1.1 INTRODUCTION

A risk assessment is a careful examination of consequences resulting from the undesired events that could cause harm to people or property, so that sufficient precautions can be taken. Workers and others have a right to be protected from harm caused by a failure to take reasonable control measures.

1.1.1 OBJECTIVES OF THE RISK ASSESSMENT

As per the requirements stated in the Terms of Reference of the EIA study, the risk assessment study has been undertaken to address the following aspects:

- To identify hazards such as fire and explosion hazards arising from handling of molten metal as well as storage of chemicals
- To predict various credible scenarios and develop maximum credible accident scenarios with consequence
- To eliminate or reduce to as low as reasonably practical in terms of risk to human health, risk of injury, risk of damage to plant, equipment and environment, business interruption or loss etc.

1.2 IDENTIFICATION OF HAZARDS

1.2.1 IDENTIFICATION OF HAZARDS BY FIRE AND EXPLOSION INDEX & TOXICITY INDEX

Fire and Explosion Index (F&EI) is an important technique employed for hazards identification process. Consequence analysis then quantifies the vulnerable zone for a conceived incident. Once vulnerable zone is identified for an incident, measures can be formulated to eliminate or reduce damage to plant and potential injury to personnel.

Rapid ranking of hazard of an entire installation, if it is small, or a portion of it, if it is large, is often done to obtain a quick assessment of degree of the risk involved. The Dow Fire and Explosion Index (F&EI) and Toxicity Index (TI) are the most popular methods for Rapid Hazard Ranking. These are based on a formal systematized approach, mostly independent of judgmental factors, for determining the relative magnitude of the hazards in an installation using hazardous (inflammable, explosive and toxic) materials.
The steps involved in the determination of the F & EI and TI are:

- Selection of a pertinent process unit
- Determination of the Material Factor (MF)
- Determination of the Toxicity Factor (Th)
- Determination of the Supplement to Maximum Allowable Concentration (Ts)
- Determination of the General Process Hazard Factor (GPH)
- Determination of the Special Process Hazard Factor (SPH)
- Determination of the F&EI value
- Determination of the TI value
- Determination of the Exposure Area

1.2.2 HAZARDOUS MATERIAL IDENTIFICATION METHODOLOGY

From the preliminary appraisal of Material Safety Data Sheet, it is observed that Light diesel oil (LDO) is hazardous. F&EI and TI values have been computed for LDO storage tank.

In general, the higher is the value of material factor (MF), the more inflammable and explosive is the material. Similarly, higher values of toxicity factor (Th) and supplement to maximum allowable concentration (Ts) indicate higher toxicity of the material. The tabulated values of MF, Th and Ts are given in Dows Fire and Explosion Index Hazard Classification Guide. For compounds not listed in Dow reference, MF can be computed from the knowledge of flammability and reactivity classification, Th can be computed from the knowledge of the National Fire Protection Association (NFPA) Index and Ts can be obtained from the knowledge of maximum allowable concentration (MAC) values. The MF, Th and Ts values are respectively 10, 0 and 50 for LDO.

General process hazards (GPH) are computed by adding the penalties applied for the various process factors.

Special process hazards (SPH) are computed by adding the penalties applied for the process and natural factors.

Both General process hazards and Special process hazards corresponding to various process and natural factors are used with MF to compute F&EI value and with Th and Ts to compute TI value.
1.2.3  F&EI Computation

F&EI value computed for TPS and CTT from GPH and SPH values using the following formula:

\[ F&EI = MF \times [1 + GPH (total)] \times [1 + SPH (total)] \]

1.2.4  Toxicity Index (TI)

Toxicity index (TI) is computed from toxicity factor (Th) and supplement to maximum allowable concentrations (Ts) using the following relationship:

\[ TI = (Th + Ts) \times [1 + GPH (total) + SPH (total)]/100 \]

Calculation for F&EI as well as TI is given in table shown below for Natural gas, Monoethylene Glycol and Coal.

**Table 1: Fire and explosion index for coal**

<table>
<thead>
<tr>
<th>FIRE AND EXPLOSION INDEX FOR COAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Material Factor</strong></td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>Base factor</td>
</tr>
<tr>
<td>A Exothermic reaction</td>
</tr>
<tr>
<td>B Endothermic process</td>
</tr>
<tr>
<td>C Material handling and transfer</td>
</tr>
<tr>
<td>Enclosed or Indoor process</td>
</tr>
<tr>
<td>D unit</td>
</tr>
<tr>
<td>E Access</td>
</tr>
<tr>
<td>F Drainage &amp; spill control</td>
</tr>
<tr>
<td>General process Hazard</td>
</tr>
<tr>
<td>factor F1</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>D</td>
</tr>
<tr>
<td>E</td>
</tr>
<tr>
<td>F</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>G</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>H</td>
</tr>
<tr>
<td>I</td>
</tr>
<tr>
<td>J</td>
</tr>
</tbody>
</table>
Table 2: Conclusion for Fire, Explosion & Toxicity Index

<table>
<thead>
<tr>
<th></th>
<th>Applicable Fire and Explosion index range</th>
<th>1-60</th>
<th>Light</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>61-96</td>
<td></td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>97-127</td>
<td></td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>128-158</td>
<td></td>
<td>Heavy</td>
</tr>
<tr>
<td></td>
<td>&gt;159</td>
<td></td>
<td>Sever</td>
</tr>
</tbody>
</table>

