**WORK INSTRUCTIONS FOR BALST FURNACE REFRACTORY DISMANTLING AND RELINING**

**Responsibility:**

* Objective : - Refractory dismantling and relining in Blast Furnace
* Scope : - Blast furnace
* Ref. : - Blast Furnace Drawings, manuals, Safety Standards
* Responsibility : - Furnace in-charge, Project in-charge, Refractory Engineer & Supervisor

**PPE to be used** : Helmet, safety shoes, hand gloves, goggles, full body safety harness.

* Activity No 1 : Dismantling of Blast furnace Refractory.
* Activity No 2 : Dismantling of Coffee-pot stack refractory.
* Activity No 3 : Dismantling of Main runner, Slag runner, Emergency

Launder slag runner, dismantling of Cast House Soling.

* Activity No 4 : Relining

**Aspect- Impact**

|  |  |
| --- | --- |
| Scrap generation | Resource depletion |
|  |  |

**Hazards identified**

**Mechanical:**

1.      Fall of parts during maintenance

2.      Entanglement in between blades, coupling, screws, moving wheels, etc

3.      Entanglement of refractory bag in moving blades

4.      Fall / slip / overturning of mixer from unleveled area

5.      Fall of refractory bag, ghameela, tools, hammer, and blades.

6.      Fall of castable in eyes

7.      Chemical fumes may inhale

8. Fire & explosion

**Physical hazard:**

1. Dust inhalation from castable powder
2. Fall of Refractory bricks in leg during brick shifting and relining.
3. Fall of person from platform during dismantling.
4. Cut injury due sharpness of brick in corner areas.

**Electrical hazard:**

1. Electrical Shock

***Human Hazards:***

1. Non adherence to WI
2. Nonuse of PPE
3. Under influence of alcohol
4. Not concentrating while at work

***DO’S***

1. *Use PPE’s.*
2. *Follow SOP.*
3. *Activity to be carried out during day duty hours.*
4. ***Follow confine space work procedure for Blast Furnace refractory dismantling and relining***
5. *New work permit to be taken after every 8 hrs.*
6. *For working in night prior approval should be taken from Head Operations*
7. *Unauthorized operation or repair of any equipment is a punishable offence.*

***DONT’S***

* 1. *Do not by pass SOP.*
  2. *Do not do any work without valid work permit*
  3. *Do not do any work inside furnace without proper illumination and access*

*Entering into Blast Furnace is a confined space activity. Please follow below mentioned procedure*

**FOR MORE DETAILS REFER CENTRALISED CONFINED SPACE ENTRY SOP-VL/IMS/VAB/SP44 Y**

Confined Space Checks before job start up:

1. Before Entering in Confined Space ensure –
2. Inside temperature should be less than 40°C.
3. CO Level should be 0 ppm
4. Attendant must ensure proper illumination, if illumination not found ok, he must inform concern electrical person to provide hand lamp or halogen.
5. Take the work permit from production-in-charge, Safety, electrical, mechanical for entering Confined Space.
6. The workmen (Entrant) who is trained and certified by SBU Head and having valid confined space gate pass should perform the activity and he can be replaced(in emergency) only by certified entrant .
7. A standby (attendant) who is trained and certified by SBU Head and having valid confined space gate pass should perform the activity and he can be replaced(in emergency) only by certified attendant .
8. Standby person who shall be positioned outside the confined space , must have no other duties other than monitoring people and conditions inside the confined space and coordinating with rescue personnel (he must have contact number of rescue team members) if required.
9. Standby (Attendant) person has to log down the In/Out entry of all entrants and ensure that entrant should be come out after 30 minutes from confined space for normal jobs.
10. In some cases In/Out time may be relaxed /extended based on the risk involved in the particular confined space.
11. Check Internal atmosphere of the space for sufficient oxygen content (19.5% to 23.5 %) flammable gases and vapours, and the potential for toxic air contaminants by the use of multi gas detector, if required use pump with extension before entering. If there is any deviation, do not enter into confined space.
12. Check for the presence of Chemical asphyxiates such as Carbon monoxide (CO gas detector).It should be 0 PPM
13. Check inside temperature and it should be is in the tolerable range (25°C to 40°C). If the temperature is not within limits then appropriate ventilation to be used to normalize the temp.
14. Check for suitability of equipment that is used at the confined space.
15. Check any dust due to which visibility is reduced or respiratory tract is irritated.
16. The sign-in and sign-out of all persons entering into confined Space should be recorded.
17. Use 24V DC supply illumination to avoid electrocution/electric shock.
18. Cutting or welding jobs inside the confined space should be carried out after checking for any explosive environment (LEL should be <10%) and by providing localized suction or heavy duty exhaust systems to prevent accumulation of gases inside the space.
19. Isolation of related equipment of respective confined space with personal LOTO lock to be ensured.

