7. RISK ASSESSMENT AND RISK MITIGATION MEASURES

7.1 Methodology

According to the specific items 31 (xxxi) of the Terms of Reference (ToR) issued for the project, Risk assessment shall be carried out taking into account the maximum inventory of storage at site at any point in time. The risk contours should be plotted on the plant layout map clearly showing which of the proposed activities would be affected in case of an accident taking place. Based on the same, proposed safeguard measures should be provided. Measures to guard against fire hazards should also be provided.

A preliminary hazard identification and risk assessment was undertaken to quantify the possible fire and occupational health risks associated with the operation of the project at the designated location. The good engineering practices suggested by the Central Pollution Control Board for risk assessment in industries (CPCB document Probes/133/2009-10) and CPR-18E risk assessment procedures' guidelines which are widely accepted by the Ministry of Environment and Forests (MoEF) India, have been adopted while assessing the residual risks associated with the operations of the project with specific reference to fire hazards, chemical exposure hazards, occupational hazards and natural hazards. As part of the risk assessment, a preliminary review on the hazardous materials and chemicals proposed to be handled at the site were reviewed and the storage capacities and design features of such hazardous materials were also reviewed while assessing the residual risks. Occupational health hazards such as exposure to dust emissions, thermal stress and work-zone levels were also studied. Based on the findings of the risk assessment study, a preliminary risk management plan has been developed as per the applicable rules and guidelines; wherever possible, good engineering and management practices are suggested to minimise any intolerable risks.

7.2 Construction Phase Safety Management Plan

7.2.1 General Safety Aspects

The possible safety hazards during the construction phase are primarily limited to material transport, construction and erection of material and structures and working at

heights etc. The possible occupational safety hazards with the above mentioned activities are electrical hazards at the construction activity, falling from heights, slips and fall of equipment such as cranes etc.

In order avoid the occupational safety hazards, The Indian Codes and Standards (IS 18001: 2007, IS - CED 29(7778) and 15793:2007) on construction safety best practices shall be adopted by all the contractors and sub-contractors. All the sub-contractors shall have a written health and safety and environment policy. The principal contractor will be responsible for implementing and monitoring the occupational safety programs at the construction sites. Workers & Supervisors should use the safety helmet and other requisite Personal Protective Equipment according to job & site requirement. They should be trained to use personal protective equipment. Lift the load with back straight and knees bent as far as possible. Seek the help in case of heavy load. Ensure the usage of correct and tested tools and tackles. Don't allow the make shift toolsand tackles. No loose clothing should be allowed while working near rotating equipment or working at heights. Visitors should not be allowed access to construction sites unless accompanied by or authorized by a competent person and provided with the appropriate protective equipment. Where natural lighting is not adequate, working light-fittings or portable hand-lamps should be provided at workplace on the construction site where a worker will do a job. Emergency lighting should be provided for personnel safety during night time to facilitate standby lighting source, if normal system fails. Artificial lighting should not produce glare or disturbing shadows.

The following IS codes may be adopted for construction safety related activities:

- IS Code 3696: Safety code for scaffolds and ladders, (Part 1):1987-Scaffolds, (Part 2):1991- Ladders
- IS Code 3764:1992 - Code of practice for excavation work
- IS Code 4082:1996 - Recommendations on stacking and storage of construction materials and components at site
- IS Code 512:1969 - Safety code for piling and other deep foundations
- IS Code 5916:1970 - Safety code for construction involving use of hot bituminous materials

- IS Code 7205:1974 - Safety code for erection of structural steel work
- IS Code 7969:1975 - Safety code for handling and storage of building materials
- IS Code 13416 - Recommendations for preventive measures against hazards at work places: (Part 1):1992- Falling material hazards prevention and (Part 2):1992-Fall prevention and (Part 3):1994-Disposal of debris