CONCLUSION FOR TOXICITY INDEX

<table>
<thead>
<tr>
<th></th>
<th>Applicable Toxicity index range</th>
<th>1-5</th>
<th>Light</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6-9</td>
<td></td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>above 10</td>
<td></td>
<td>High</td>
</tr>
</tbody>
</table>

| K | Hot oil heat exchange system | 0.15-1.15 | 0 |
| L | Rotating equipment          | 0.5      | 0 |
|   | Special process Hazard F2   | 2.50     |   |
|   | Process unit hazard         |          |   |
|   | factor(F1×F2)=F3            | 4.75     |   |
|   | Fire and Explosion          |          |   |
|   | Index(F3×MF)                | 76       |   |
|   | Toxicity number Th          | 50       | Nh=1 |
|   | Penalty factor Ts           | 50       | TLV 0.5 ppm |
|   | Toxicity Index              | 3.40     |   |
1.2.5 Hazards Ranking

Table 3: Hazards Ranking

<table>
<thead>
<tr>
<th>Substance</th>
<th>F&amp;EI value</th>
<th>TI value</th>
<th>F&amp;EI range</th>
<th>TI range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>76</td>
<td>3.4</td>
<td>Moderate</td>
<td>Light</td>
</tr>
</tbody>
</table>

1.3

From the above index calculations and process analysis various hazards identified from the proposed project activities are as under:

- Fire and explosion hazard due to handling of molten metal
- Fire hazard due to handling and storage coal

Other hazards are:

- Occupational health hazards
- Other hazards

1.3.1 Hazards due to handling of molten metal

Wet material charging and failure of refractory are common cause of molten metal spillage / splashing in induction furnace.

Wet charge materials are a serious safety hazard in all foundries. Water, moisture, or any liquid-bearing material instantaneously turns to steam when coming in contact with molten metal — expanding to 1,600 times its original volume and producing a violent explosion. This occurs without warning and throws molten metal and possibly high-temperature solids out of the furnace, putting workers, the furnace itself, and nearby plant and equipment at risk.

A water/molten metal explosion can occur in any type of furnace. For an induction furnace, however, the aftereffects may be more serious, including the possibility of additional explosions caused by liquid in a ruptured cooling system coming in contact with molten metal in the bath. Molten metal need not be present in the furnace for a water/molten metal explosion to occur. Explosions also can occur if sealed drums or containers containing water are charged into an empty but hot furnace. In this case, the force of the explosion will eject the newly charged material and quite likely damage the refractory lining as well.
Bridging

When charge material in the top portion of the furnace is not in contact with the molten metal below it, the dangerous condition known as bridging exists. When bridging occurs, charge material is no longer serving to moderate the temperature of the bath during the melting cycle. Also, the air gap between the molten metal and the bridge acts as an insulator. The molten metal below the bridge, under the impact of full melting power, will superheat.

This superheating in an induction furnace will occur very rapidly and will raise the temperature of the molten bath above the maximum temperature rating of the refractory. Also, excessive metal stirring below the bridge, due to the small metal mass and high power density, will combine with the high metal temperatures to cause rapid lining erosion or possibly complete refractory failure.

Without immediate attention to a bridging condition, a run-out due to refractory failure may occur. If the run-out is through the bottom of the furnace, it can cause a fire under the furnace and in the pit area resulting in a loss of hydraulics, control power, and water cooling.

If the run-out is through the side of the furnace, the coil may be compromised and when cooling water comes in contact with the molten metal, the water instantaneously turns into steam. If the water becomes trapped by the molten metal, this instantaneous expansion may produce an explosion which could cause injury or death and extensive damage to equipment. Bridging can occur in any induction furnace.

Physical damages to refractory

Metal run-out ranks among the most severe accidents that can occur during melting and holding operations. Runouts occur when molten metal breaks through the furnace lining. If cooling, electrical, hydraulic or control lines become damaged, there is danger of a fire or water/molten metal explosion.

- The sudden or cumulative effects of physical shocks and mechanical stress can lead to failure of refractory lining. Most refractory materials tend to be brittle and weak in tension. Bulky charge material dropped into an empty furnace can easily cause the lining to crack upon impact. If a crack goes unnoticed, molten metal may penetrate,
leading to a run-out with the possibility of a water/molten metal explosion. Physical damages to refractory during installation

- Mechanical stress caused by the difference in thermal expansion rates of the charge and refractory material can be avoided by assuring charge material does not become jammed within the furnace

- In induction furnaces, refractory linings and crucibles are subject to regular wear from the scraping of metal on the furnace walls, largely because of the induction stirring action caused by the furnace’s electromagnetic field. In theory, refractory wear should be uniform, but in practice this never occurs. The most intense wear occurs:
  - At the slag/metal interface;
  - Where sidewalls join the floor; and,
  - At thin spots caused by poor lining installation.

- Thermal shock also can be caused by excessive heating or improper cooling. If furnace operating conditions heat or cool the lining beyond its specified range, the resulting thermal shock can damage the integrity of the lining

Fins of molten metal can penetrate worn or damaged refractory and come into contact with the coil.
• Highly abrasive materials, slag and dross erode lining near the level of the molten metal. It is not uncommon for this part of the furnace, above the molten metal line, to be patched between scheduled relining. In extreme circumstances, this erosion may expose the induction coil, creating the risk of a water/molten metal explosion.

1.3.2 Hazards in Coal Handling

1.3.2.1 Exposure to coal dust in handling coal.

• Inhalation
• Ingestion
• Skin contact
• Eye contact
• Fall of object [Coal Pieces] while collecting spilled coal below running conveyors.