Please note that this area is considered as Confined Space so needs to maintain the checklist of the activity. All in time and out time details of entrants, levels of gases to be logged in checklist (yellow copy) or in any alternate document and to be documented.

***Role of Rescue Team***

***As the work is being carried out inside confined Space, in an emergency victim can be taken out by use of rescue apparatus such as stretcher. However attendant should call ambulance which is fully equipped. However rescue team members should take a charge of the situation.***

**Activity No 1: Dismantling of Blast furnace Refractory:**

* 1. All persons should wear PPE.
  2. Unauthorized operation or repair of any equipment is a punishable offence.
  3. After quenching give clearance for removal of Blow pipe, Tuyere and tuyere cooler.
  4. Start coke raking with two firefighting hoses or water hoses. Stop coke raking if hot coke is observed during coke raking and quench the hot coke. Please take water from jetty or cooling tower.
  5. Give clearance to cut the tap hole jacket, and tap hole plate during coke raking.
  6. During coke raking top charging can be removed.
  7. After finishing the coke raking and removal of top charging start erection of hanging platform.
  8. Close all tuyere and tap hole opening by bricks or by GI sheet
  9. Use furnace top 5 ton crane for lowering the platform.
  10. After locking the platform at four points, allow workers to use the platform.
  11. Barricade the area around the tuyeres.
  12. Start dismantling top refractory with the help of crow bar, pneumatic beaker, hooks and with cutting torches if required.
  13. Where ever possible refractory thickness at different levels to be noted and logged down in the register.
  14. Passing jet of water between the furnace shell and the refractory bricks can also be taken up from the opening at lower stack to facilitate speedy collapse of the bricks.
  15. After clearing all over head and side refractory of the furnace all opening at the bottom to be opened and raking of the dismantled material to be taken up with the help of long hook standing outside at safe distance.
  16. After removing all the overhead refractory from top/sides, entry in to the furnace from down to be allowed.
  17. Ensure all persons executing above activities are trained and are using all PPE’s viz hand gloves, safety shoes, goggles, dust mask.
  18. Dismantling of the refractory should be done layer by layer to note thickness.
  19. Hearth Metal jam/ fused bricks removal: For removing the metal jam, dismantle the side/peripheral brick network with the help of pneumatic breakers. place the hydraulic jacks underneath the metal/fused bricks, Lift the metal jam with hydraulic jack (150 or 100 ton capacity) and lock the metal jam in raised position by placing bricks underneath the metal jam.
  20. **Ball throwing for breaking of metal jam**
  21. Ensure load tested wire rope slings are arrange (5t capacity) 2 nos.
  22. Ensure two sets of walky talky available for clear communication during the operation.
  23. Lift and shift the metallic ball inside the furnace with the help of 5 t furnace top crane
  24. Close the all the tuyere/tap hole opening of the furnace at cast house level.
  25. Evacuate all persons from the cast house before starting the balling operation
  26. Position the ball in front of the shell opening at lower stack
  27. From the opening at the lower stack cut the sling with the help of cutting torch attached to a long rod.
  28. Repeat the exercises of throwing the ball till job is accomplished of breaking the metal/brick chunk into pieces of 2 to 3 t approx.
  29. Ensure sufficient cushioning around the metal/brick jam to avoid ball rolling over and damaging the shell plate.
  30. Shift the ball outside the furnace with load tested 5 t slings.
  31. Lift/shift the jam from inside the furnace with the help of furnace top crane after firmly securing the jam with load tested wire rope sling on to the cast house platform.
  32. Ensure whenever lifting and shifting of the ball or the jam is carried out by the overhead crane no persons are below or around the area.(cordon off the area)

**Activity No 2 : Dismantling of Coffee-pot stack refractory:**

After inspection of the coffee-pot stack, if any cracks are found in the stack, .start dismantling, the castable without damaging the shell and anchors.

