# CHAPTER-8
# RISK ASSESSMENT

## 8.1 DESCRIPTION OF PLANT LAYOUT

The general layout plan for the proposed project is depicted in Exhibit-4.1.

A total of two (Heavy Fuel Oil) HFO and one (Light Diesel Oil) LDO storage tanks have been proposed for the project (Refer Exhibit-4.1).

## 8.2 FUEL FOR PLANT OPERATIONS

The basic fuel for this project has been considered as coal. However, HFO and LDO will be required for boiler start-up and flame stabilization purposes.

A total of three tanks of capacities mentioned below will store the fuel oil required for the 660 MW unit. This fuel oil will be pumped from the fuel dyke area to the boilers. The details of the tanks are as under:

| Material | Tank No | Storage Tank Capacity ($M^3$) | Diameter (mts) | Height (mts) |
|---|---|---|---|---|
| HFO | 1 | 1500 | 16.0 | 8.0 |
| HFO | 2 | 1500 | 16.0 | 8.0 |
| LDO | 1 | 1000 | 15.0 | 6.0 |

## 8.3 HAZARD IDENTIFICATION

Disaster scenarios for the purpose of this study is defined as an accident viz., Fire, Explosion, Release of Toxic substances, where

- There may be multiple casualties needing hospitalization and /or
- Significant loss to plant and surrounding areas.

The following failure scenarios are derived for further consequence analysis and risk estimation.

### 8.3.1 Possible Risks at Plant Area

- Pipeline rupture or Leakages (Continuous release)
- Fuel oil storage/dyke fire (Instantaneous release)

## 8.4 MAJOR HAZARD INSTALLATIONS

Major Hazard Installations are usually defined with the help of the list of hazardous substances and their triggering quantities (threshold limits). As per the Ministry of Environment and Forests Notification No. S.D. 227 (E) dated March 24, 1992, the noted substances in the quantities equal to or greater than those specified are hazardous substances. This list of hazardous substances is divided into 5 groups as stated below :

| | |
|---|---|
| Group 1 & 2 | Toxic Substances |
| Group 3 | Highly Reactive Substances |
| Group 4 | Explosive Substances |
| Group 5 | Flammable Substances |

## 8.5 CONSEQUENCE ANALYSIS

The facilities at the Fuel Dyke area terminal mainly comprise of HFO and LDO storage tanks. The hazards posed by them are mainly in the form of fire. There is a possibility of flash fire taking place in the event of large spill of hydrocarbons, mainly major failure scenarios were evaluated to assess the effect on people and property inside the plant area as well as outside.

a) Tank Fire
b) Bund Fire
c) Flash fire

The effect of fire on people and property outside will chiefly manifest itself in the form of thermal radiation. A criteria was selected for deciding the maximum level of thermal radiation to which the outside population can be subjected. Thermal radiation levels from fire scenarios of each tank are worked out at various distances and their effects are evaluated against the set criteria.

### 8.5.1 Thermal Radiation

Thermal radiation due to pool fire may cause various degrees of burns on exposed human bodies. Moreover their effects on inanimate objects like piping, equipment or vegetation also need to be evaluated to assess their impact.

For continuous presence of persons, the following thermal radiation intensity levels are usually adopted :

- 1.6 Kw/m$^2$ for outside population.
- 4.5 Kw/m$^2$ for plant operators.

This is the criteria that is followed in case of flare design where peak load condition may occur for a short time but mostly without warning. The operators are usually trained and properly clothed; they are expected to run for shelter quickly. For secondary fire, an incident radiation intensity of 12.5 Kw/m$^2$ is required. This is usually taken as the minimum criteria.

The facilities at the storage area mainly comprises of vertical cylindrical tanks of structural steel (IS-2062 Grade-A). The hazard posed by them are mainly in the form of fire. There is a possibility of tank fire taking place and is evaluated to assess the effect on people and property.

## 8.5.2 Damage Criteria

Damage estimates due to thermal radiation has been arrived at by correlating recorded incidents. The consequences can then be visualized by super imposing the effects on the proposed site plan and identifying the elements within the project site as well as the neighboring environment which may be affected.

The damage criteria due to accidental release of hydrocarbon arise primarily from fire. Contamination of soil or water is not expected as fuel will vapourise quickly and would not leave any residue as it happens with oil. The vapour of HFO/LDO are not toxic and hence no effects of toxicity are expected.

## 8.5.3 Consequence of Fuel Oil Spill

The tank on fire situation would occur if the heat on peripheral surface of the tank leads to internal tank pressure. Pool fire would occur when fuel oil collected in the dyke due to leakages get ignited.

### 8.5.3.1 Thermal Damage

The following table presents the damage and effects due to thermal radiation on inanimate objects like piping, equipment or vegetation in addition to effects on human beings.

| Incident radiation (in kW/m$^2$) | Type of damage |
|---|---|
| 62.0 | Spontaneous ignition of wood. |
| 37.5 | Sufficient to cause damage to process equipment. |
| 32.0 | Maximum thermal radiation intensity allowed on thermally protected adjoining equipment |
| 25.0 | Minimum energy required to ignite wood at infinitely long exposure (non-piloted) |
| 12.5 | Minimum energy required for piloted ignition of wood, melting of plastic |

| Incident radiation (in kW/m²) | Type of damage |
|---|---|
| 8.0 | Maximum thermal radiation intensity allowed on thermally unprotected adjoining equipment |
| 4.5 | Sufficient to cause pain to personnel if unable to reach cover within 50 seconds, however blistering of skin (1st degree burns) |
| 1.6 | Causes no discomfort on long exposures |
| 0.7 | Equivalent to solar radiation |

The effect of incident radiation and exposure time on lethality is stated in the following table :

**Radiation Exposure and Lethality**

| Incident Radiation (Kw/m²) | Exposure time (seconds) | Lethality (%) | Degree of burns |
|---|---|---|---|
| 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 |

### 8.5.4 Model Details

The hazard distances are computed based on the guide lines specified by World Bank, Technical Paper No. 55 (Techniques for Assessing Industrial Hazards, Technica, Limited).