1.3.2.2 Fire hazards in Coal Storage

• Self heating of coal to its ignition temperature, resulting in what is called spontaneous combustion, is a phenomenon identified with coal storage in industries. Virtually all grades of coal (except high grade anthracite) are vulnerable to spontaneous heating and ignition. Although the precise cause of the spontaneous combustion of coal is not well defined, it is believed that when coal is freshly mined, the fresh surface of coal pieces liberate absorbed hydro-carbons, chiefly methane (in varying amounts). After the escape of the absorbed gases, the exposed surface of coal particles get oxidized by the oxygen in the ambient air. The oxidation is very slow but heat is generated in the process. If the heat is not allowed to dissipate, the temperature of the coal may rise gradually but sufficiently enough to cause the mass to ignite. It is also believed that this self heating of coal usually occurs in about 90 to 120 days after the coal is extracted in mining operations.

• Oxidation in coal stacks takes place mainly from loosely packed coal stacks and the consequent availability of oxygen in the voids of the stacks. The rate of oxidation is high at the outer surface of the stacks because of the availability of abundant oxygen there. The rise in temperature, however, cannot be detected due to the dissipation of heat by air movement. This zone extends roughly up to a depth of 0.5m. The
situation beyond this zone, say up to a depth of 1.5m, is different. The coal in this zone is also different. The coal in this zone also oxidisers fairly rapidly in the presence of adequate quantity of air entering the stack, but the heat generated in the course of this reaction is generally partially dissipated through convection and conduction. The heat transfer from this zone depends on factors like ambient temperature, rate of air movement around that zone, free moisture available in the material and thermal conductivity. The residual heat thus present in this zone further raises the temperature of the coal mass until it attains the critical (threshold) temperature i.e. the auto ignition temperature. Once it reaches critical temperature, the coal in the zone starts burning and smoking and eventually erupts in flames. Proneness to spontaneous combustion, therefore, can be determined by ascertaining the critical oxidation temperature or crossing point. The lower the crossing point, the more is the proneness to self heating.

- All types of coal, when exposed to the atmosphere, are liable to suffer deterioration of quality through surface oxidation, but the extent of deterioration differs from type to type. Lignite is a type of brown coal containing a high percentage of volatiles. It is subject to weathering much more rapidly than bituminous coal. It contains a large percentage of moisture (as much as 40%) as mined, of which nearly 20% exists even before it is mined. Under dry hot ambient conditions, particularly in India where temperature in a shed could go up to 450°C and humidity to less than 30%, lignite oxidation rate could be high. The rate of release of carbon monoxide which is indicative of the oxidation rate may be as high as 70 m³ of CO per ton of lignite, which is about 100 times that of normal bituminous coal. It has also been observed that in large coal storage yards left undisturbed for long periods, smoldering takes place at the surface layers of the pile. In case of lignite, this phenomenon is more rapid. Highly volatile coal is particularly liable to spontaneous combustion.

- Coal is highly combustible and the range of ignition temperature range for coal is 260-365 degF.

1.3.2.3 Explosion hazard during coal storage:

Dust Explosion, an explosion caused by the sudden igniting of a mixture of air and a heavy concentration of combustible dust particles. A mixture containing fine dust is more explosive because there is more exposed particle surface.
The flame or spark that sets off a dust explosion can be produced by friction, static electricity, matches, defective wiring, blowtorches, or any open flame. Dust composed of grain, flour, starch, coffee, cotton, coal, sugar, or other organic materials is highly explosive.

1.4 CONTROL MEASURES FOR ABOVE HAZARDS

Out of above mention hazards, various control measures suggested based on their cause of failure are as under.

1.4.1 Molten metal spillage and splashing

- Diligently examining and treating scrap, following induction furnace safety procedures, properly training and retraining personnel, and use of automated melt shop equipment, founders can be confident their operations are as safe as possible.

- Bridging can be minimized by using proper charge material and by making sure the different sizes of charge material are added correctly. If a bridge occurs, power must be turned off and the melt deck and surrounding areas evacuated immediately until enough time has elapsed to allow the molten metal to solidify.

- Bridging may reveal itself with several warning signs. The clearest warning sign that bridging has occurred is that the melt is taking longer than calculated. Rather than increase the power, the operator should switch off power immediately. Under no circumstance should the operator increase power.

- Many serious foundry accidents occur during furnace charging, when foundry workers come in close proximity to the molten bath. Splashes caused by dropping large pieces of scrap and water/molten metal explosions caused by wet or damp scrap can be reduced through the use of drying and preheating systems and remotely controlled charging systems.

- Appropriate Personal Protective Equipment (PPE) protects melt shop workers from both metal splash and radiant heat.

- Do not allow water or hydraulic fluid to accumulate in the pit. It is designed to hold molten metal in case of an emergency and must be kept clean and dry.

- Choosing appropriate refractory lining material and their additives / bonding material.
• Proper installation of the lining is as important as selection of the right material. If the material is inadequately compacted during installation, voids or areas of low density may form, creating a weak spot easily attacked by molten metal. If the crucible is created with a lining form that is improperly centered, or one that has been somehow distorted during storage or shipment, lining thickness will be uneven. As a result, the lining may fail before the end of its predicted service life.

• The refractory manufacturer’s procedures for installation, drying and sintering must be followed. If sufficient time is not allowed for refractory materials to bond, the lining will be more prone to molten metal and slag attack.

• The entire furnace should be visually inspected whenever it is emptied. Special attention should be paid to the high wear areas described above. Observations should be logged.

• Follow refractory manufacturer’s instructions for lining inspection and maintenance.

• Operators should be properly trained to identify unevenness in operation through
  • Visual inspection
  • Attainment of maximum power at a lower than normal applied voltage.
  • In a fixed-frequency power supply, an increase in the number of capacitors needed to be switched into the circuit to maintain unity power factor.
  • In a variable-frequency power supply, running at a higher than normal frequency. Useful though they may be, changes in electrical characteristics must never be thought of or used as a substitute for physical inspection of the lining itself.