**Activity No 3: Dismantling of Main runner, Slag runner, Emergency launder slag runner:**

* + Remove all the sand, metal / slag jams
  + Remove the runner mass.
  + Remove the bricks
  + Shift all the dismantled material to the respective locations.
  + Hand over the runner to mechanical for inspection and re fabrication of steel structure.
  + Tools to be used for dismantling viz crowbar pneumatic riggers etc.

**DISMANTLING:**

1. Coke racking and Dismantling of refractory:
   1. Coke raking will be carried out by the tenderer and also will have to do all the necessary requirement like fixing of trough, hoses, etc for coke raking. Then, the tender shall also shift material like coke, bricks, debris to different location by properly segregating them as instructed by company person. In coke raking tenderer need to strictly follow all the precautions to avoid gas poisoning if gas exists. During coke raking tenderer are not allowed to enter inside the furnace unless overhead lining is dismantled completely.
   2. Dismantling includes bricks around the cooling plates and furnace hearth bricks. Since the cooling plates will be jammed, refractory will be dismantled without removing the cooling plates.
   3. Dismantling of cast house soling bricks and salamander launder.
   4. Dismantling of Main runner, Emergency Launder, Salamander launder and PCM launder.
   5. Dismantling of Back draught pipe, blow pipe etc.
   6. Dismantling of entire Bustle pipe and hot blast main of certain length.
   7. Inspection, Cleaning, Replacement of checker and Repairs of Hot blast stoves wherever required.

* **Activity No 6 : Relining**

Relining of the furnace could be started only when mechanical clearance after shell repairs. Before starting relining the following activity should be checked. 1) Check furnace center from the furnace top on to the hearth. 2) Check the tuyere centre on the hearth. These are the Mechanical responsibilities. The difference in these two centres is to be noted and to be reported. These two centres are to be marked on the hearth.

1. Provide proper ventilation/ exhaust/Lighting.
2. Check Overhead plat forms are perfectly sealed so that no material or any welding sparks can fall.
3. Check the entry /exit points are safe enough.
4. Mark the tap hole centre line through the tuyere centre which is marked earlier on the hearth.
5. Mark the following axes on the hearth.
   1. 45 degrees to the tap hole axis.
   2. 90 degrees to the tap hole axis.
   3. 135 degrees to the tap hole axis

5. The end points of the axis are to be transferred on the shell at the hearth bottom

Weld and to be marked with punch and painted. Responsibility third party

Relining and counter checked by the company representative.

6. Take equal sizes of bricks of 9 nos. and place at the hearth centres, ends of each

Point. The take the water levels of each point with respect to the centre.

7. Check the availability of measuring tools like 1.Measuring tapes, 2. Gauges,

3. Plumb, 4.Right angle, 5.Sprit level, 6.Water level, 7.Pnuematic rammer 8.Refractory material like mortar, bricks, mixer, brick cutting machine etc.

After checking all the above points start the lining as per instructions and as per drawing.

During the lining the following points are to be checked thoroughly.

1. Verticality/horizontality of the bricks.
2. Water level of the lining.
3. Lining joints.

a. Lining joints are to be staggered between the layers, between the rings; b. All joints are to be completely filled with mortar; c. Gap of the joint should be in specified thickness only, d. The location, orientation of the key bricks; e. No. of key bricks, f. dimensions of the key bricks, g. Diameter of the rings/ dimension of the lining. Etc.

