

SAFETY CODE FOR IRON & STEEL SECTOR		
MINISTRY OF STEEL, GOVT. OF INDIA	SAFE HANDLING OF LIQUID METAL	Doc. No: SC/23
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1. OBJECTIVE

Handling of hot liquid metal involves many potential hazards namely Fire, Explosion, Radiation, Burns, etc.

This code has been prepared to introduce safe methods of handling hot liquid metal in different areas of Iron & Steel industries, for facilitating mitigation of these hazards & prevention of accidents.

2. SCOPE

This code is applicable for safe handling of hot liquid metal in different areas of Steel Plants, viz., Blast Furnaces, Steel Melting Shops, Foundries, Pig Casting Machines, Electric Arc Furnaces, etc.

The code covers the following aspects related to hot liquid metal handling:

- i) Ladle preparation
- ii) Inspection and maintenance of ladle cars
- iii) Pouring into ladle
- iv) Transportation of hot liquid metal
- v) Inspection and maintenance of hot liquid metal tracks
- vi) Hot liquid metal pouring
- vii) Dumping

3. PROCEDURE

3.1. Ladle / Torpedo Ladle Preparation

- i) Before the ladle is placed for pouring the hot liquid metal, it shall be inspected for the following & the activities carried out as mentioned below:
 - a) If metal jams have been removed from the lip / mouth of the ladle.
 - b) The condition of the lining of the lip / mouth.
 - c) The shell condition.
 - d) Cleaning / changing the nozzle.
 - e) Cleaning / changing the slide gate plate / purging plug.
 - f) Checking the tare weight of the ladle / torpedo; if more than normal tare weight then de-slagging to be done at pit (de-slagging pit should be filled with dry sand / dry granulated slag).
 - g) Checking the shell condition; if shell temp. $>300^{\circ}\text{C}$ (mouth & charging pad) gunning with suitable refractory to be done.

- ii) Place the cleaned and prepared ladle, at heating stand for preheating / on transfer car.

3.2. Inspection & Maintenance of Ladle Cars / Torpedo Ladles

- i) Inspect the ladle car for the condition of:
 - a) The chassis.
 - b) The suspension springs.
 - c) Bearing covers and alignment.
 - d) Coupling and coupling handle.
 - e) Any metal jam, etc. spilled on the car.
 - f) Cable and cable reeling drum (if provided).

- ii) Inspection of Torpedo Ladle:
Cover the mouth of the torpedo before starting the inspection. Inspect for the condition of:
 - a) The chassis and staircase.
 - b) The suspension spring.
 - c) Bearing covers and alignment.
 - d) DP and UT test of axle.
 - e) Presence of any metal jam / debris on the torpedo platform.
 - f) Drive system and limit switches.

- iii) Place the inspected and cleaned car near the heating stand. If the inspection / maintenance time is more than 16 hr then place the torpedo under heating station to heat up to 900 °C.
- iv) Place the preheated ladle / prepared ladle on the car, centering it properly following the signals.
- v) Check the clearance of chassis of the ladle car with the wheels after placing the ladle.
- vi) Damaged chassis / suspension spring, etc. should be rectified.
- vii) All the metal transfer cars should be fitted with warning bells which should ring during movement of the transfer cars.
- viii) Mechanical ladles should be fitted with devices for smooth positive control when tilting and pouring, so as to stop accidental tilting.
- ix) Hand-tilted transport ladles should have an integral locking device to prevent accidental tipping.
- x) Large transport ladles (>500 kg) should have a self-restraining anti-tipping device.

3.3. Pouring / Torpedo Ladle Filling

i) General Practices

- a) Place the ladle car below the spout exactly aligned below the chute.
- b) Put a skid below the wheels.
- c) Remove loco to a safe distance (6 m).
- d) Hot Metal / Teeming ladles to be placed on the stand.