• A magnetic contact thermometer attached to the steel shell of a channel furnace will indicate lining wear by revealing the position of a hot spot. Infrared thermometers make it possible to remotely measure temperature by looking at a furnace through the eyepiece of a device resembling a hand-held video camera. State-of-the-art, automatic lining-wear detection systems that display the lining condition graphically are available also.

• Bulky material should be lowered into the furnace. If it must be “dump charged,” be sure there is adequate charge material beneath the charge to cushion its impact.

• In the event of a prolonged power failure, a loss of coolant or other prolonged furnace shutdown, the furnace must be emptied.
• Avoid excessive superheating of the molten bath providing controller for temperature

• When working with a cold holding furnace, be sure it is properly preheated to the refractory manufacturer’s specifications before filling it with molten metal to avoid thermal shock.

• Ground leak detection system should be provided.

1.4.2 CONTROL MEASURES FOR HANDLING AND STORAGE COAL

1.4.2.1 Control measures to be adopted during storage of coal

• Storage of large quantities of coal requires two conditions to be met viz. (i) avoidance of deterioration in quality and (ii) avoidance of heating in the pile. While neither of the conditions can be fulfilled completely, deterioration and risk of fire can be reduced to a minimum by careful manipulation of the conditions of storage.

• As basic necessary steps to avoid spontaneous heating in coal storage, the following guidelines will be adopted:
  * The ground or floor where coal is to be stored will be thoroughly cleaned of leaves, grass, weds, pieces of wood, cotton waste or other organic waste and precautions taken to prevent such matter from getting under, into or on the coal pile.
  * There will not be any steam or hot process pipelines or openings or sewers under, into, through or adjacent to coal piles.
  * The storage site will be provided with drainage facility to prevent accumulation of water on the ground.
  * Special attention will be given to monitoring of the coal stack, in excess of 42°C.
  * The pile will be planned so as to facilitate dissipation of heat by wind from the surface of the pile. Any barrier / obstruction to wind will be removed.
  * Newly broken fines of coal are more susceptible to spontaneous heating. Dropping coal from heights while piling will be avoided.
  * Conical piles will be avoided - these storage will be built up in layers by roll packing - this helps to exclude oxygen and thus prevents fires by discouraging spontaneous heating.
  * As far as possible coal piles from different sources will not be stored together.
• Coal stock should be limited in height. Low-grade coal will not be piled higher than 3 meters and best grade not higher than 4-5 meters. Coal will be stored in mixed sizes as too many fines will be hazardous.
• No standing timber or pipes, poles, etc. will be allowed in the piles. These may give rise to formation of duct which allows sluggish air flow which may be sufficient for heating the coal but not sufficient to dissipate the heat.
• It is recommended to locate coal yards at least 6-7 meters away from any important buildings and other combustible storage areas.

1.4.2.2 Control measures to be adopted for prevention of Coal Stock Fires

• During the period of low off take, coal stock generally tends to build up to alarming levels. Since most of the grades of coal are susceptible to spontaneous ignition if it is undisturbed for a certain period of time, risk of fire exists in coal stacks. Following precautions will be taken for preventing spread of coal stock fire:
  • Consumption of coal will be done on first in-first out basis. (FIFO)
  • Temperature of the coal pile will be checked regularly. Specific attention will be given to the sloped sides of the piles where vulnerable air pockets exist. If pile temperature exceeds 70°C, the pile will be opened and placed the overheated material in a separate small pile or use it promptly.
  • Inspection of stack will be done to detect smoldering and organize removal / consumption of the smoldering coal on priority and to extinguish the flames in time. Such inspections are vital after the rains as water falling on the surface and penetrating the coal pile may aggravate and accelerate spontaneous heating by assisting oxidation.
  • Coal having high moisture content will be stored separately, if possible, and used promptly.
  • Continuous water sprinkle system is working in the coal shed yard and open area to avoid Self heating of coal to its ignition temperature.

1.4.2.3 Resources:

• Availability of fire hydrant and spray system around the stack yard.
• Fire fighting tenders.
• Portable diesel fire fighting pump.
• Trained fire fighting personnel.
• Earth moving equipment (2 nos. dozers & one pay loader).
• 200 m of fire fighting hose along with different kinds of nozzles.

1.4.2.4 Procedure:

• On observation of emergency fire situation in coal stack yard CHP operation engineer shall immediately report to ECC (Emergency Control Center).
• On receipt of communication from ECC all key personnel shall reach to designated emergency control centre.
• Work incident controller shall ensure containing of the fire affected stack yard by cutting of coal on either side of coal stack by means of available machinery such as dozers.
• The coal so removed shall be transported to the unaffected portion of the stack yard or adjacent stack yard.
• After ensuring complete isolation of the affected portion of stack yard, press spray of water from water hydrant from all possible directions along with tenders. Ensure quenching of flames and smoldering coal. Spontaneous hibernation of steam from the quenched coal stack should not be a cause of worry, however care to be exercised that persons involved in tackling the emergency does not get hurt by the steam burst.
• Excess fire fighting water going through the drain shall be contained in the holding pond and shall be released only after complete settling of coal in the holding pond.
• After containing the fire completely, press dozers in service and compact the coal further. Reclaim the partially burnt coal at the earliest opportunity to bunker.

1.4.2.5 Other precautions:

Following precautions related to safety would be taken while installing the machine:

• It will be ensured that there is ready access to the Grease Nipple.
• Sufficient clearance will be kept between ground and discharge chutes for fitting of discharge conveyor.
• It will be ensured that the side door is accessible and does not foul on surrounding structure.
• V belts will be tightened as specified.
• A magnetic separator will be provided to avoid ingress of any non-crushable material.

