

SAFETY GUIDELINES FOR IRON & STEEL SECTOR		
MINISTRY OF STEEL, GOVT. OF INDIA	<b>STEEL MAKING-Route - ELECTRIC ARC FURNACE (EAF)</b>	Doc. No: SG - 34
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### 1. OBJECTIVE:

The main function of EAF Steel Making is to convert Solid Metallics like Steel Scrap, Sponge Iron, Hot Briquetted Iron and sometimes Hot Metal into Liquid Steel. This gets further processed into Billets, Blooms, Ingots, Slabs by various solidifying processes like Ingot casting or Continuous casting. (Refer Steel Melt shop, SMS, Guidelines for secondary metallurgical processes and subsequent casting of liquid steel)

This entire process of EAF steel making is associated with various safety hazards and risk of injury. These hazards and risk arise due to extremely high temperature in EAF area. These process hazards and control measures are enumerated in this guideline to make a safe working environment.

### 2. SCOPE:

This Guideline of safety is applicable to Electric Arc Furnace whether an Integrated Steel Plant or a Mini Steel Plant.

### 3. PROCESS BRIEF :

The EAF Steel Making area has following main sections

#### I. EAF mains:

Various sub-sections of EAF and their functions are as follows:

- a) **Scrap Yard:** To prepare scrap basket as per steel grade with different quantities of scrap, sponge iron, coke, lime and calcined dolomite.
- b) **EAF unit:** This is the melting unit consisting of refractory lined lower shell, upper shell, graphite electrodes, water cooled panels (WCP) or refractory lined shell, water cooled roof, electrode mast, electrode holding arm and holder, secondary power cables, electrode regulation unit, tap hole or launder, slag door, hydraulic tilting mechanism, rocker platform. All Metallic charge and flux is charged into the Furnace from the Scrap basket lifted with an EOT crane. Power is put on through the Electrode and arcing takes place which starts melting the charge. The gangue in the charge combines with the lime and dolomite to form the slag. The Metallic charge melts to form liquid steel. Oxygen is blown to reduce carbon and burn the Carbon Monoxide formed. This play with oxygen and carbon foams the slag and covers the arc. The slag coats the Copper and steel panel or refractory lined wall as the case may be, and protects it from the bare arc. As soon as the Liquid bath achieves a Temperature of near to 1620-1650°C it is tapped into Steel ladle for further processing.

- c) **Transformer and Static VAR Compensator (SVC):** The main energy an EAF operates is electrical energy. Energy consumption varies from 300 – 600kWh/ Ton of liquid steel produced. So EAF's are rated by transformer capacity per ton of tapped steel. Low Power (LP), High Power (HP) and UHP (Ultra high Power) are in general ranges. Any EAF with a transformer of upto 0.5 MVA per ton is LP between 0.5-0.8 MVA is HP and above 0.8 MVA per ton is UHP. So a 50 ton EAF with 50 MVA transformers is an UHP EAF. This transformer steps down voltage from 33kV or 11kV to 300-600V and a tap changer is available with the melter to change voltage according to the melting profile and the Arc length. SVC (Static VAR Compensator) is a capacitor bank to take care of power factor, Harmonics and Flickers.
- d) **Gunning and fettling Machine:** These machines are used for refractory repair of EAF in operation during the turnaround time.
- e) **Injection Machines:** Coke combined with Oxygen injection is a normal practice in an EAF. These has two functions. One to control oxygen and carbon in the bath and oxy-cut any large piece of scrap which may lead to an electrode breakage and the other one to maintain foamy slag to cover the arc for better absorption of the electrical energy.
- f) **Continuous Material feeding System:** In a large steel making set up fluxes i.e. calcined lime and dolomite are not added in the basket. They are fed in a continuous mode. This system also has also cold DRI/cold HBI feeding system. All these materials are kept in a bunker or hopper and are carried through a system of conveyors. At the exit of each bunker or hopper is a weigh feeder.
- g) **Hot DRI feeding system:** Many energy efficient plants have different type of hot DRI feeding systems like gravity fed hot DRI containers, hot DRI sealed conveyors.
- h) **Lower Shell preparation area:** Nowadays instead of stopping the EAF for lining the eroded refractory, the lower shell is changed after dismantling the upper shell. This helps in reducing the shutdown time for refractory repair and increase EAF productivity. A separate work area for masons and refractory workers are assigned in the EAF main crane approach.
- i) **Electrode Nipping area:** Similar to point (g), addition of electrodes to the short electrodes column is no more done on the EAF top platform. A new electrode column is changed with the short electrode column. Here EAF workers under the Melter do electrode piece addition with the help of an EOT crane.
- j) **Fume Extraction System, Canopy and bag house:** EAF roof has a side fourth hole meant exclusively to suck out fumes generated. A movable elbow and a