- e) Before pouring is started, it shall be ensured that:
 - Only minimum required no. of persons shall be present.
 - They all shall use PPEs like face shield, flame retardant suit, anklets, goggles, hand gloves, helmets and safety shoes.
- f) Newly lined torpedo after proper heating to be filled 50% for the first time.
- g) After taking out the metal it should be kept under cover for soaking.

ii) Specific Practices

- a) Ladles shall be placed on both the lines on both sides of the rocking runner. Track line of torpedo must be marked for proper placement below (marking will be at position of last wheel of torpedo car). Track line should be dry and filled with sand.
- b) Rocking runner shall be checked before pouring. Check proper placement of torpedo by taking metal for few seconds and changing to other side. If proper placement is not there replacement to be done.
- c) After opening the tap hole, pouring shall be done in one ladle leaving 250 mm empty from the top to avoid spillage during transportation. After filling up to 90% of the torpedo, tilt the runner to other side.
- d) As soon as one ladle is full (250 mm empty from top) rocking runner shall be turned to fill ladle on other side.
- e) Next ladle shall be brought in position on the other side using the pusher car. Before removing the filled torpedo, tilting runner drive must be under control stop. Remove filled torpedo and place empty torpedo as soon as possible and check proper communication between cast house and traffic crew.
- f) As soon as tapping is completed, ladles with hot liquid metal shall be removed by locos.
- g) Then Hot Metal ladles / Torpedoes shall be sent to Steel Melting Shop, Pooling Pit Foundry or Pig Casting Machines, as per requirement.

3.4. Transportation

- i) The ladle cars and the ladle shall be inspected again for spillage after pouring.
- ii) Before withdrawal, track position, metal jamming, etc. shall be checked.
- iii) Ladle shall be removed only after clearance from the Furnace In-charge.
- iv) If any ladle / torpedo is overfilled, it shall be transported with utmost care at a very slow speed of less than 5 kmph and taken to pooling pit, and about 10-15 ton of metal dumped & then again sent to steel melting shop.
- v) Loco Shunting Staff shall come down at every rail-road crossing and caution people before allowing the train to pass. Park the torpedo before fouling mark to avoid side collision.
- vi) Loco shall move at slow speed and shall not apply sudden brakes to prevent spillage and splashing of hot metal.
- vii) Ladle shall not be transported in tilted condition.
- viii) It shall be ensured that persons are not in the vicinity of the track during movement of ladles.

- ix) Stopper-operating mechanisms on bottom-pouring ladles should be secured prior to transport so as to ensure that they do not operate accidentally while in motion.

3.5. Inspection and Maintenance of Hot Metal Tracks

- i) Hot metal transport tracks shall be regularly inspected for any undulations and prompt action to remove undulations shall be ensured.
- ii) Track alignment shall be checked periodically and any sinking shall be immediately attended.
- iii) Tracks shall be inspected regularly for any scrap and other materials lying in the area.
- iv) De-weeding shall be done to ensure the safety of the persons moving along with rolling stock.
- v) All the dry weeds along the track shall be removed to avoid fire due to metal splashing during transportation of hot metal.
- vi) Accumulation of water on the tracks or near the tracks shall not be allowed.
- vii) It shall be ensured that there is no gas or water lines in the work area, which can cause explosion if a spill occurs.

3.6. Liquid Metal Pouring

Hot Metal tapped from Blast Furnaces, and transported as described earlier is poured as per the following details:

i) Ladle to Mixer

- a) Ladles are brought to the line below Mixers and loco removed.
- b) The Crane Operator lowers and engages the hooks in ladle.
- c) The Crane Operator lifts the ladles full of hot metal continuously giving siren / alarm so that people working in the area move away.
- d) Ladle is brought near the Mixer platform where the crust is broken using lancing or punching as per requirement.
- e) Ladle is then taken to the top of the Mixer.
- f) Lid of the pouring hatch of Mixer is opened.
- g) Metal from the ladle is poured very slowly and continuously into the Mixer, carefully avoiding jerks and sharp movement so that there is no spillage of hot metal.
- h) Ladle is fully drained off as per signals of the Mixer Operator.
- i) Falling out of any crust pieces (during pouring) is avoided. This is watched by the Mixer Operator who stops the pouring whenever the crust is about to fall.
- j) Straighten and lower the ladle.
- k) Place empty ladle back on the ladle car.
- l) Repeat the process with other ladles.

ii) Ladle / Mixer Ladle Mixer to Hot Metal

- a) Ladle shall be inspected for the condition of refractory lining.
- b) All the ladles shall be placed below the spout of the Mixer one by one.