7.2.2. Occupational Health Risks and Risk Mitigation Plan – Construction Phase

7.2.2.1. Heat Stroke

In the recent past, based on the information provided by IMD, Madhya Pradesh and Bihar are experiencing the heat waves in the month of May and June. The heat wave is caused in large part by sparser pre-monsoon season showers, which brought less moisture than normal to the area, leaving large parts of India arid and dry. The sudden end of pre-monsoon rain showers, an uncommon trend in India, has contributed to the heat waves. The peak temperatures in the Buxer region was reported t be as high as 48^0Ctemperature. When a person works in a hot environment, the body must get rid of excess heat to maintain a stable internal temperature. It does this mainly through circulating blood to the skin and through sweating. When the air temperature is close to or warmer than normal body temperature, cooling of the body becomes more difficult. Blood circulated to the skin cannot lose its heat. Sweating then becomes the main way the body cools off. But sweating is effective only if the humidity level is low enough to allow evaporation and if the fluids and salts that are lost are adequately replaced. Heat stroke can occur when the body's system of temperature regulation fails and body temperature rises to critical levels. This condition is caused by a combination of highly variable factors, and its occurrence is difficult to predict. Heat stroke is a medical emergency. The primary signs and symptoms of heat stroke are confusion; irrational behavior; loss of consciousness; convulsions; a lack of sweating (usually); hot, dry skin; and an abnormally high body temperature, e.g., a rectal temperature of 41°C (105.8°F). If body temperature is too high, it causes death. The elevated metabolic temperatures caused by a combination of work load and environmental heat load, both of which contribute to heat stroke, are also highly variable and difficult to predict.

In order to reduce the risk associated with heat exposure the following measures can be adopted:

- Avoid working for prolonged period during the hot sunny hours especially during 1 to 3pm during summer conditions,
- Adopted staggered times to avoid over exposure to direct sun,
- In the case the ambient temperatures exceed more than $45^{O}C$, the construction works in open areas shall be suspended.

7.3 Safety Hazards During Operational Phase

7.3.1 Hazard Operations

Unlike other process industries, power project does not handle any major flammable materials (Class A and Class B Flammable material) except small quantities of furnace oil for boiler start up conditions. Other hazardous materials that will be handled at the power plant will be small quantities of Chlorine used as biocide in the cooling tower. In the presence scenario, the management STPL has proposed to adopt non-elemental chlorine based biocides will be used in the cooling tower application. Both Hydrochloric acid and Sodium Hydroxide will be used for regeneration of the De-Mineralization Plant resin beds. Two day storage tanks of capacity 200 m^3 each with adequately designed dyke system will be installed in the DM plant area. Although coal is not a self igniting compound at ambient temperatures, prolonged exposure to heat during the hot summer days, may lead to partial ignition due to the presence of volatile compounds in the coal. Based on the preliminary analysis, the major fire hazards envisaged are from storage and handling of furnace oil at the Mill site.

7.3.2 Safety Aspects of Storage of Furnace Oil

A preliminary risk assessment study was undertaken to establish the possible heat radiation effects due to accidental fires at furnace oil storage tanks. Small quantities of furnace oil (2 tanks of 200 m^3 each) will be stored in a dedicated tank with a dyke designed for 100% containment. Furnace oil falls under Class 3 combustible material as per OISD standards and hence the possible fire hazards will be less significant. Hence, these fuels will undergo only pool fire scenario in the presence of any ignition source. Since the quantity of furnace oil proposed to be stored will be very small. In order to

assess the heat radiation from the pool fire scenario of accidental spills from furnace oil (full bore rupture of the storage tank), consequence modeling was undertaken using SAFETI software, which is recommended by Ministry of Environment and Forests, India. For the purpose of the consequence modeling, it has been assumed that due to mechanical failure of the tank, entire inventory of the furnace will be retained in the dyke. In the presence of external fire such as electrical fire or vehicular exhaust sparks etc, the contents in the dyke will catch fire and release thermal energy. The predicted heat radiation levels due to pool fire of furnace oil pool fire scenario are presented in **Table 7.1**. Radiation contours are presented in **Figure 7.1.**

It may be inferred from the model heat radiation contours with 4.5kW/m^2 would occur within the facility boundary and hence the overall impacts due to any fire accidents will be less significant. In addition there are no public roads and settlements located within the predicted heat radiation contour of 1.6 kW/m^2, hence the impacts on the neighbouring areas will be insignificant. As per the published literature (CP18E and CPCB Manual for fire risk assessment), the possible frequency of occurrence of such accidents will be less than 40 in one Million events. Hence, the overall risk due to handling of such a small quantity of furnace oil at the Mill site will be insignificant.