combustion chamber and system of duct take the fumes away to a System of bag house. On the EAF bay shed over the cranes there is canopy which also picks up fugitive fumes and sends it to the bag house. It is also cooled. Ducts are all water cooled. This ensures EAF emission to limit PM10 and PM2.5 within the norms.

- k) **External Oxygen Lance (If not provided inside EAF) and manipulator:** High pressure oxygen through steel pipes (consumable) are injected through joystick controlled manipulating device. The device helps to centre the pipes through the slag door and blow oxygen at high pressure. When oxygen blowing is complete the lances/pipes are taken out and parked away from the slag door.

## II. SECONDARY METALLURGY SECTION:

The tapped liquid steel is further processed in a Ladle Refining Furnace (LRF)/ Ladle Heating Furnace (LHF). In this section there may be a tank degasser or RH degasser.

### This plant comprises of the following sections:-

- i. LRF with a hood, electrode mast, holder and arm and a transformer.
- ii. Ferro Alloy feeding system,
- iii. Cored wire injection system
- iv. Ladle preparation, ladle drying and preheating area
- v. Ladle de-slagging and de-skulling area
- vi. Ferro Alloy storage area
- vii. Ferro-alloy and flux addition System
- viii. Ladle purging System with inert gas mainly Argon or Nitrogen depending on the grade of steel.
- ix. Temperature and sampling system

Some of critical Equipment/ facilities in EAF Steel Making Department are as follows:

Sl. No.	Area	Major equipments
1.	EAF	Scrap transfer car, grab crane, orange peel type charging basket, EOT cranes, Fork lift with boom for slag door cleaning, conveyors, bins/ silos, screens, weigh feeders, diverter gates, screw conveyors, charging chutes, Hot Metal charging launders,
2	LRF	Electrode handling cranes

**4.0 PROCESS HAZARD ANALYSIS & NECESSARY RISK CONTROL MEASURES:**

Sl. no .	Area/Section	Hazards	Risk Control Measures
<b>A) ELECTRIC ARC FURNACE</b>			
1)	EAF proper	A. Explosion and spillage of hot slag and metal due to Minor Water Leakage from Water Cooled panel inside EAF with upto half processing of heat.	<ul style="list-style-type: none"> <li>❖ Stop Arcing.</li> <li>❖ Stop tilting or stop any Furnace movement</li> <li>❖ Identify and close the water valve</li> <li>❖ Identify the puncture</li> <li>❖ Develop and Follow SOP</li> <li>❖ <i>(Refer SG-23 : Safety Guidelines for safe handling of liquid metal)</i></li> </ul>
		B. Carbon boil and violent throw of hot metal and slag through the slag door	<ul style="list-style-type: none"> <li>❖ Stop Arcing.</li> <li>❖ Stop tilting or stop any Furnace movement</li> <li>❖ Develop and Follow SOP</li> <li>❖ <i>(Refer SG-23 : Safety Guidelines for safe handling of liquid metal)</i></li> </ul>
		C. Possibility of explosion due to Water leakage and entrapment of water at the verge of completion of heat but from top panel	<ul style="list-style-type: none"> <li>❖ Stop Arcing.</li> <li>❖ Stop tilting or stop any Furnace movement</li> <li>❖ Identify leakage</li> <li>❖ Develop and Follow SOP based on location of the leakage.</li> <li>❖ <i>(Refer SG-23 : Safety</i></li> </ul>