- c) Ladle shall be aligned / placed below the spout perfectly by the Loco Operator following signals of the Pourer.
- d) Mixer shall be tilted by the Pulpit Operator and metal poured into the ladle as per requirement.
- e) After completion of pouring, the ladles shall be drawn and brought to the Twin Hearth Furnaces / Converters.

iii) Torpedo Ladle to Metal Transfer Car

- a) Place the torpedo at the desired pit at Steel Melting Shop following light signal.
- b) Plug the torpedo drive connection for pouring.
- c) After complete evacuation of hot metal plug out the drive connection.
- d) Ensure that the torpedo should not be in tilted condition.
- e) Remove the torpedo from SMS and send for filling or maintenance.

iv) Ladle to Furnace (Twin Hearth)

- a) The furnace bottom is to be inspected when repair is being done.
- b) It is to be prepared with dry raw dolomite.
- c) It shall be ensured that scraps, lime, etc. free from moisture are charged.
- d) As soon as the furnace is ready to receive metal, doors are lowered and closed.
- e) Spout (prepared and inspected) is lifted and fixed into the door with the help of hot metal crane.
- f) Hot metal crane then lifts ladle and pours into the spout as per the signals of the Furnace Charge Man / Melter.
- g) Place back empty ladle on the car.
- h) Repeat this process with other ladles till the furnace has received the required quantity of metal.

v) Hot Metal / Mixer Ladle to Converter

- a) Ladle, after filling the required quantity of hot metal, is brought to Converter platform on the self propelled ladle car / HMTC.
- b) It is lifted with the help of hot metal / charging crane.
- c) Converter vessel after emptying and slag coating is charged with heavy and light scrap.
- d) It is tilted again to receive metal and lifted ladle is correctly positioned.
- e) Ladle is then tilted gradually and metal is poured slowly into the converter taking care that no splashing takes place.
- f) Ladle is then made upright, taken back and placed on the ladle car.
- g) Converter vessel is brought to upright position to start the process.

vi) Converter to Steel Ladle

- a) Inspected and preheated ladle is placed on transfer car and placed below the Converter for tapping.
- b) After the blow is over, first slag is tapped in the slag ladle. Ensure that slag ladle is dry.

- c) Ladle car is then moved back to bring ladle below the spout of the Converter vessel, after removing the slag ladle.
- d) Vessel is tilted to other side and liquid steel is slowly tapped into the ladle till the slag appears.
- e) The metal car is then brought to slag and ladle preparation bay.
- f) Slag ladle is then taken out with the help of crane and the car with metal ladle goes to Argon Rinsing Station.

vii) Movement of Steel Ladle to Continuous Casting Machine through Secondary Refining Units

- a) After Secondary Refining, the ladle is moved forward on car towards the caster side / lifting pit of CCS.
- b) EOT crane is brought above it from side movement.
- c) The hook is lowered and ladle is engaged as per the signals of the Charge Man / Operator. Ensure that area must be free from moisture.
- d) Ladle is then lifted slowly and very carefully to CCS pouring platform (on turret arm – in charging side).
- e) It is then placed on the other side by lifting the arm and rotating the turret for pouring and casting.
- f) After pouring and casting, turret arm is lifted and rotated to charging side for removal of empty ladle by crane. After that it is returned to pit side of SMS / Ladle Preparation Bay (after dumping) by Ladle Transfer Car.

viii) Twin Hearth Furnace to Steel Ladle

- a) Proper preheating and inspection of ladles shall be done before tapping.
- b) Ladle shall be inspected for shell condition and skull free condition of refractory lining.
- c) Rigidity of slide gate mechanism shall be ensured.
- d) Ladle shall be placed at tapping stand.
- e) Graphite powder shall be placed at bottom of ladle exactly over the nozzle.
- f) Dried out coke to be added at bottom of ladle before tapping.
- g) Oxygen ppm (particle per million) of the heat shall be optimum.
- h) Required quantity of Ferro Alloys to be added during tapping with help of crane.
- i) Aluminium bars can be added manually.
- j) Continue tapping till molten steel gets exhausted at furnace.
- k) In case of high oxygen ppm, the flow of reactive slag into ladle is to be avoided by using suitable means.
- l) After filling up, ladle shall be covered with heat shield cover.
- m) Ladle shall be lifted by traverse hanger hook with the help of crane.

ix) Teeming Operation

- a) The ladle shall be positioned to the required teeming platform through crane.
- b) HPP cylinder shall be fixed to ladle for opening slide gate.
- c) Ideally on opening the slide gate, nozzle filling compound should fall down.
- d) Ladle nozzle shall be placed at the centre of mould for uniform flow.