Table 7.1 Estimated Heat Radiation Levels due to Fire from Furnace Oil Tank Rupture

Heat Radiation Level (kW/m^2)	Possible Physical Effect due to Heat Radiation (ref)	Heat Radiation Distance for Furnace Oil Tank Fire (Pool Fire Scenario)
37.5	Sufficient to cause damage to process equipment	Within the dyke
25.0	Minimum energy required to ignite wood	Within the dyke
12.5	Melting of cables and plastic	<25m
9.5	Second degree burns in 20 seconds	<45m
4.5	Zero percent lethality, but may cause blisters	<80m
1.6	Will cause no discomfort on prolonged exposure	<110m

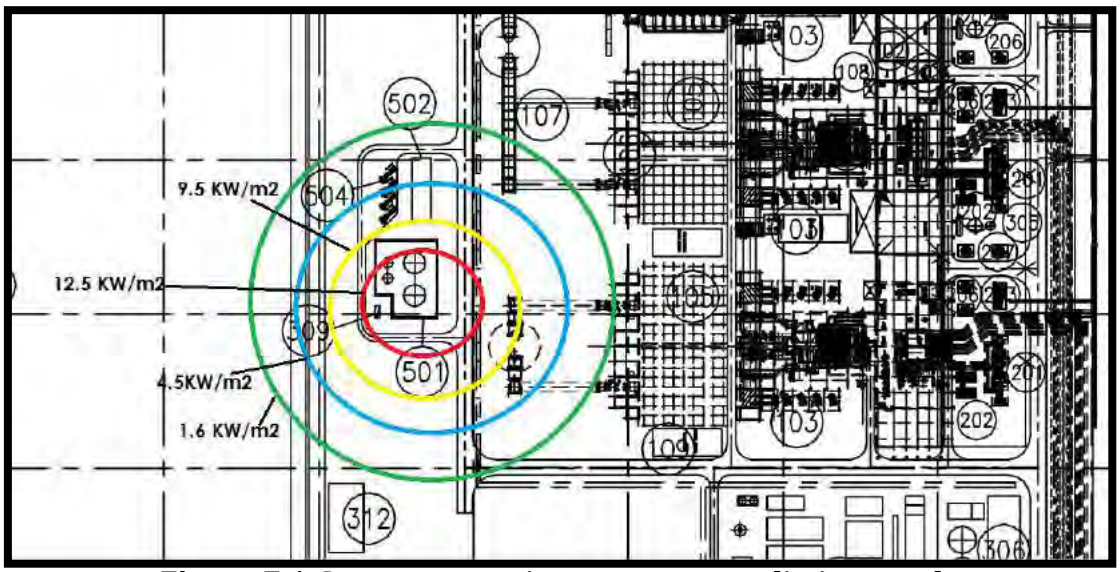

Figure 7.1 Consequence Distance – Heat Radiation Levels

The following safety measures will be adopted for handling of furnace oil.

- According to the OISD standards, an adequately design dyke with 110% of the largest tank volume, will be provided to retain the oil spills, if any,
- The fuel transfer pumps & motors will be of fire proof type and will be located outside the dyke area.
- A level indicator with alarm will be provided for the fuel tanks.
- Fuel unloading from the trucks will be taken up only in the presence of authorized supervisor.
- The transfer hose pipelines and truck discharge line will be connected to a temporary earth arrangement as per BIS codes to avoid any static electricity.
- A spill collection pit will be provided near the fuel tank dyke.
- As far as possible, plant office areas, common gathering points and canteen shall be located at least 15 m away from the fuel oil storage areas to avoid any exposure to heat radiation effects on the workers and employees.
- It has been recommended to provide a hand-held foam tender and fire water hydrant line in the vicinity of the storage tanks.