1. Shell to brick lining. The gap should be maintained 25-40 mm only.
2. Quality.
3. Quantity.
4. Safety: man, machine, material etc.
5. Ramming: Before ramming ensure that ramming surface is free of any foreign material. Hoses of the pneumatic rammer should be firmly fixed to the rammer and hose is to be clamped to the rammer. Ramming of the Carbon mass should be done in layer by layer with pneumatic rammer unless specified by the authority. After finishing ramming the surface should not be roughened.
6. Casting of any castable: Before casting, the surface is free of any foreign material. Ensure the vibrator is made ready. Ensure spare needle is also is ready. The size of the needle is should be 25 mm. After finishing ramming the surface should not be roughened.

Curing of the Castable Curing of the castable should be done as per the instruction. Use wetted jute gunny bags for curing.

1. Housekeeping and disposing the unwanted material. Follow SP 44 for housekeeping.

For Scaffolds preparation, working at heights and general safety refer SP 44, 46

**Top cone/ dome Repairs of the furnace**:

Provide a blank just below the dome. Seal the blank perfectly, so that there is no material will fall down the blank. Inspect the castable. If the castable is good in condition, no need to do the repairs. If the castable is found damaged, dismantle the whole casting. Do anchoring. Paint with the bituminous paint. Do the casting as per drawing.

**Relining of Coffee-pot / Back draught pipe**:

After clearance from mechanical for coffee-pot, coat the anchors with bituminous paint. Place the 20 mm ceramic felt compressed to 10 mm on to the shell. Do the casting with 60% Al2O3 castable for the first half of the stack horizontally. After 2 hrs inspect the casting weather the casting is getting hot or not. If the casting is getting hot, put some wet jute gunny bags over the casting for wetting. After 24 hrs inspect the casting and rotate the stack and do the casting for the rest. Follow the mixing instructions for mixing of the castable. Please take care that casting should not bulge above the flange. Maintain the diameter as per drawing or instruction.

**Relining of the Main runner, Slag runner, and Emergency launder**:

After getting clearance from mechanical, start brick lining of main runner with 62% Al2O3 bricks. Lay three layers of 460x230x75.

**Bustle pipe and hot blast pipe Inspection and repairs**:

For inspection of bustle pipe, hot blast pipe inspection at least three members, with two walky talkies are required. Before going in to the bustle pipe announce the inspection to the all other departments who are working around and to the higher authorities. Make sure of the presence of ventilation, and all blow pipes are removed. Insert one compressed air point, two hand lamps and take along at least one torch light. Compressed air should be opened such that comfort ability attained. Ensure the temperature inside the bustle is below 35 degree C. Enter two persons with one walky talky, one CO detector, one torch light by keeping one person outside with one walky talky. If any uncomfortably felt come out of the bustle and ensure the comfort ability and then enter again. Inspect all the brick joints, junctions, blow pipe joints for failures, and also for slag existence. For any deviations are observed and ask the third party for repairs and for cleaning. The same procedure is applied for the Hot blast pipe by locking all hot blast valves manually in open condition by taking electrical shut down, all chimney valves in open condition, and when stove become cold. Inspect riser, ceramic burners etc. for damages/cleaning.

**Waste gas main inspection/Repairs**:

For checking the waste gas main, open the inspection door. Ensure the chimney valves are open, locked or taken shut down electrically, mechanically. Ensure the temperature inside the waste gas main is below 45 degree C. Check the CO presence inside the waste gas main. While inspection also CO detector should be accompany the person who is inspection. Complete the inspection of waste gas main, especially junctions of waste gas main and stove out lets and if require do repairs.

**Chimney Inspection and cleaning**:

Keep the waste gas main inspection door open. Open the chimney inspection flange. Ensure that there is no gas presence in the chimney. Inspect the chimney.

**Erection of Refractories**

The broad scope of work of the Tenderer shall cover erection of refractories including fire clay bricks, gunning and pressure grouting as per indicative Bill of Quantities for Erection of Refractory Works as of this TS.