## 8.6 METHODOLOGY

Each tank at the storage facility is evaluated to assess the effect in the event of its catching fire.

For the present study, the scenarios under consideration assume that the peak level of radiation intensity will not occur suddenly. Based on the past experience, it is found that 20-30 minutes time will be required before a tank fire grows to full size. For radiation calculations, full tank fire has been considered. From the above considerations, the criteria of 4.5 kW/m$^2$ has been selected to judge acceptability of the scenarios.

The assumptions for calculations are :

- it is not continuous exposure;

- there is not enough time available for warning the public and initiating emergency action;
- Within 10 minutes, plant personnel would attend any eventuality
- secondary fire at public road and building is not likely to happen;
- the effect of smoke on reduction of source radiation intensity has not been considered; therefore hazard distances calculated tend to be conservative; and
- Shielding effect of intervening trees or other structures has not been considered. No lethality is expected from this level of intensity although burn injury takes place depending on time of exposure.

## 8.6.1 Pool Fire

Following an accidental release, chemicals will form a confined pool with in the dyke area or an unconfined pool in case liquids were allowed to be stored in the absence of a dyke. Should the vapour above the pool ignite, the liquid will burn as a pool fire. The pool fire will result in thermal radiation. It could also damage the storage tanks located within the common dyke area.

### 8.6.1.1 Release Rate Estimation

Leakage rates for various scenarios are estimated based on the storage facilities. These are given below.

**Release Rate Estimation**

| Fuel | HFO | LDO |
|---|---|---|
| Roof Type | Fixed Roof | Fixed Roof |
| Capacity of each Tank (KL) | 600 | 150 |
| Failure of Liquid Fuel supply line (Kg/S) | 1.33 | 1.33 |

### 8.6.1.2 Model Computations

Although the interest of this study is to find out the distance from a burning tank to a radiation intensity level of 4.5 $Kw/m^2$, calculations of the levels of radiation intensity as indicated have been included, the hazard distances for storage tank on fire: (i) Plant area instantaneous spill (Single Tank, HFO) (ii) Plant area instantaneous spill (Single Tank, LDO) and (iii) Catastrophic rupture of storage facility Continuous spill (All tanks) are stated in Tables-8.1, 8.2 and 8.3 and are shown in Exhibits-8.1 and 8.2.

Radiation distances shown in above tables are at tank elevations. At ground level the radiation intensity will be comparatively low.

## 8.7 CONCLUSION

1. The 4.5 $kw/m^2$ heat intensity radiation will not spread beyond the plant boundary.

2. The following arrangements are available for the storage tanks:

   Independent high level alarm and trip off liquid inlet-line.

   Low level alarm.

   Provision of auto deluge water sprinkler system for each bulk storage tank. The auto deluge water sprinkler would be set to start working at a temperature of $66^0$ C.

3. The turbine building, switchyard, transformer yard, administrative building, pantry, first aid center, fire stations etc. should be located safely, if viewed in the light of worst accident scenarios.

4. In case of any tank on fire or fire in the vicinity, the cooling of adjoining tank should be resorted promptly in addition to tank on fire so that the tank shell of neighboring tanks does not give away.

5. The night vision wind sock is mounted on top of administrative building, and Fuel Dyke area with adequate illumination so that people can move in upwind directions in the event of massive spillage.

6. Population growth around the plant and colony should be watched by appropriate authorities. Unauthorised growth of shanty colonies and hutments around Power Project should be avoided.

7. No machinery of vital importance like fire fighting pump house, Hydrant and Fuel oil pump house should be placed within radiation contours of 32.0 $kw/m^2$ heat intensity.

Strict adherence to standards and accepted maintenance and operation of the plant plays a vital role in maintaining the plant. The monitoring of the health of equipment, pipeline and machines, thickness survey will improve plant performance and safety.

## Table-8.1
## Distances of Occurence of Various Thermal Radiation Intensities
## Storage Tank on Fire
## Plant Area Instantaneous Spill (Single Tank, HFO)

| **Radiation Intensity ($kw/m^2$)** | **Distance of Occurrence (metres)** |
|---|---|
| Tank Capacity (KL) | 600 |
| 37.5 | 10.20 |
| 32.0 | 11.00 |
| 12.5 | 17.50 |
| 8.0 | 22.00 |
| 4.5 | 29.30 |
| 1.6 | 49.20 |

## Table-8.2
## Distances of Occurrence of Various Thermal Radiation Intensities
## Storage Tank on Fire :
## Plant Area Instantaneous Spill (Single Tank, LDO)

| **Radiation Intensity ($kw/m^2$)** | **Distance of Occurrence (metres)** |
|---|---|
| Tank Capacity (KL) | 150 |
| 37.5 | 2.70 |
| 32.0 | 3.00 |
| 12.5 | 4.40 |
| 8.0 | 5.85 |
| 4.5 | 7.80 |
| 1.6 | 13.10 |

## Table-8.3
## Distances of Occurrence of Various Thermal Radiation Intensities
## [Catastrophic Rupture Storage Facility Continuous Spill (All Tanks)]

| **Radiation Intensity ($kw/m^2$)** | **Distance of occurrence from dyke centre (metres)** |
|---|---|
| 37.5 | 7.60 |
| 32.0 | 8.24 |
| 12.5 | 13.20 |
| 8.0 | 16.50 |
| 4.5 | 22.00 |
| 1.6 | 34.25 |