Like any other transmission machinery, belt conveyors present risk of injury. Experience shows that conveyor accidents often involve fatal or very serious injuries and severe damage to property.

• As conveyor systems are vital links in the production chain, their stoppage due to accidents or breakdowns can lead to serious business interruption loss.

• In bulk material transportation systems, excessive spillage represents wastage of material, and emission of dust can present occupational safety and health problems.

• Most personal injury accidents with belt conveyors occur when hands of persons are trapped in inadequately guarded nip points and pinch points near pulleys and idlers.

• Mechanical failure of conveyor components due to deficiencies in design and operational and maintenance procedures also render the conveyor systems hazardous.

• Spillage of materials, fires from friction, overheating, static charge and other electrical sources are the other typical hazards encountered in belt conveyor systems.

1.4.2.6 Grounding and Lightning Protection

The grounding requirement of the power plant is divided into the following two main categories:

• System grounding

• Equipment grounding

The system grounding is adopted to facilitate ground fault relaying and to reduce the magnitude of transient over-voltage. The system grounding involves primarily the grounding of the generators and transformer neutrals. High impedance grounding is envisaged for 13.8 kV system generator neutrals, which would be achieved through neutral grounding Transformer. The 6.6kV system will be operated with medium resistance grounded. 220kV and 415 V systems will be solidly grounded and the 220 V DC system will be ungrounded.

The equipment body grounding (at least two numbers) is to be adopted to provide protection to personnel and equipments from potentials caused by ground fault currents and lightning discharges.
A stable ground grid will be provided for grounding of equipment and structures maintaining the step and touch potentials within safe limits. An earth mat would be laid in and around the power plant. This mat would be buried at a suitable depth

Below the ground and provided with ground electrodes at suitable spacing. All non-current carrying metallic parts of equipment will be connected to the grounding mat. Buildings, structures, transmission towers will also be connected to the grounding mat.

Lightning protection system will be installed for protection of the buildings / structures and equipment against lightning discharge. This will be achieved by providing lightning masts, down conductors on buildings/structures, towers in switchyard and connecting these with ground grid.

Besides this, for outdoor equipment exposed to atmosphere, protection against lightning surges will be provided with lightning surge arresters at suitable locations, over and above the shielding wires and lightning masts to safeguard the equipment.

1.4.3 OCCUPATIONAL HEALTH AND SAFETY

During the project work lot of activities will be involved such as construction, erection, testing, commissioning, operation and maintenance, the men, materials and machines are the basic inputs. Along with the boons, the industrialization generally brings several problems like occupational health and safety.

The following occupational health and safety issues are specific to proposed plant activities will arise during project work as well as regular operation of plant:

- Physical hazards
- Radiation hazards
- Respiratory hazards
- Electrical hazards
- Noise
- Burial hazard
- Entrapment hazards
- Fire and explosions

1.4.3.1 Physical Hazards

Industry specific physical hazards are discussed below.
Potential physical hazards in proposed plant are related to handling heavy mechanical transport (e.g. trucks) and work at heights (e.g. platforms, ladders, and stairs).

**Heavy Loads / Rolling during construction phase**

Lifting and moving heavy loads at elevated heights using hydraulic platforms and cranes presents a significant occupational safety hazard. Recommended measures to prevent and control potential worker injury include the following;

- Clear signage in all transport corridors and working areas;
- Appropriate design and layout of facilities to avoid crossover of different activities and flow of processes;
- Implementation of specific load handling and lifting procedures, including:
  - Description of load to be lifted (dimensions, weight, position of center of gravity)
  - Specifications of the lifting crane to be used (maximum lifted load, dimensions)
  - Train staff in the handling of lifting equipments and driving mechanical transport devices
- The area of operation of fixed handling equipment (e.g. cranes, elevated platforms) should not cross above worker and pre-assembly areas;
- Material and product handling should remain within restricted zones under supervision;
- Regular maintenance and repair of lifting, electrical, and transport equipment should be conducted.
- Use appropriate PPE (e.g. insulated gloves and shoes, goggles to protect against radiation, and clothing to protect against heat radiation and liquid metal splashes);
- Install cooling ventilation to control extreme temperatures;
- Implement work rotations providing regular work breaks, access to a cool rest area, and drinking water.

Physical hazards in foundry operations may be related to handling of large, heavy, and hot raw materials and product (e.g. charging of furnaces); accidents related to heavy mechanical transport (e.g. trains, trucks and forklifts); injuries from grinding and cutting
activities (e.g. contact with scrap material ejected by machine-tools); and injuries due to falls from elevation (e.g. high platforms, ladders, and stairs).

**Product Handling**

Prevention and control of injuries related to handling, grinding and cutting activities, and use of scrap, include the following:

- Locate machine-tools at a safe distance from other work areas and from walkways.
- Individual, enclosed workplaces should be provided to prevent accidents resulting from fettling or the use of grinders;
- Conduct regular inspection and repair of machine-tools, in particular protective shields and safety devices / equipments;
- Provide rails along the transfer plate with interlocked gates that open only when machine is not in use;
- Train staff to properly use machines-tools, and to use appropriate personal protection equipment (PPE).