7.3.3 Risk Mitigation Measures for the Storage and Handling of Coal

Although coal fires are infrequent, there is a possibility of coal fires at the coal stock yards during the summer conditions due to burning of volatile compounds. Coal stock

yard fires can be avoided by providing proper stacking design to prevent air movement inside the coal lumps, minimising the duration of coal storage at the site and water sprinkling operations to maintain adequate moisture. Power plants store, transfer, and use coal; therefore, careful handling is necessary to mitigate fire and explosion risks. Recommended measures to prevent minimise, and control fire hazards at proposed power plants include:

- Use of automated combustion and safety controls
- Proper maintenance of boiler safety controls
- Implementation of startup and shutdown procedures to minimise the risk of suspending hot coal particles (e.g., in the crusher) during startup
- Regular cleaning of the facility to prevent accumulation of coal dust (e.g., on floors, ledges, beams, and equipment)
- Removal of hot spots from the coal stockpile (caused by spontaneous combustion) and spread until cooled, avoid loading of hot coal into the pulverised fuel system
- Use of automated systems such as temperature gauges or carbon monoxide sensors to survey solid fuel storage areas to detect fires caused by self-ignition and to identify risk points
- For planned outages, operators should take every precaution to ensure that all idle bunkers and silos are completely empty and also verify by visual checks. Bunkers and silos should be thoroughly cleaned by washing down their interior walls and any interior structural members but not their horizontal surfaces. Idle bunkers and silos that contain coal/lignite should be monitored frequently for signs of spontaneous combustion by using CO monitors, infrared scanning, or temperature scanning.
- Fire fighting systems and fire hydrant systems shall be installed at all hazard prone areas such as coal stock yards, bunkers and silos as per the applicable fire safety standards

7.4 Occupational Safety Management and Surveillance Program

The Ministry of Labour and Employment, Government of India has a nodal organization viz. Directorate General Factory Advice Service and Labour Institutes (DGFASLI) in dealing with Occupational Safety and Health issues in Industries. The Directorate General Factory Advice Service and Labour Institutes (DGFASLI) is the technical arm of the Ministry on matters connected with Occupational Health in the manufacturing and port sectors.

The Factories Act, 1948 provides for appointment of qualified Medical Practitioners and Certifying Surgeons to examine young persons engaged in dangerous manufacturing processes and to ensure medical supervision in case of illness due to the nature of manufacturing processes. The Factories Act, 1948 also provides for notification of certain occupational diseases as listed in the Third Schedule of the Act. As per Section 90 of the Factories Act, 1948, the State Govt. is vested with the powers to appoint a Competent Person to conduct inquiry into the causes of any accident or notifiable diseases.

The following measures needs to be implemented in the work places to enhance occupational health: (1). Identify and involve workers in assessing workplace risks, (2). Assess and consider employees' needs when planning and organising work, (3). Provide advice, information and training to employees, as well as mechanisms for employee feedback such as a suggestion scheme, (4). Occupational health surveillance and Occupational health audit, To develop a system of creating up to date data base on mortality, and morbidity due to Occupational diseases and use it for performance monitoring of the same and (5). Extending support to the state government for effective enforcement of the health provisions stipulated under section 41F of the Factory Act by equipping them with work environment monitoring technologies

The occupational health safety system should be headed by a competent and qualified safety office that will be supported by a team of safety volunteers from each plant and department within the facility. The safety team will take up a detailed task based risk assessment studies and will develop task based safety procedures and work permit

systems. The safety team should record the near misses in the plant and take necessary corrective action to minimize the occupational risks.

A dedicated occupational health centre shall be developed consisting the following facilities: (1) a full time doctor may be appointed to monitor the day-to-day occupational health aspects and also to provide medical advice to the workers, employees and residents of the colony, (2). Minimum facilities such as oxygen cylinder for emergency medical use, two bed clean room for first aid applications, first aid kits as per the Factories act, (3). ECG and XRay facilities, (4). Peak Expiratory flow Meter to check the lung function.