The scope of work of the tenderer shall also include the following:

1. Loading, transportation, unloading and storage of all materials required for the lining from stores or any other place of storage to blast furnace storage site (previously where tenderer unloaded when the time of receipt from the refractory supplier) and sorting according to size, quality or any other criterion, wherever required. All equipment namely, Hydra, forklift, truck etc. and required manpower/labour are to be arranged by the erection contractor at their own cost. Before taking delivery of the material-either refurbished or new, the contractor shall satisfy himself regarding the completeness and correctness of the items as per manufacturer’s specifications, packing lists, etc. The contractor shall also check the items for absence of external damages, cracks and other visible defects. The contractor shall issue a receipt of acceptance of items to this effect. It may be noted various agencies shall be working at site simultaneously and some of equipment require multiple handling i.e. installation, dismantling and re-erection to suit the erection sequence during the BF shut down.
2. Preparation and maintaining covered and open storage sheds at work site for the safe storage of materials. Suitable space for this purpose shall be allotted by the purchaser within a reasonable distance from the work site.
3. Shifting of all materials from blast furnace storage site to different work sites including all leads and lifts is in the scope of tenderer.
4. Supply and erection of all scaffoldings, temporary ladders, hanging platforms, other platform, supports and other necessary facilities required for handling, erection and visual inspection of the work. Platforms including hanging platform for blast furnace are included in the scope of erection. The design & engineering of hanging platform and all other platforms will be done by the erection contractor. The approval of design from the purchaser is to be obtained.
5. Providing all tools and tackles like brick cutting machines, mortar mixer, gunning machine, rammers, masonry tools, spirit level, cutting blades, metallic pokers, vibrators, needles, rammers and any other erection equipment like winches, trolleys, belt conveyors, air compressor etc. including erection consumables and their spares is in the scope of tenderer.
6. Fabrication and erection of all centering.
7. Fabrication and supply of all templates required for checking the proper contour of different walls, arches etc. as per drawings.
8. Nozzle fixing for grouting and removal of the same is included under the scope of the refractory erector.
9. Cutting of cardboard, ceramic felt, oil paper etc. as per the requirement
10. Survey work and fixing of various bench marks/marking lengths required for the control of brickwork dimensions and levels.
11. Cleaning and disposal of entire debris arising during erection of refractories with all leads and lifts included to dump yard or any other area specified by the Purchaser within a lead of 3 km(s) inside plant boundary.
12. Cutting of refractory bricks including carbon/ graphite blocks to required shape or size and their sorting as per site requirement, wherever required.
13. The Tenderer shall render account of all materials issued to him.
14. Power supply and water shall be provided at one point only. The bidder shall arrange transmission/ transportation of these items by himself. Requirement of compressed air, if any, has to be arranged by the bidder.
15. The Tenderer shall perform cutting-off and cleaning of all cleats used for facilitating erection and restore all structures, platforms, etc. cut-off/removed temporarily to facilitate erection.
16. The Tenderer shall provide any other arrangement required during testing or heating-up like temporary blanking, opening and closing of manholes, etc. as directed to by the Purchaser.
17. The Tenderer shall return all the surplus refractories and returnable empties to the SIL stores in good condition by properly sorted condition.
18. The Tenderer shall be responsible for the management of erection work with proper and adequate supervision for ensuring progress of refractory erection work, quality of workmanship and completion of work as per schedule.
19. The Tenderer shall submit scheme along with write up for carrying out refractory erection work & obtain purchaser's clearance on the same before commencement of refractory erection work.

**6. ERECTION OF REFRACTORIES**

Erection of Refractories covers the following areas.

* + 1. Erection of Salamander Main Runner before shutdown of the furnace.
    2. Erection of PCM Runner.
    3. Erection of BF Main Launder, Slag Launder, Emergency Launder.
    4. Erection of Hot Blast Main, Bustle main.
    5. Casting of Blow pipe.
    6. Cleaning/ replacement of damaged checkers.
    7. Inspection & Repairing of stoves where ever damaged.
    8. Inspection, Repairing & cleaning of Hot Blast Main, Waste gas main, Chimney, chimney valves, hot blast valves, back draught pipe line.
    9. Soling of cast house and tuyere platform. (Supply of bricks for soling & for salamander will be in the scope of SGL).
    10. Welding of anchors where ever required for refractory.

