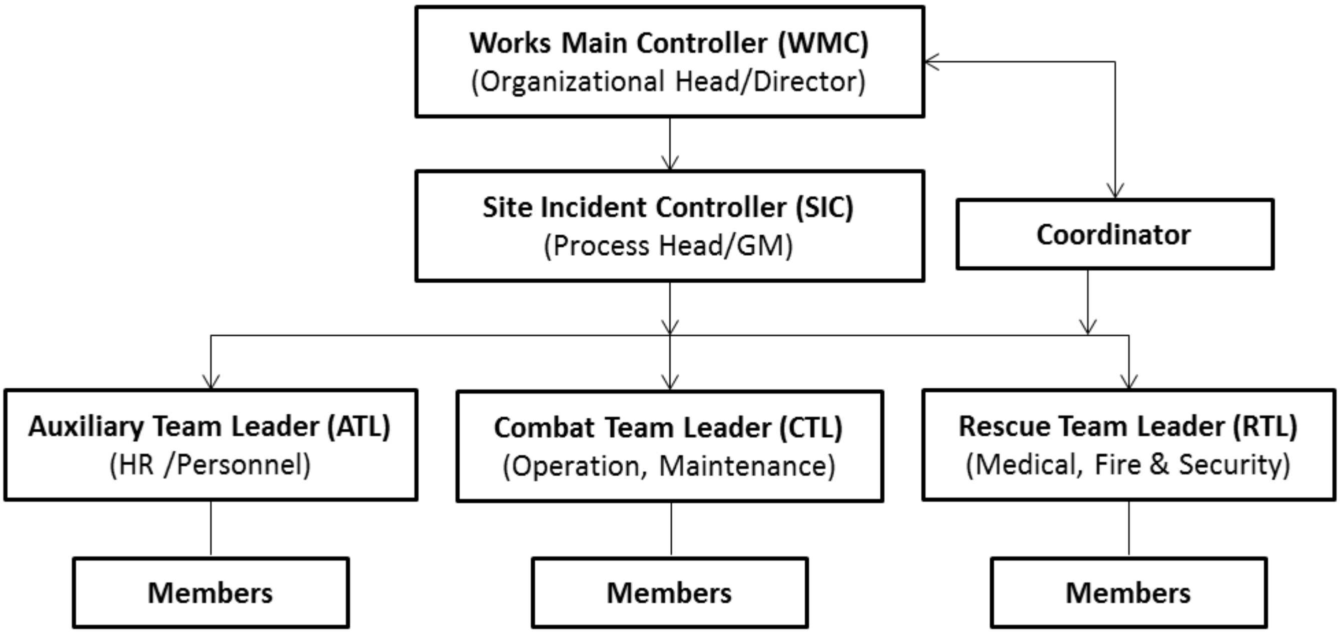
**Figure 7.4 Flow chart of on-site emergency control action plan**



### 7.8.1 Silent hour command structure

Silent hour period is from 6.00PM to 10AM i.e. after the General shift. During that hour the Works main controller (WMC),Site incident controller (SIC), Auxiliary team leader (ATL), Combat Team Leader (CTL) and Rescue Team Leader (RTL) will be not available at site as their duty is in general shift. During the silent hour also the action plan is the same as during normal hour. As the WMC, SIC, ATL, CTL, RTL will not be available in the odd hour, they will be informed by the acting site incident controller (shift in-charge) over telephone or by sending special messenger on urgent basis for their quick arrival. Till their arrival persons of silent hour command structure will work actively as per scheduled procedure for mitigating the situation. After the arrival of the designated (WMC, SIC, ATL, CTL, RTL) shall immediately take the charge without lapse of time , from silent hour team and will actively take further action judiciously as per normal hour command structure activities procedure. The silent hour command structure is given in **Figure 7.5.**

**Figure 7.5 Silent hour command structure**




### 7.9 Off-site Emergency Plan

When the consequence of an emergency situation goes beyond the plant boundaries, it becomes an off-site emergency. 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. Off-site emergency is essentially the responsibility of public administration. However, the factory management will provide the public administration with technical information relating to the nature, quantum and probable consequences on the neighboring population.

The roles of various parties who will be involved in the implementation of an off-site plan are described below. The plan will identify an emergency coordinating 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 coordinating office. Consideration of evacuation may include the following factors:

- In case of a major fire, 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 them from the fire.

**a) Role of the Emergency Coordinating Officer (ECO)**

The ECO will work 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.