As a part of the surveillance program, the following minimum medical expansion may be undertaken during the pre-employment phase: 1. General physical examination and blood pressure, 2. X-Ray of chest & ECG, 3. Sputum examination, 4. Detailed routine blood & urine examination, 5. Audiometry and 5. Spirometry.

As a part of the routine and annual medical examinations on the persons working in the high noise generating areas, stress areas and dust exposure areas, a comprehensive surveillance program may be adopted. Some of the good management practices are suggested in Table 7.2 and 7.3.

Table 7.2 Suggested Frequency of Medical Examination under Occupational Health Surveillance Program

Age (yrs)	Periodicity	Duration of exposure	Periodicity
< 30 yrs	Once in five years	< 10 yrs	Once in five years
31-40	Once in four years	10 to 20	Once in four years
41-50	Once in three years	21-30	Once in three years
> 51	Once a year	> 31	Once a year

Table 7.3 Suggested Medical Tests under Occupational Health Surveillance Program

S.No	Disorder	Tests to be conducted
1	Heart Diseases	ECG, Blood for Lipid Profile, Stress Test, 2D-Echo and other required Tests
2	Anemia	Hb%, TC,DC, ESR & Stool for Occult Blood, Ova and Cyst
2	Lung Diseases	Sputum, X-Ray Chest, Spirometery
4	Diabetes	Random Blood sugar, Urine sugar, if positive, BSL-Fasting/PPBS iabetic profile
5	Hypertension	Blood Pressure reading, If required Renal profile + ECG and stress test.

6	Urine Examination	Routine and Microscopic

Medical records - A record-keeping system for holding results of medical examinations and reports of symptoms will be needed as part of the health surveillance scheme. These are confidential medical records relating to individuals. As part of the health surveillance programme, workers should be informed of the confidential results of each assessment and of any implications of the findings, such as the likely effects of their continuing to work with vibration.

7.5 Fire Protection and Fire Fighting Systems

Fire fighting systems shall be designed based on the National Building Codes. Since the facility falls under medium-hazard category fire fighting system shall be designed according to the Table 23 of the section 5 in the National Building Codes and summary of the minimum fire fighting systems' requirements are presented in **Table 7.4**. It has been proposed to install jockey pump, diesel pump and electrically operated centrifugal pump for fire water net-work arrangements. Ring-main pipeline systems will be provided to cater to the fire hydrant requirements across the facility. Fire house reels will be provided as per the National Building Code requirements.

Table 7.4 Minimum Required Fire Protection Systems as per National Building Code

Fire extinguisher	Hose Reel	Dry Riser	Wet Riser	Down comer	Yard Hydrant	Automatic Sprinkler system	Manually Operated Electric Fire Alarm Systems	Automatic Detection and Alarm System	Under ground sump	Terrace Tank	Ground Pump Min 3.5Kg/cm2 at terrace level	Terrace Pump 2.0Kg/cm2
b) Moderate Hazard G-2 (see Note 14)												
i) Builtup area up to 100 sq.m												
R	R	NR	NR	NR	NR	R	NR	NR	NR	10000	NR	450
ii) Builtup area more than 100 sq. m and up to 500 sq.m												
R	R	NR	NR	NR	NR	R	NR	NR	NR	10000	NR	900
iii) Builtup area more than 500 sq.m and up to 1000 sq.m												
R	R	NR	R	R seeNote 7	R	R	R	R	75000	20000	seeNote 20	900
iv) Builtup area more than 1000 sq.m												
R	R	NR	R	R seeNote 7	R	R	R	R	100000	20000	seeNote 20	900

R : Required
NR : Not required
Note 7 : Required to be provided for buildings with height more than 15m.
Note 20 : one electric and one diesel pump of capacity 280 liters/minute each and one electric pump of 180 liters/minute