**7. Sequence of erection:**

It is necessary to carry out Refractory erection job at least in three stages simultaneously by providing 3 platforms at following levels:

a) First, platform at Top of the Hearth level with monorail underneath to handle carbon & graphite blocks (brought inside furnace either on roller table or by transporting trolley).

b) Second, the movable platform in stack zone to place coolers and refractory lining in the Bosh ,Belly and the stack.

c) Third, the movable platform at throat level for erection of throat Armour, Refractory lining behind the throat armour and Gunning of BF Cone.

The movable platforms shall be suspended from four numbers of chains hanging inside the furnace. Above arrangement along with other construction and erection activities shall be as per safety and statutory norms.

Following sequence shall be followed for the erection of BF1

a) Making ready cooler feeding arrangement from cast house to inside the blast furnace.

b) Making chain suspension system ready at dome or uptakes

c) Erection of chains inside the blast furnace and taking movable platforms inside the furnace.

d) Erection of top fixed platform and electric hoists for erection of cooling plates.

e) Erection of cooling plates

g) Making ready brick feeding system for taking bricks inside the furnace.

For erection of carbon blocks, feeding system for carbon blocks is to be installed at Tap Hole level

a) BF refractory lining, erection of carbon blocks and refractory lining and erection of cooling plates and refractory lining of the BF Cone area shall be carried out parallelly.

b) After completion of erection of carbon blocks, the fixed platform is carefully dismantled into smaller pieces and removed from inside the furnace.

c) Remaining refractory lining in Bosh and other areas of stack is completed by lowering movable platform in the level.

d) After completion of all works in throat area, the fixed platform installed is to be removed out and all windows are closed and refractory works of those areas is to be completed by moving movable platform in the area.

e) In the end, movable platform and suspension chains are to be taken out.

**7.1 Erection Specification of Refractories**

**Sequence:**

The feeding system for bottom blocks/tap hole bricks shall be through the tap hole opening or tuyere hole as applicable at site.

1. After completion of erection of bottom blocks, refractory lining in the hearth wall bosh and stack is completed by using hanging platform.
2. After completion of all works in throat segment area, all platforms, structure, scaffoldings etc. installed for erection shall be removed through tuyere opening.
3. In the end, hanging platform and suspension chains are to be taken out.

The erection specifications and drawings for the works shall be provided by Purchaser and the same shall be returned to Purchaser after completion of the job. For deviations at site or points not covered by the specifications, the instructions given at site shall be binding.

The instruction given in these chapters are indicative.

Before starting of the brick installation the Successful Bidder shall be required to check the following aspects of the steelworks installation as per the relevant mechanical drawings.

1. Roundness and local deformations, if any.
2. Flatness of the bottom plate and perpendicularity of the steel shell of blast furnace stove proper etc.
3. Presence of any loose layer of rust or other foreign material.

Before starting the brick work loose layers rust or other foreign material on the interior of the steel shell must be removed with a wire brush or scraper.

The refractory bricks shall be handled carefully and kept stacked properly to avoid breakage of corners and edges. The surfaces of the bricks shall be thoroughly cleaned of dirt and greases with wire brush prior to use.

All bricks, mortars, castables, and all other auxiliary materials likely to be damaged in the open shall be stored under cover in dry conditions.

Refractory works shall be carried out with the completion of structural erection work. The bidder shall provide necessary protective cover for the safety of workman and proper execution of the job.

The successful bidder shall provide wooden form work duly lined with thin metallic sheets for all temporary platforms, scaffoldings and any other area required to be covered during the course of the work.

Hanging platforms/lifting mechanism as required for stove and other area shall be provided by the successful bidder.

The successful bidder shall provide fans for ventilation purpose at places as instructed to by Purchaser at no extra cost.

The successful bidder shall perform cutting of ceramic felt, cardboard, oil paper, etc. as per the instruction of purchaser, wherever required.

The successful bidder shall make his own arrangement for material supply, fabrication and installation of protective platforms etc. at no extra cost to Purchaser.