**b) 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 work to obtain the information to provide the basis for the plan. This liaison will ensure that the plan is continually kept up-to-date. Rehearsals for off-site plans will be organized by the EPO.

**c) 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.

**d) 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 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.

**e) 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.

## 7.10 Disaster Management Plan

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 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 loss of human life and property and reduce costs to the society.

### 7.10.1 Types of disasters

There are two major types of disasters generally seen in the industrial activities a) natural disasters and b) man-made disasters

**a) Natural Disasters:**

A natural disaster is the result of a natural phenomenon (e.g., flood, tornado, earthquake, land slide etc.) leading to economic, environmental or human losses. The resulting loss depends on the vulnerability of the affected population to resist the hazard, also called their resilience. The area is not prone to any major natural disaster as it is a plain land.

**b) Man-made disasters**

Man-made disasters are of an anthropogenic origin, and exemplify some of the terrible accidents that have resulted from human beings interaction with artificial environment, which they themselves have created.

### 7.10.2 Objectives of DMP

The objective of the industrial DMP 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 for the needs of relatives;
7. Provide authoritative information to the news media;
8. Secure the safe rehabilitation of affected area;
9. Preserve relevant records and equipment for the subsequent inquiry into the cause and circumstances of the emergency

In effect, it is to optimize operational efficiency to rescue, rehabilitate and render medical help and to restore normalcy.

### 7.10.3 Earthquake Mitigation Plan

However, the project area fall under Seismic Zone II (low risk/least active zone), the earthquake disaster mitigation program consists of three components which are preparedness, rescue and rehabilitation as described below.

**a) Preparedness**

The preparedness phase involves the following aspects;

- Hazard zoning
- Earthquake prediction and warning
- Implementation of earthquake engineering codes
- Strengthening of existing structures
- Education and Training
- Seismic instrumentation – new and up-gradation
- Insurance
- Emergency preparedness
- Training for handling damaged buildings

**b) Rescue**

Rescue at the time of emergency involves the following operations:

- Maintenance of law and order, prevention of trespassing, looting, keeping roads clear from sightseeing persons so that free movement of rescue vehicles is assured, etc.
- Evacuation of people
- Recovery of dead bodies and their disposal
- Medical care for the injured
- Supply of food and water and restoration of water supply lines
- Temporary shelters like tents, metal sheds
- Restoring lines of communications and information
- Restoring transport routes
- Quick assessment of damage and demarcation of damaged areas according to grade of damage
- Cordoning off severely damaged structures that are liable to collapse during after shocks
- Temporary shoring of certain precariously standing buildings to avoid collapse and damage to other adjoining buildings

**c) Rehabilitation**

After the emergency, rehabilitation involved the following aspects:

- Repair, restoration, strengthening or demolition of damaged structures
- Selection of sites for new settlements, if necessary
- Adoption of strategies for new constructions like construction through contractors, by self-help, construction of core house only or supply of construction material only
- Execution of the construction program
- Preview/ review of seismic codes and construction norms
- Training of personnel, engineers, builders and artisans
- Rehabilitation of destitute persons, orphans, widows, the aged and the handicapped persons

### 7.10.4 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 |
| SE/O&M | - | Vice Chairman |
| SE/CHP | - | Member |
| Fire Officer | - | Member |
| DE/E&P | - | Member |
| Safety Officer | - | Member |
| Medical Officer | - | Member |
| Security Officer | - | Member |

**The committee shall supervise the following activities:**

- Functioning of ECC, specifically availability of all facilities as mentioned in the plan and its functional healthiness.
- 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.
- 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.
- Ensure that employees are fully aware of the steps to fight any emergency like sealing of chlorine leakage, firefighting or other such causes.
- All employees are trained about their responsibilities /duties. They are all aware of evacuation routes, direction of evacuation, first aid and the equipment to be used during evacuation or the method of evacuation.
- Alarms and PAS should be in working condition.
- Telephone lines / communication systems will be provided in control rooms and there will no removal of the facilities (as prescribed) for the control rooms.

#### 7.10.4.1 Steps of Mock Drills

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

- 1$^{st}$ Step : Test the effectiveness of communication system.
- 2$^{nd}$ Step: Test the speed of mobilization of the plant emergency teams.
- 3$^{rd}$ Step : Test the effectiveness of search, rescue and treatment of casualties
- 4$^{th}$ Step : Test Emergency isolation, shut down and remedial measures taken on the system.
- 5$^{th}$ Step : Conduct a full rehearsal of the actions to be taken during an emergency.

The DMP should be periodically revised based on experience gained from the mock drill.