**Heat and Hot Liquid Splashes**

High temperatures and direct infrared (IR) radiation are common hazards in foundries. High temperatures can cause fatigue and dehydration. Direct IR radiation also poses a risk to sight. Contact with hot metal or hot water may result in severe burns. Recommended measures for prevention and control of exposure to heat and hot liquids / materials include the following:

- Shield surfaces where close contact with hot equipment or splashing from hot materials is expected (e.g. in cupola furnaces, EAF, induction melting ladles, and casting);
- Implement safety buffer zones to separate areas where hot materials and items are handled or temporarily stored. Rail guards around those areas should be provided, with interlocked gates to control access to areas during operations;
- Use appropriate PPE (e.g. insulated gloves and shoes, goggles to protect against IR and ultraviolet radiation, and clothing to protect against heat radiation);
- Implement shorter shift durations for work in high air temperature environments. Provide regular work breaks and access to drinking water for workers in hot areas;
• Install cooling ventilation to control extreme temperatures.

1.4.3.2 Radiation hazards

Workers may be exposed to gamma rays and related ionizing radiation exposure risks. The following techniques may be used to limit the worker exposure risk:

• Gamma ray testing should be carried out in a controlled, restricted area using a shielded collimator. No other activities should be undertaken in the testing area;
• All incoming scrap should be tested for radioactivity prior to use as feedstock material;
• If the testing area is near the plant boundary, ultrasonic testing (UT) should be considered as an alternative to gamma ray techniques;
• Regular maintenance and repair should be conducted on testing equipment, including protective shields.

1.4.3.3 Respiratory Hazards

Dust and Gas

Dust generated in foundries includes iron and metallic dusts, which are present in melting, casting and finishing shops; and wooden and sand dusts, which are present in the molding shop. In the former, workers are exposed to iron oxide, and silica dust that may be contaminated with heavy metals such as chromium (Cr), nickel (Ni), lead (Pb), and manganese (Mn). The dust present in the melting and casting shops is generated by high temperature operations, and the fine particle size, and potential metallurgical fumes, creates a serious occupational inhalation risk. In the molding shop, workers are exposed to sand dust, which may contain heavy metals, and wood dust, which may have carcinogenic properties, particularly if hard wood is used. Recommendations to prevent exposure to gas and dust include the following:

• Sources of dust and gases should be separated and enclosed;
• Design facility ventilation to maximize air circulation. Outlet air should be filtered before discharge to the atmosphere;
• Exhaust ventilation should be installed at the significant point sources of dust and gas emissions, particularly the melting shop;
• Use automated equipment, especially in the fettling process;
• Provide separated eating facilities that allow for washing before eating;
• Provide facilities that allow work clothes to be separated from personal clothes and for showering / washing after work and before eating;
• Implement a policy for periodic personnel health checks.
• Respiratory hazard control technologies should be used when exposure cannot be avoided with other means, such as operations for creating sand moulds; manual operations such as grinding or use of non-enclosed machine-tools; and during specific maintenance and repair operations.

Recommendations for respiratory protection include the following:

• Use of filter respirators when exposed to heavy dust (e.g. fettling works);
• For light, metallic dust and gases, fresh-air supplied respirators should be used.
• Alternatively, a complete facial gas mask (or an “overpressure” helmet) can be used, equipped with electrical ventilation;
• For carbon monoxide (CO) exposure, detection equipment should be installed to alert control rooms and local personnel. In case of emergency intervention in areas with high levels of CO, workers should be provided with portable CO detectors, and fresh-air supplied respirators.

**Insulation Materials**

The use of insulation material is widespread in foundries and handling of this material during construction and maintenance may release fibers and present an occupational health hazard. Asbestos and other mineral fibers widely used in older plants may expose people to inhalation risks of cancer-causing substances. In order to limit releases, appropriate and material specific work practices should be applied.

1.4.3.4 **Electrical Hazards**

Workers may be exposed to electrical hazards due to the presence of heavy-duty electrical equipment in plant.

1.4.3.5 **Noise**

The foundry process generates noise from various sources, including scrap handling, furnace charging and EAF melting, fuel burners, shakeout and mould / core shooting, and
transportation and ventilation systems. Recommended noise management techniques include the following:

- Enclose the process buildings and / or insulate them;
- Cover and enclose scrap storage and handling areas, as well as shake out and fettling processes;
- Enclose fans, insulate ventilation pipes and use dampers;
- Implement management controls, including limitation of scrap handling and transport during nighttime. Noise abatement measures should achieve the ambient noise levels

1.4.3.6 Explosion and Fire Hazards

Handling of liquid metal may generate a risk of explosion, melt run out, and burns, especially if humidity is trapped in enclosed spaces and exposed to molten metal. Other hazards include fires caused by melted metal, and the presence of liquid fuel and other flammable chemicals. In addition, iron foundry slag may be highly reactive if calcium carbide is used to desulfurize the iron. Recommended techniques to prevent and control explosion and fire hazards include the following:

- Design facility layout to ensure adequate separation of flammable gas and oxygen pipelines, and storage tanks, away from heat sources;
- Separate combustible materials and liquids from hot areas and sources of ignition (e.g. electrical panels);
- Protect flammable gas and oxygen pipelines and tanks during “hot work’ maintenance activities;
- Emergency preparedness and response.

1.4.4 OTHER HAZARDS AND ITS CONTROLS

The other hazards possible at site are as given below:

<table>
<thead>
<tr>
<th>Name of possible hazard or source &amp; reason</th>
<th>Its effects on person, property &amp; environment</th>
<th>Place of effect</th>
<th>Control measures provided</th>
</tr>
</thead>
</table>

Table 4: Other Hazards and Its Controls
<table>
<thead>
<tr>
<th>emergency</th>
<th>Building collapse Earthquake</th>
<th>Injuries &amp; Fatalities Building damage.</th>
<th>All building &amp; sheds of the company as given in the Fac. layout</th>
<th>Structure stability is by competent person for all structure. No overloading of structures and building.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Any natural Calamities Week structure Over loading</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Installation failure like Transformer, PCC etc.</td>
<td>Overload Loose contacts Short circuit</td>
<td>Fire Suffocation of persons inside the plant</td>
<td>Electrical transformer switch yard Electrical MCC rooms Power plant</td>
<td>Installation as per electricity rules. Other Controls provided Rubber mat provided Earthing provision</td>
</tr>
</tbody>
</table>

### 1.5 AUTOMATIC FIRE DETECTION AND CONTROL MEASURES

#### 1.5.1 General

The plant's fire protection shall consist of structural solutions, fire extinguishing systems and fire alarm systems. The fire extinguishing system shall consist of the fire water system with fire pumps distribution pipelines, hydrant valves and fire hoses and the portable fire extinguishers.