Plugs reuired for handling carbon refractory will be made available to the tenderer. All other arrangements required for transportation, handling & laying of hearth refractory shall be provided by the tenderer.

7.2 **General specification for brick laying**

1. For checking the horizontally and verticality of the lining straight-edge, spirit level and plumb bobs shall be issued.
2. The contour of different walls shall be checked by means of templates made out of plywood or aluminum. For doing the hearth bottom lining of the blast furnace wooden crosses will be used.
3. The correctness of the geometrical sizes of the lining for hearth and stack of blast furnace shall be checked with the help of movable radius. The permissible deviation from the desired radius shall not be more than 20 mm.
4. The keying of individual brick layer or ring and successive layer rings must be right in terms of basic masonry rules. The bricks laid must be true to the radius of curvature all over and right up to the final keying bricks smaller than half brick for keying purpose shall not be used.
5. For cutting of bricks, cutting machine shall be used. However, in exceptional cases where use of cutting machine becomes impractical /difficult, manual cutting by brick cutting chisel shall be allowed as per discretion of the purchaser.
6. The thickness of mortar joints of the complete lining shall be checked by means of a set of metallic gauges of different thickness and width 25 mm.

The permissible variations in the horizontal level of brick work are as under.

|  |  |
| --- | --- |
| Bottom and hearth | 1 mm |
| Bosh and lower part of stackesz | 1 to 2 mm |
| Upper part of stack | 1 to 2 mm |

1. All mortar required for the work shall be prepared in mortar mixer only and shall be mixed well without lumps.
2. Mortar mixers and boxes for storing mortars shall be thoroughly cleaned up before starting to prepare another quality of mortar.
3. When sodium silicate is added to the mortar, it shall be used within 2 hrs.
4. The surface of completed brickwork shall be required to be cleaned and pointing done.
5. Final instruction for erection & inspection for lining shall be given to successful bidder.

**7.3 Mortar joints**

1. All mortar joints must be completely filled and mortar must adhere to all surfaces to be joined. Mortar should not be feathered around the joints.
2. The permissible mortar joint thickness for the radial and horizontal joints shall be as given below.

| **Sl.**  **No.** | Location | **Joint Thickness**  **(mm)** |
| --- | --- | --- |
| 1. | Blast furnace  Bottom  Hearth including tuyeres, tap hole  Hearth wall  Bosh  Stack  Throat | 1.0  1.0  1.0  1.0  1.0  1.0 |
| 2. | Bustle Main & Part of Hot Bustle Main | 2.0 |
| 3. | Cast house  Runner for metal & slag  Inner side  Outer side | 2.0  3.0 |
| 4. | Encasing works  Parapet  Encasing of cast house columns | 3.0  3.0 |

7.4 **Blast furnace lining**

1. Before starting the laying of hearth bottom brickwork, the following should be done.
2. Inserted portion of the thermocouples should be mounted in the design position. Any cutting in brickwork, making of groove etc. in the brick work shall be done by the successful bidder as per site condition.
3. A course of refractory concrete should be placed at bottom plate.
4. Fixing and marking of center of hearth bottom
5. The hearth bottom consists of a leveling layer to be provided over the bottom plate.
6. The gap between the shell and hearth bottom lining shall be rammed with cold ramming carbon mass.
7. The hearth bottom lining shall be done in a cross wise way breaking joints in all directions. For this purpose before starting each course, wooden crosses shall be laid aligned. For making the pattern, hard dry wood shall be used to avoid warping.
8. After completing each course of hearth bottom and before starting the next course the bidder shall be required to check the horizontal level of the completed course. The top surface shall be ground, if required.
9. The lining of the hearth wall shall be done in circular form. The lining shall be controlled by means of sliding movable instrument called “Portable Radius” to be provided by the bidder.
10. In the hearth area the gap between the brickwork and shell shall be filled with cold ramming carbon mass thoroughly rammed.
11. The openings for iron notches and tuyeres shall be made according to pattern and lining shall be done in a step-wise fashion horizontally.
12. The refractory lining in the bosh, bosh parallel and stack shall be done in concentric rings with staggered vertical, radial and circumferential joints. The quantity of refractory material for lining bosh, bosh parallel, stack and throat areas are shown on the drawing. The lining can be done simultaneously is not more than 3 courses at a time. The gap between the brickwork and shell/coolers shall be filled with cold ramming carbon mass thoroughly rammed.