- e) During teeming, add aluminium shots as deoxidiser.
- f) Slide gate shall be closed after the mould is full.
- g) Crane along with ladle shall be moved to subsequent moulds till the teeming is complete.

x) Blast Furnace Ladle to Foundry Ladle

- a) BF ladle shall be lifted by crane by engaging traverse in BF ladle properly.
- b) BF ladle shall be slowly tilted to transfer the hot metal into foundry ladle.
- c) Foundry ladle filled with hot metal kept on Hot Metal Transfer Car shall be driven slowly towards pouring bay.
- d) Ladle shall be lifted slowly by crane by engaging traverse in foundry ladle properly.
- e) Centering the foundry ladle on the pouring basin of Ingot moulds / Bottom plates, ladle shall be opened.
- f) No rolling of crane on the tracks shall be permitted.
- g) After pouring and filling the Ingot moulds / Bottom plates, foundry ladle shall be tilted with the help of auxiliary hoist of crane and total residual slag / metal shall be dumped into slag pots slowly.
- h) Foundry ladle shall then be kept horizontally before the lancing stand for lancing the nozzle of the ladle properly.

xi) Ladle pouring at PCM

- a) Ladles are brought to PCM line (track) at the approach of shunting winch.
- b) PCM operator positions the ladle with shunting winch to PCM runner.
- c) With the help of vertical winch hook, ladle is slowly and continuously lifted from the bottom.
- d) After ladle is poured and emptied fully, it will be positioned into chassis and then pushed out of machine through the shunting winch.

3.7. Safety Precautions for handling liquid metal in Converter / Concast /Twin Hearth & Teeming

- i) Before ladle is lifted by the hanger hook, the hook and the crane shall be checked for its rigidity by lifting loaded ladle to smaller height and holding momentarily and checking the breaking effect of both downward and upward movement before it is further transported.
- ii) Person working in pit side should not come beneath the raised load.
- iii) Other activities, viz., cleaning, lancing, relining and de-bricking shall be momentarily stopped during heat movement in the area.
- iv) At pit side, persons shall maintain safe distance at the time of tapping and teeming operations.
- v) All workmen involved in teeming, shall wear all necessary protective appliances in proper manner, viz., safety helmets, safety shoes, smelter glasses, face shields flame retardant suits, hand gloves, anklets, etc.
- vi) During movement of crane, sound alarm shall be used to caution persons working below.
- vii) Ensure proper coordination between different agencies at pit side.

3.8. Hot Metal Ladle cleaning and dumping at Ladle Repair Shop (LRS)

- i) Ladles from SMS, PCM and Foundry shall be brought to LRS for cleaning and inspection.
- ii) With the help of LRS crane, punching and hooking shall be done.
- iii) All scraps and slag shall be dumped in the skull pot.
- iv) Ladle structure and refractories shall be inspected.
- v) If repair is needed, it shall be repaired and ladles shall be sent to furnaces for placement and metal filling.

3.9. General Safety Points for all the jobs related to handling of liquid metal

- i) The crane shall be load tested and inspected periodically.
- ii) Load test date and SWL bearing capacity board shall be displayed prominently over the crane.
- iii) The ladle hook arm and wire rope shall be tested for rigidity.
- iv) Crane shall be made free from loose materials and inflammable materials.
- v) Crane shall be provided with cut off limit switches for all movement and maintained in operable condition.
- vi) Sufficient clearance is needed by the side of railway track. There should not be any obstruction over the tracks.
- vii) Structures shall be periodically inspected and tested.
- viii) All lifting equipment, tools and tackles are to be checked periodically.
- ix) At the time of handling and transferring liquid metal, person shall be well trained in signaling operation to guide the Crane Operator.
- x) Ladles, cranes and locos when handling liquid metal, shall be driven at safe speed.
- xi) Ladle trunion diameter shall be periodically checked for timely replacement.
- xii) Locking devices on casting and transport ladles should be engaged prior to filling to prevent accidental spillage; they should only be released immediately before tipping the ladles.

References:

1. IPSS:1-11-009-15 (CODE OF PRACTICE FOR SAFE HANDLING OF LIQUID METAL (First Revision))
2. INTERNATIONAL LABOUR ORGANIZATION
(Sectoral Activities Programme: Code of practice on Safety and Health in the Iron and Steel Industry)