#### 1.5.2 FIRE WATER SYSTEM

Separate fire water tank is proposed for firefighting system. Water will be taken from underground water storage tank from there water require for firefighting will be taken to fire water tank for firefighting system.

Details of fire water reservoir are as under:
1.5.3 Fire Water / Hydrant System

**Fire pumps**

There shall be two fire pumps, one electric and one diesel engine driven. The pumps supply water for the fire line and the fixed fire extinguishing systems. Either of these centrifugal pumps can alone deliver the required amount of water. At the rated flow, the pressure produced by the pumps shall be adequate, at least 6 bar by the rated flow, and at a zero flow not exceed 10 bar.

**Jockey Pumps**

An electric motor driven jockey pump will maintain automatically system pressure in the fire line. In case of emergency main pump will be turned on manually.

Pressure switches located in the fire water main shall sense sudden drop of pressure below set point, due to opening of any hydrant valves, which shall provide the starting signal to the jokey pumps. For stopping of the pumps only manual arrangement shall be provided.

The run and fault alarms from the fire pumps are led to the control room. The pumps will be located in pump house which shall be constructed by purchaser based on input from supplier.

Details of fire fighting main pumps and jokey pump for fire hydrant and sprinkler system are as under:

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>Pumpset</th>
<th>Start</th>
<th>Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>HYDRANT</td>
<td>Jockey pump</td>
<td>6.00</td>
<td>7.00</td>
</tr>
<tr>
<td></td>
<td>Main pump</td>
<td>5.00</td>
<td>Manual</td>
</tr>
<tr>
<td></td>
<td>Stand by pump</td>
<td>4.00</td>
<td>manual</td>
</tr>
</tbody>
</table>

---

**Table 5: Fire tank capacity details**

<table>
<thead>
<tr>
<th>Sr no</th>
<th>Proposed</th>
<th>Volume m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fire hydrant tank</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>500</td>
</tr>
</tbody>
</table>
**Diesel Engine**

Diesel engine shall be equipped with an approved automatic auxiliary starting device having a sufficient capacity for at least six starts of fire pump. The diesel pump shall have a fuel tank containing sufficient fuel to enable the pump to run on full load for at least three hours.

**Water distribution system**

Fire piping shall be of MS Class “C” with supports for above ground lines. For underground piping GI class “C” pipes with necessary fittings will be used. The piping will be externally painted. The codes IS1239/IS 3589 will be followed. All underground pipes shall have cathodic protection. Sufficient no of isolation valve shall be provided to Isolate the area in case of maintenance. The diameter of the fire pipes shall be sufficient for the effective use of at least two fire hoses. The pipes and hydrants will be so placed that the fire hoses may be easily coupled to them.

**Hydrants**

Hydrant type Fire Protection System essentially shall consist of a network of piping and hydrant valves- both indoor & outdoor. The distance between any two hydrants shall not be more than 45 meters. Each hydrant shall be provided with a hose cabinet (mounted along side the hydrant on a steel column, lockable type) containing two nos. of 15 M long hoses and branch pipes/nozzles. For multi-stored office building, a wet riser tapped off from the hydrant main, shall be provided for each stair case inside the stair case and on this riser hydrant outlet with first aid hose reel connection shall be provided on each floor. Each hydrant shall be provided with a wall/column mounted on hose cabinet containing two nos. of hose and branch pipe/nozzle.

The number and position of the hydrants shall be such that spray from at least two hoses with combined jet and water fog nozzles may reach any part of the engine hall or auxiliary room and spray from one combined jet and water fog nozzles may reach any part of other places. A hydrant unit inside the power house shall consist of two hose couplings of size DN50, both equipped with a shutoff valve. There will be two couplings beside each other to make it possible to use the water hose and mobile foam unit simultaneously. Some hydrants shall also to be installed on an external wall, to allow the use of hoses outside a building.

Fire hoses shall be cotton and nylon jacket seamless woven and rot proofed material equipped with quick couplings and adjustable water fog nozzles. Hose couplings and nozzles throughout the fire line shall be completely interchangeable. Hose couplings shall be made of a copper alloy or other approved material.
Hose length : 15 m
Hose diameter : 63 mm
Busting pressure test : 32 kg/cm²

Adequate number of fire hydrant accessories including single headed hydrant valves, fire escape hydrant valves and water monitors will be installed in fire hydrant network system.

1.5.4 Fire Alarm And Detection System

The fire alarm and detection centre shall be located in the control room. Manual call points shall be installed at critical points and escape routes. Manual alarms shall set off by breaking a glass disk and pressing a button.

The fire detection system shall comprise of smoke and heat detectors. The fire detection system shall be installed throughout the area and shall at least cover the following areas: melting, moulding, heat treatment as well as packaging area.

Siren

A siren with minimum range of 300 m in addition to flashing lights & alarm bells shall be provided.

1.5.5 Fire Extinguishing Equipment

Portable extinguisher such as pressurized water type, carbon dioxide type and foam type will be located at strategic locations throughout the plant.