			<i>Guidelines for safe handling of liquid metal)</i>
		Injury during Manual filling of tap hole by movement of furnace roof and/or tilting	<ul style="list-style-type: none"> <li>❖ Siren system prior to start of tilting and locking.</li> <li>❖ Joy stick locked</li> <li>❖ Develop and Follow SOP</li> </ul>
		Explosion and fire and spillage of slag and/or metal during Charging of Scrap basket during Rains	<ul style="list-style-type: none"> <li>❖ Wet charging materials such as scrap (may have been kept in an uncovered scrap yard) is a serious hazard. Entrapped water to be examined.</li> <li>❖ Siren system prior to charging</li> <li>❖ Control Room shutter to close</li> <li>❖ Slow and intermittent opening of the basket</li> <li>❖ Develop and Follow SOP</li> </ul>
		Injury from Moving Conveyor during breakdown of feeding system	<ul style="list-style-type: none"> <li>❖ Shutdown/permit to work with electrical isolation.</li> <li>❖ No work should be done on conveyor in running condition.</li> <li>❖ Always operate Local emergency switch for approaching conveyor.</li> <li>❖ Availability of Pull chord.</li> <li>❖ Siren system prior to restarting conveyor.</li> <li>❖ Develop and Follow SOP</li> </ul>

			<p>❖ Crossing the conveyor only through the designated place.</p> <p><i>(Refer SG-19 : Safety Guidelines on Operation and Maintenance of Conveyor Belts)</i></p>
		<p>Injury from Rotating machineries (gunniting machine, fettling machines, screw conveyors etc.)</p>	<p>Coupling guards to be in place. Loose cloth to be prohibited</p> <p>Develop and Follow SOP</p> <p><i>(Refer SG-09 Safety Guideline in Equipment &amp; machine Guarding)</i></p>
		<p>Injury from spillage of Hot DRI</p>	<p>Mechanised charging of Hot DRI ensuring proper sealing with Nitrogen/process gas. Improper or inadequate sealing may lead to fire and explosion.</p> <p>SOP to be developed and followed.</p>
2)	EAF turnaround activity	<p>Burn Injury due to splashing slag</p>	<p>Proper PPE and visor. Covering of all exposed area with cloth</p>
		<p>Explosion due to water ingress into slag/metal while Gunniting and fettling operation</p>	<p>❖ Start the gunniting machine outside EAF</p> <p>❖ Start water</p> <p>❖ Check the quality of mix</p> <p>❖ Develop and Follow SOP</p> <p>❖ <i>(Refer SG-23 : Safety Guidelines for safe handling of liquid metal)</i></p>
3)	Electrode changing	<p>Falling of hot electrode/ hot loose piece falling off.</p>	<p>Siren on crane and EAF operator to coordinate shop floor movement</p>

			No person to be below a red hot electrode
		Lifting plug giving way/ Crane hook getting disengaged and subsequent injury during Electrode Jointing at Nippling stand	<ul style="list-style-type: none"> <li>❖ Electrode to be lifted under the guidance of the crane operator with a cushion of electrode packaging material</li> <li>❖ Nipple to be centred over short electrode column</li> <li>❖ Develop and Follow SOP</li> </ul> <p><i>(Refer SG-04 : Safety Guidelines for Permit to Work(Operation &amp; Maintenance))</i></p>
		Person hit by moving machines	<ul style="list-style-type: none"> <li>❖ Siren, gong bell during movement machines.</li> <li>❖ Auto announcement during any operation.</li> <li>❖ Before starting a standing car long hooter should be given and operator to check for any person doing any job.</li> <li>❖ <i>(Refer SG-04 : Safety Guidelines for Permit to Work(Operation &amp; Maintenance))</i></li> </ul>
4)	EAF Tapping Area	Metal Splashing/Metal falling into tapping pit over water and explosion	<i>(Refer SG-23 : Safety Guidelines for Safe handling of Liquid Metal)</i>
5)	EAF shop floor area and general process management	•	<p>Develop following SOPs and follow</p> <ul style="list-style-type: none"> <li>❖ Slag handling in slag pit and water spraying SOP</li> </ul>

			<ul style="list-style-type: none"><li>❖ Slag pot carrier movement and pathway SOP</li><li>❖ Slag dumping area SOP</li></ul>
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