7.5 **Hot blast system**

1. The hot blast main and bustle pipe shall be lined with 1 course of dense 62% Al2O3 bricks. Behind 62% Al2O3 bricks, Hot Face & Cold Face Insulation bricks shall be laid. In between the insulation layer and the steel shell, insulation slab be laid.
2. The lining shall be done with staggered joints.
3. The lining of the circumferential row shall be done with the help of wooden centering. The centering shall not be removed till the key brick are put in positions.
4. Expansion joints shall be provided as shown in the drawings. The joints shall be suitably filled with ceramic fibre.
5. Tuyere branch shall consist of 1 layer of 62% Al2O3 brick and backed up by Hot Face & Cold Face Insulation bricks and insulation slabs.

7.6 **Cast house**

1. The runner shall be lined with 62% alumina bricks.
2. The lining around the trough (along the sides) and its base, for both metal and stag shall be done with fire clay bricks.
3. The complete cast house floor, except the runner area shall be laid with fire clay bricks. In between the brick course and cast house concrete floor sand shall be spread. The flooring shall be in Herring bond pattern or any other pattern as specified in the drawings and shall be done maintaining the desired slopes. To keep the sand in position along the edges of the cast house floor and along opening in the floor over the concrete slab, refractory brickwork in fire clay quality shall be laid along with red brick in bonding. After brick lying is over sand be sprinkled and worked up to fill up the joints in the brickwork. The supply of sand and red bricks and their erection is covered under civil scope.
4. Cast house columns, parapets, etc. wherever required, shall be encased by fire clay bricks, using cement and mortar, up to heights as specified in the relevant drawing.

7.7  **Gunning Work of top cone of blast furnace.**

Before gunning, the erection contractor has to read the instructions given in drawing which will be given by purchaser.

Proper quality of gunning castable shall be used as per the specification and drawing to ensure good workmanship of gunning.

Gunniting of all equipment shall be carried out at ground floor except for dust catcher and top cone of blast furnace.

Prior to gunning, read the instruction of the manufacturer, gunning should be carried out only by experienced masons.

Prior to gunning, ensure that the required quality and number of anchors are welded to the shell and the gunning surface is cleaned. Welding of anchors are in the scope of tenderer only.

7.8  **Filling works with refractory materials**

Certain gaps in between the lining and casing and in between the refractory brickwork has to be filled with insulating materials, or admixtures of insulation materials and mortars as specified in the instructions or as instructed to at site shall be packed to the required specifications. A few such cases are enumerated below as examples.

Stack - Filling of gap in between the brick lining and shell with carbon mass/ fireclay mass.

7.9 For the purpose of measurement, only the corresponding brick work inclusive of mortar joints shall be taken. The rate quoted for brick work shall be inclusive of filling works with insulation materials and mortar and all charges for executing the work as specified above and as per terms of the special and general conditions of contract.

7.10 On completion of refractory erection work all balance refractory materials shall be handed over to purchaser with proper cataloguing.

7.11The expected quantum of work area wise is as per “Bill of Quantities for erection of Refractories”.

**Drawing of General arrangement of BF2 refractory lining (2014) with additional cooling plates**



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| **Prepared By:**  Head – Production PID I | **Reviewed & Issued By:**  Management Representative | **Approved By:**  Head – Pig Iron Division |
| **Signature:** | **Signature:** | **Signature:** |
| **Date: 10.07.2023** | **Date: 10.07.2023** | **Date: 10.07.2023** |

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| **Amendment Record** | | | |
| **Revision date** | **Manual Section ref. and para** | **Brief details of revision** | **New Revision No.** |
| 15.07.2022 | Physical hazard 2,3,4 added  Change in format  General arrangement of BF2 refractory lining (2014) with additional cooling plates drawing added |  | 04 |