Modular type carbon dioxide panel injection fire extinguishing system will be provided in control equipment room, cable space below control room and at other unmanned electrical and electronic equipment room.

1.5.6 Nearest fire station

All contact numbers of nearest fire station should be displaced in control room so, that in case of emergency they can be contacted without any delay.

Nearest fire station is situated at BHACHAU, which is around 17 kms from the proposed sit and it will take around 10-15 minutes for fire tenders to reach to the site.
1.6 SAFETY ORGANIZATION AND ITS ACTIVITIES FOR IMPLEMENTATION OF OHS STANDARDS

1.6.1 Construction and Erection Phase

A qualified and experienced safety officer will be appointed. The responsibilities of the safety officer includes identification of the hazardous conditions and unsafe acts of workers and advise on corrective actions, conduct safety audit, organize training programs and provide professional expert advice on various issues related to occupational safety and health. He is also responsible to ensure compliance of Safety Rules/ Statutory Provisions. In addition to employment of safety officer by Plant, every contractor, who employs more than 250 workers, will also employ one safety officer to ensure safety of the worker, in accordance with the conditions of contract.

1.6.2 Operation and Maintenance Phase

On completion of construction phase, the posting of safety officers would be in accordance with the requirement of Factories Act and their duties and responsibilities would be as defined thereof.

1.6.3 Strengthening of HSE and Meeting by Safety and quality circle

In order to fully develop the capabilities of the employees in identification of hazardous processes and improving safety and health, safety and quality circles would be constituted in area of work. The circle normally will meet for about an hour fortnight.

1.6.4 Safety Training

Safety training would be provided by the Safety Officers with the assistance of faculty members called from Corporate Center, Professional Safety Institutions and Universities. In addition to regular employees, limited contractor labors would also be provided safety training. To create safety awareness safety films would be shown to workers and leaflets would be distributed

1.7 MEDICAL CENTRE

Even though negligible accident occurs at the site since observation of necessary safety requirements has to be strictly followed. However, first aid should be made available at the site and a 24 hour standby vehicle (ambulance) should also be available at the site for quick transfer of any injured personnel to the nearest hospital, in case an accident occurs and medical emergency arises.
Tie up with nearby hospitals and ambulance facilities should be made and their contact numbers should be displayed. Contact numbers of for those hospitals and doctors working in the hospitals should be displayed in medical centre. Trained medical officer should also be appointed for regular check up and management of medical facilities. The Factories Medical Officer shall be M.B.B.S. with a certificate of Training in Industrial Health of minimum three months recognized by state government.

Pre employment medical examination shall be conducted and details should be provided in form number 33 as per factory act. Medical centre should be operated round the clock for attending emergency arising out of accidents, if any. All workers shall be medically tested once in a year and at the end of his term of employment and details to be maintained in form number 32 as per factory act. Medical records of all employees should be maintained.

1.8 **APPOINTMENT OF INDUSTRIAL HYGIENIST**

A qualified industrial hygienist should also be appointed on contract / part time basis for work zone ambient air quality monitoring and comply applicable standard related to industrial hygiene and health.

1.9 **OCCUPATIONAL HEALTH MONITORING PLAN**

All the potential occupational hazardous work places would be monitored regularly. The health of employees working in these areas would be monitored periodically for early detection of any ailment due to exposure.

For Occupational Health monitoring following plan should be implemented :

**Medical Surveillance:**

All employees should be medically examined by Factory Medical officers once in two years to ascertain the health status of all workers in respect of Occupational Health hazard to which they are exposed.

Medical officer will prepare a list of hazardous area both area wise and trade wise Specific tests are performed for identification of such occupational hazard. No person is employed to operate a crane, locomotive or work-lift or give signals unless his eye sight and color vision have been examined by qualified ophthalmologist.
**Employee information and training:**

The industry will provide training program for the employees to inform them of the following aspects; hazards of operations, proper usage of nose mask and earplugs, the importance of engineering controls and work practices associated with job assignment(s).

List of Tests to be conducted and recorded every two years:

1. Eyes  
2. Respirator system  
3. Abdomen  
4. Locomotor System  
5. Hernia  
6. Urine  
7. Audiogram  
8. Ears  
9. Circulatory system (Blood Pressure)  
10. Nervous System  
11. Skin  
12. Hydrocele  
14. Chest X Ray

**Medical Examination:**

The following medical checkup/examinations will be done:

1. Comprehensive Pre-employment medical checkup for all employees.
2. X-ray of chest to exclude pulmonary TB, Silicosis etc.
3. Spirometry test
4. Lung function test.
5. Audiometer test to find deafness.
6. Vision testing (Near and far as well as colour vision)

**Schedule of medical examination:**

The following schedule for medical checkup will be followed:

1. Comprehensive Pre-employment medical checkup for all employees.
2. Chest X- Ray once a year
3. Chest X- Ray for all other employees once every 3 years.
4. Spirometry & Lung function test for all employees once every 6 months.
5. Clinical examination of all employees once every 6 months.
6. Comprehensive medical examination of all the employees after retirement and all those employees with more than 5 years of service leaving the company.

**Report of schedule medical examination:**

Report of schedule medical examination should be published within the company and also report to higher management with safety & health magazines published within the company. Also workers whose schedule examinations are pending to be intimated through their respective department heads to avoid any worker / employee left out for schedule medical examination.

**1.10 WORK AREA MONITORING PLAN**

Work area monitoring plan should be develop and implemented as per Gujrat Factory rules 12-B for air born contamination including cement and silica dust. Periodic air sampling to be carried out and their testing results should be noted in form number 37 prescribed in Gujrat Factory rule and record of the same should be maintained.

Work areas are also to be monitored for lighting, temperature and other ambient condition.